APPENDIX J

Preliminary hazard analysis

REPORT

PRELIMINARY HAZARD ANALYSIS

BIRRIWA SOLAR AND BATTERY PROJECT

ENVIRONMENTAL IMPACT STATEMENT

EMM CONSULTING PTY LTD

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Title: **Report** **Preliminary Hazard Analysis** **Birriwa Solar and Battery Project** **Environmental Impact Statement**	**QA verified:** K. Shen **Date:** 20-Jul-2022

CONTENTS

TABLES

FIGURES

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	Central West Orana
DC	Direct Current
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency
EMF	Electric and Magnetic Fields
EMM	EMM Consulting Pty Limited
FRNSW	Fire and Rescue NSW
HAZID	Hazard Identification
HIPAP	Hazardous Industry Planning Advisory Paper
HV	High Voltage
HVAC	Heating Ventilation Air Conditioning
Hz	Hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IP	Ingress Protection
ISO	International Standards Organization
km	Kilometres
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt hours
LPG	Liquefied Petroleum Gas
LV	Low Voltage
MV	Medium Voltage
MW	Megawatt

MWh	Megawatt hours
NFPA	National Fire Protection Association
NSW	New South Wales
OEM	Original Equipment Manufacturer
PCS	Power Conversion System
PHA	Preliminary Hazard Analysis
PPE	Personal Protective Equipment
PV	Photovoltaic
REZ	Renewable Energy Zone
RFS	Rural Fire Safety
SEARs	(Planning) Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy

TERMINOLOGY

Associated residence	A dwelling whose owners have a landholder agreement with ACEN for the project. In the EIS, residences identified with an 'A' are associated residences
Consequence	Outcome or impact of a hazardous incident, including the potential for escalation
Development footprint	The area to be developed within land where ACEN holds landholder agreements. All operational components of the project will be within the development footprint. The development footprint is the outcome of the iterative process outlined in the EIS which led to excluding certain areas of environmental or social constraint
Non-associated residence	A dwelling that is not associated with the project, with no landholder agreement with ACEN. Residences identified with an 'R' are non-associated
Offsite	Areas extending beyond the development footprint boundary
Onsite	Areas within the development footprint boundary
Operational Infrastructure area	Proposed operational infrastructure area including substation, operational facility and BESS
Project	Birriwa Solar and Battery Project
Study area	The area of assessment for baseline surveys and studies conducted for the EIS. The study area comprises the maximum area considered for the project based on the extent of land where ACEN holds landholder agreements and the area of potential impact for road upgrades
Proponent	ACEN Australia (ACEN)
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 Birriwa Solar and Battery Project (the project); a large-scale solar photovoltaic (PV) generation facility with associated infrastructure in Birriwa, approximately 15 kilometres (km) south-west of the township of Dunedoo, in the Central West of New South Wales (NSW) within the Mid-Western Regional Council Local Government Area.

The project involves the development, construction and operation of a solar PV electricity generation facility and will comprise solar arrays, a Battery Energy Storage System (BESS), transformers, inverters and associated infrastructure. The project will have an estimated generation capacity of up to 600 megawatts (MW) and include a centralised BESS with 1000 MW/1000 MWh capacity. The electricity generated onsite will contribute to and connect to the Central West Orana Renewable Energy Zone (CWO REZ) at the Merotherie Energy Hub proposed by EnergyCo.

The project is a State Significant Development under the *State Environmental Planning Policy (Planning Systems) 2021* (Planning Systems SEPP) and requires an Environmental Impact Statement (EIS) to accompany the Development Application submission, in accordance with the Environmental Planning and Assessment Regulation.

ACEN has commissioned EMM Consulting Pty Ltd (EMM) to prepare an EIS for the project. EMM has retained Sherpa Consulting Pty Ltd (Sherpa) to undertake a Preliminary Hazard Analysis (PHA) for the project for input to the 'Hazards and Risks' section of the EIS.

1.2. Objectives

The overall study objective was to address the 'Hazards and Risks' component of the Planning Secretary's Environmental Assessment Requirements (SEARs), Ref [1], which include:

1. A Preliminary Hazard Analysis (PHA) must be prepared in accordance with *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 onsite and offsite receptors to prevent fire propagation and compliance with *Hazardous Industry Advisory Paper No. 4, 'Risk Criteria for Land Use Safety Planning' (DoP, 2011)*;
2. An assessment of potential hazards and risks including but not limited to bushfires, spontaneous ignition, electromagnetic fields for the proposed grid connection infrastructure against the *International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields*.

1.3. Scope

The scope of the study includes the following project infrastructures:

- PV panel and solar arrays.
- Electrical collection and conversion systems, including inverter, transformer units, switchyard and a control room.
- Underground and aboveground cable network.
- An operational infrastructure area including:
  - A 1000 MW/1000 MWh BESS
  - An onsite substation
  - Staff office, amenities and meeting facilities
  - Operations and control room
  - Workshop and spare parts storage facility
  - Parking facilities and internal access roads.
- Fencing, landscaping, vegetation management.
- Temporary compound for construction and decommissioning.

1.4. Exclusions and limitations

The scope of work is limited to the requirements under the 'Hazards and Risks' component of the SEARs. The study exclusions are as follows:

1. State Environmental Planning Policy (SEPP) No. 33[1] *Hazardous and Offensive Development* risk screening. A risk screening is typically undertaken to determine whether (1) the development is considered as 'potentially hazardous' in the context of SEPP 33 and hence (2) requirement for a PHA. The SEARs issued for this development requires a PHA to be undertaken notwithstanding the SEPP 33 risk screening outcome. A SEPP 33 risk screening was not completed for the EIS. A PHA was completed to (a) assess the offsite risk to surrounding land uses and (b) demonstrate that the BESS is suitably located and risks to neighbouring land uses are minimised.
2. Bushfire hazard assessment. A separate bushfire hazard was completed by Coolburn Pty Ltd (Coolburn) for input to the EIS. Risk events associated with bushfire and the identified controls (i.e. asset protection zone requirement, fire management plan) have been included in this study to demonstrate that this event has been considered and assessed.

[1] SEPP 33 has been consolidated into the new *SEPP (Resilience and Hazards) 2021*. It now forms Chapter 3 of the new Resilience and Hazards SEPP. Supporting documents such as Applying SEPP 33 have not been updated to reference the Resilience and Hazards SEPP.

3. Construction safety study. This study does not constitute a Construction Safety Study. Requirement for the study at a later stage will be subject to the conditions of consent of the Development Application approval. For more information, refer to the NSW Department of Planning and Environment Hazardous Industry Planning Advisory Paper (HIPAP) No. 7 *Construction Safety*, Ref [2].
4. The study identified and assessed credible hazards associated with proposed operations of the project and associated infrastructure, and excluded specific hazards relating to construction, commissioning, and decommissioning. This approach is assumed appropriate for EIS assessment at the Development Application stage aimed to obtain approval for the project.
5. Design elements for the BESS are subject to change prior to construction. Sherpa noted that the selection of the BESS supplier and layout of the BESS units within the compound will be finalised during detailed design. Detailed design will be conducted upon project approval to allow sufficient flexibility in the selection of technology. This approach will allow for the rapid technology advancements currently being developed in the BESS industry to be accommodated.

2. PROJECT DESCRIPTION

2.1. Location and project site

The project will be located within the localities of Birriwa and Merotherie in the north-western corner of the Mid-Western Regional Local Government Area in the Central West Region of NSW. The site is situated within the CWO REZ.

The project will be developed within a study area of approximately 1,300 hectares. The study area can currently be accessed via both the Castlereagh Highway (via Birriwa Bus Route South or Barneys Reef Road) and the Golden Highway (via Merotherie Road and Birriwa Bus Route South).

The locations of the study area, development footprint and proposed operational infrastructure area being considered (i.e. Options A and B) are shown in Figure 2.1. The general layout of the project is shown in Figure 2.2.

2.2. Surrounding land use

The entire development footprint is zoned RU1 Primary Production under the Mid-Western Regional Local Environmental Plan 2012, and is mainly freehold land, excluding small sections of Crown roads. The land is currently used for agricultural purposes and farming (i.e. grazing and cropping). These existing uses will continue with minimal interruption from the project's operation. Several other renewable energy generation projects (proposed and approved) are located in the vicinity of the project area.

There are four associated residences[3] located in the vicinity or within the development footprint. Within a 2 km radius of the development footprint boundary, there are 22 scattered non-associated residences[4]. These are shown in Figure 2.1. The non-associated residences or occupied areas are considered as sensitive receivers for the purposes of this risk assessment.

The nearest township to the project is Birriwa, located approximately 2 km west of the development footprint.

[3] Residences that are part of the project and holds an agreement with ACEN.

[4] Residences that are not part of the project.

Figure 2.1: Project location and development footprint

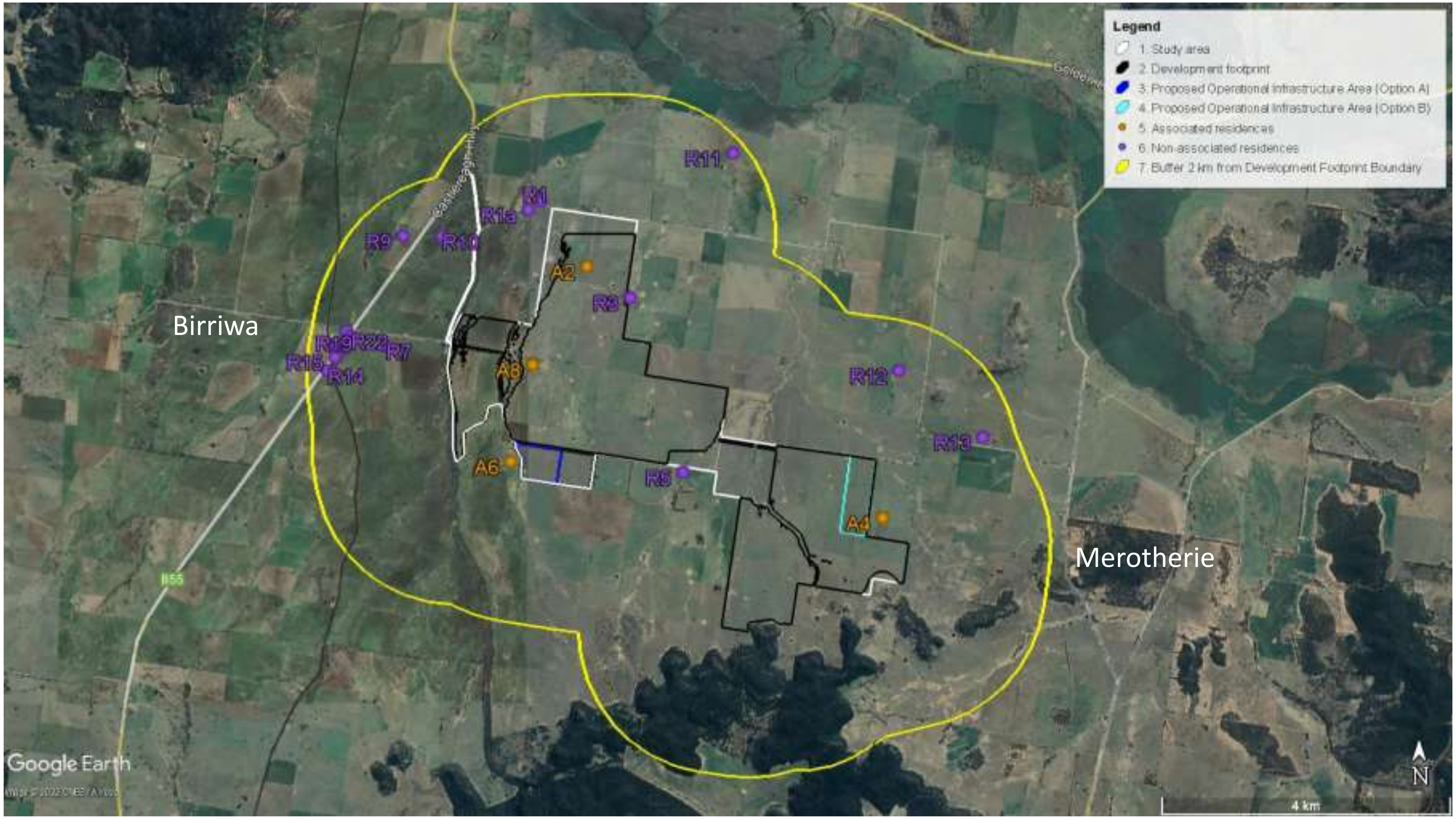
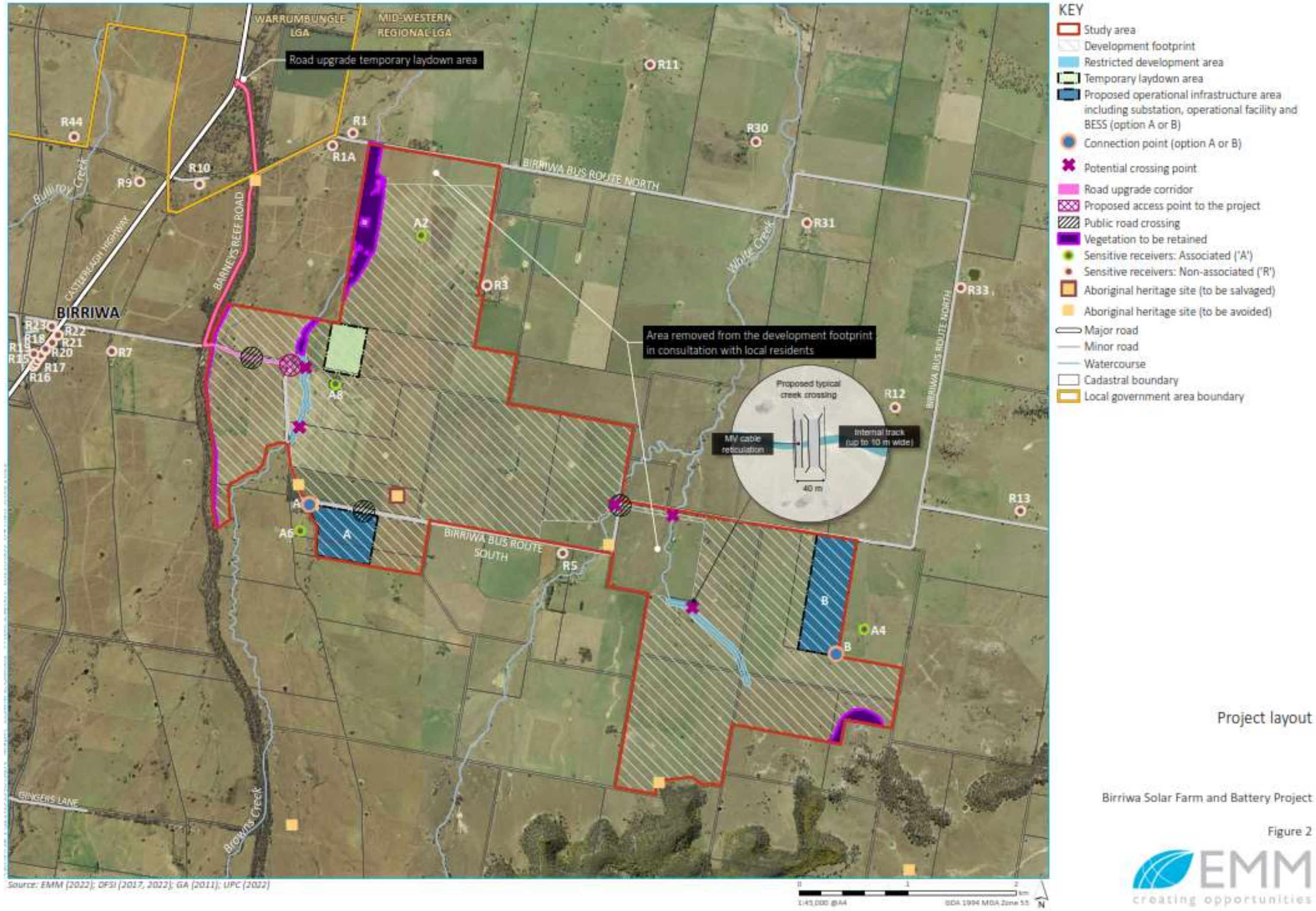


Figure 2.2: General layout of the project



2.3. Project key infrastructure

2.3.1. PV panels and solar arrays

Solar PV module technology will be connected via a Direct Current (DC) collection system consisting of cables mounted on the module support structure. The racking system will be a Single Axis Tracker system. The PV modules will be installed on racking frames fixed onto a horizontal tracker tube, with this mounted on top of vertical piles driven or screwed into the ground; and installed in rows spaced between 5 m and 12 m apart. The rows of PV modules will be aligned in a north-south direction, allowing the panels to rotate from east to west during the day, tracking the sun's movement.

The project will involve a network of approximately 1 million panels and associated mounting infrastructure.

2.3.2. Electrical collection and conversion systems

A typical collector system will include DC reticulation cabling run along each solar array and then below ground to the inverter stations. Inverters will convert the DC to Alternating Current (AC) with Medium Voltage (MV) and/or High Voltage (HV) transformers increasing the voltage for export to the grid.

Collector cables will be of sufficient length to minimise the use of cable joints between inverter/transformer assemblies, wherever possible. Cables will be buried and covered to a depth that meets Australian standards. Where cables are buried in the same trench, a minimum calculated separation will be maintained to ensure thermal constraints are complied with.

2.3.3. Substation and grid connection

An onsite substation (500 or 300 kV) will be constructed to allow grid connection to the CWO REZ at the Merotherie Energy Hub. The substation will be located within the operational infrastructure area and anticipated to be adjacent to the proposed BESS. A minimum of 10 m Asset Protection Zone (APZ) will be provided around the substation area, Ref [3].

2.3.4. Battery Energy Storage System

The purpose of the BESS will be to provide a dispatchable capability to the project's energy generation profile, provide synthetic inertia and system strength to the proposed CWO REZ and support stabilising the supply of electricity to the National Electricity Market. Indicatively, the proposed BESS will have a capacity of up to 1000 MW/1000 MWh with up to 20% overbuild to account for losses and degradation and make use of lithium-ion technology.

The BESS will be located within the operational infrastructure area, near or adjacent to the project's substation. A minimum of 10 m APZ will be provided around the BESS with security fencing around the area perimeter, Ref [3].

At the time of this study, Sherpa was advised that three different types of enclosures are being considered by ACEN for the battery system. The assessment made in this study was based on the potential use of the following BESS enclosures:

- Containerised
- Outdoor rack
- Indoor rack within a building.

Major components for the proposed BESS and specific features for the battery systems for the various enclosures being considered are provided in Table 2.1, Ref [4].

The selection of the BESS supplier, layout of the BESS units within the compound and amount of overbuild required will be finalised during detailed design. Detailed design will be conducted upon project approval to allow sufficient flexibility in the selection of technology. The following were assumed for the PHA:

1. The BESS units will be installed in accordance with the manufacturer'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 applicable Australian Standards and other applicable codes and standards such as the National Fire Protection Association (NFPA) 855 *Standard for the Installation of Stationary Energy Storage Systems*. For BESS installation in dedicated use buildings this also includes the National Construction Code requirements.
3. The BESS units will be tested and certified to UL 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*.

Table 2.1: Potential BESS options for the development

Component	Containerised	Outdoor rack	Indoor rack within a dedicated building
Description	Modular design where the battery modules are assembled in standard 40-foot ISO containers (L 1,220 mm x W 2,400 mm x H 2,600 mm) with externally 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.	Modular design where the battery modules are assembled in battery racks. The indoor racks are similar to the outdoor-rated racks but allows for the use of a lower ingress protection (IP) rating. Each battery rack consists of battery modules, a control box, chiller and fire protection system. The size of each battery rack is approximately: L 924 mm x W 1,185 mm x H 2,329 mm.
Battery modules	Each container will be rated for 4.6 MW/4.6 MWh. Accounting for AC/DC losses and usable capacity, to achieve the proposed capacity (1000 MW/1000 MWh) a total of 268 containers and 268 PCS skids will be installed.	Each battery rack consists of eight battery modules. Each battery rack is rated for 372.7 kWh. Accounting for AC/DC losses and usable capacity, to achieve the proposed capacity (1000 MW/1000 MWh) a total of 3312 battery racks and 276 PCS skids will be installed. Each PCS skid will feed 12 battery racks via a DC combiner box.	Each battery rack consists of eight battery modules. Each battery rack is rated for 372.7 kWh. Accounting for AC/DC losses and usable capacity, to achieve the proposed capacity (1000 MW/1000 MWh) a total of 3312 battery racks and 276 PCS skids will be installed. Each PCS skid will feed 12 battery racks via a DC combiner box.
Power Conversion systems (PCS) or inverters	Inverters are electrical devices that convert Direct Current (DC) to Alternating Current (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.	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 a built-in fire protection/ suppression system which includes a smoke detector, heat detector and aerosol spray fire extinguishing device. When both smoke and heat detectors are triggered, the aerosol spray will be released.	Each battery rack is provided with a built-in fire protection/ suppression system which includes a smoke detector, heat detector and aerosol spray fire extinguishing device. When both smoke and heat detectors are triggered, the aerosol spray will be released.

2.3.5. Supporting infrastructure

The following supporting infrastructure will also be developed as part of the project:

1. Staff office, operations and control room, meeting facilities and amenities
2. Workshop and spare parts storage facility
3. Supervisory Control and Data Acquisition facilities
4. Parking facilities and internal access road
5. Fencing and landscaping around the development area boundary
6. Temporary compound for construction and decommissioning.

Security fencing will be installed to restrict public access to the project infrastructure. The location of the security fencing will be determined in consultation with the project landholders.

A temporary construction compound will be established before the construction work commences. The compound will be dismantled, and its footprint rehabilitated once the project is built and moves into the operational stage.

2.4. Construction

Construction of the project will take approximately 24 months from the commencement of site establishment works. During the peak construction period, a workforce of approximately 800 people will be required. Construction activities will be undertaken at the following hours:

- Monday to Friday: 7am to 6pm
- Saturday: 8am to 6pm
- Sunday and public holidays: no construction work.

ACEN proposes the following construction activities may be undertaken outside these hours without the approval of the Secretary:

- Activities that are inaudible at non-associated residences
- The delivery of materials as requested by the NSW Police Force or other authorities for safety reasons
- Emergency work to avoid the loss of life, property and/or material harm to the environment.

Construction equipment, materials and infrastructure will be transported to site. These will include use of heavy vehicles, B-doubles and oversized vehicles to deliver large equipment (e.g. transformers).

2.5. Operations

The PV solar panels will operate during daylight hours, seven days per week, 365 days per year. The BESS will operate 24 hours per day, seven days per week, 365 days per year and is normally manned.

The operational lifespan of the project may be in the order of 30 years, depending on the nature of solar PV technology and energy markets. Should the PV modules be replaced during operations, the lifespan of the project may extend to up to 50 years. During the operations phase, the project will employ a workforce of up to 20 full time employees.

2.6. Decommissioning

Once the project reaches the end of its investment and operational life, the project infrastructure will be decommissioned, and the development footprint returned to its pre-existing land use, suitable for farming (cropping and grazing), agricultural uses, or another land use as agreed by the project owner and the landholder at that time.

ACEN will attempt to recycle all dismantled and decommissioned infrastructure and equipment, where possible. Structures and equipment that cannot be recycled will be disposed of at an approved waste management facility.

3. METHODOLOGY

3.1. Overview

This PHA was carried out in accordance with the requirements of HIPAP No. 6 *Hazard Analysis*, Ref [6], and included the following steps:

1. Establishment of the study context.
2. Identification of hazards resulting from the project operations and events with the potential for offsite impact *(Hazard Identification)*.
3. Analysis of the severity of the consequences for the identified events with offsite 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 identified events with offsite 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 Development Application stage, the PHA is focused on the risk to surrounding land uses (offsite impacts) and assesses if the development is appropriate for the location. The development footprint boundary was used to define and determine offsite impact (i.e. impact extending outside of the development footprint boundary). In this PHA, offsite impacts were determined based on potential to impact non-associated residences. Associated residences were not considered as offsite receptors as they have an agreement in place with ACEN and consent to the risk exposed by the development and proposed infrastructure.

In addition to the PHA, the 'Hazards and Risks' assessment requirement also requires "an assessment of potential hazards and risks" associated with the project infrastructure and proposed operations. This requirement is addressed by the PHA which is aligned with the risk management process outlined in AS ISO 31000 *Risk Management Guidelines,* Ref [7].

3.2. Level of analysis

The *Multi-Level Risk Assessment* guidelines, Ref [8], 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 offsite consequences and societal risk is negligible.
2	Partially quantitative	The frequency of occurrence of risk contributors having offsite consequences is low.
3	Quantitative	There are significant offsite 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 [9], 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. Previous risk assessments for similar solar projects/developments and BESS systems completed by Sherpa.
2. Review of AS/NZS 5139:2019 *Electrical installations – Safety of battery systems for use with power conversion equipment*, Ref [10].
3. Literature research of past incidents involving similar BESS systems.
4. Review of the Birriwa BESS Design Considerations report, Ref [4].
5. Review of a typical battery manufacturer's product brochure, Ref [11], product specifications, Ref [5], and fire safety design, Ref [12], for controls provided.
6. Consultation and feedback from ACEN.

At the time of this study, the specific Safety Data Sheet and/or emergency response guide for the battery systems were not available. The HAZID for the battery system was based on Sherpa's experience for similar BESS facilities, which assumed that the modes of failure of lithium-ion batteries are not dissimilar. This was further supplemented with a review of the AS/NZS 5139 and literature research of past incidents involving similar BESS systems. The HAZID was reviewed by the stakeholders and accepted for the project.

4.2. Identified hazard and events

The following factors were considered to identify the hazards:

- Project infrastructure 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 major consequence impacts to people (i.e. injury and/or fatality) were identified. The study excluded hazards related with Occupational Health & Safety, 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, water ingress (rain and flood)

In this study, bushfire was considered as a cause of fire resulting from encroachment of an offsite bushfire impacting the project infrastructure. A separate bushfire hazard assessment was completed by Coolburn for input to the EIS. Identified controls have been referenced (i.e. asset protection zone requirements, fire management plan) in this study, where applicable.

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

4.3. Exposure to EMF

The SEARs for 'Hazards and Risks' include a requirement to assess potential hazards and risks associated with exposure to EMF against the ICNIRP guidelines. Details on exposure to EMF and assessment against ICNIRP guideline and reference levels are presented in Section 5.

4.4. Separation distances to offsite receptors

To inform whether the consequence of a hazardous event has the potential to impact offsite receptors, separation distances from the development footprint boundary to the nearest non-associated residences were reviewed. This review is provided in Section 6.

Table 4.2: Hazards by project infrastructure

Project infrastructure	Hazards							
	Electrical	Arc flash	Fire	EMF	External factors	Chemical	Explosive gas	Reaction
1. PV panels and solar arrays	✓	✓	✓	✓	✓	-	-	-
2. Electrical collection and conversion systems	✓	✓	✓	✓	✓	-	-	-
3. Substation and grid connection	✓	✓	✓	✓	✓	-	-	-
4. BESS	✓	✓	✓	✓	✓	✓	✓	✓
5. Supporting infrastructure - Office, workshop, amenities - Control room, Supervisory Control and Data Acquisition facilities - Parking and internal roads - Fencing and landscaping - Construction compound	-	-	-	-	✓	✓	-	-

4.5. HAZID register

The identified hazards, events, applicable infrastructure and the relationships with causes, consequences and controls are summarised in the HAZID register. Information contained in the register are described in Table 4.3.

The HAZID register is provided in Table 4.4. The findings are as follows:

- A total of 18 hazardous events were identified.
- As some project infrastructure will be located close to the development footprint boundary, some hazardous events with potential for escalated fire may extend beyond the development footprint boundary (i.e. offsite impact in the context of HIPAP No. 6). However, the consequences from these events are not expected to result in significant offsite impacts (serious injury and/or fatality to the public or offsite population) as:
  - The project will be situated in a rural area.
  - For both operational infrastructure area locations considered (Options A and B) where the proposed BESS and substation will be located, the closest non-associated residence is located at least 1.2 km away (R12 or R5).

Table 4.3: Information description – HAZID 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
Controls	Any existing aspects of the design and operations which prevent and/or mitigate against the event and resulting consequences
Other comments	Miscellaneous notes applicable for the line item
Significant offsite impact?	Determination whether the consequence of the event have the potential to result in significant offsite impact (i.e. Yes or No).

Table 4.4: HAZID register

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Controls	Other Comments	Significant offsite impact?
1	Electrical	PV panels Solar arrays cable network Electrical conversion systems (i.e. inverters, transformers) BESS Substation Transmission line	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)	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards 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 by trained personnel (including reputable third party) in accordance with relevant procedures - Independent certifiers/owner's engineers - 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 - Emergency Response Plan - External firefighting assistance (FRNSW & RFS) - Use of appropriate PPE - Rescue kits (i.e. insulated hooks)	-	No
2	Arc flash	PV panels Solar arrays cable network Electrical conversion systems (i.e. inverters, transformers) BESS Substation Transmission line	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 offsite impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards and guidelines. - Warning signs (arc flash boundary) - Engagement of reputable contractors - Installation, operations and maintenance by trained personnel (including reputable third party) in accordance with relevant procedures - Independent certifiers/owner's engineers - Site induction/substation training (i.e. high voltage areas) - Maintenance procedure (e.g. deenergize equipment) - Preventative maintenance (insulation) - Emergency Response Plan - External firefighting assistance (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 [10]. 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	Infrastructure/Area	Event	Cause	Consequence	Controls	Other Comments	Significant offsite impact?
3	Fire	Electrical conversion systems (i.e. inverters, transformers)	Fire on electrical conversion system equipment	- Transformer oil leak - Faulty equipment - Arc flash - External fire (e.g. fire from adjacent infrastructure) - Bushfire	- Localised fire - Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees Localised effects, the effects are not expected to have an offsite impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian 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 (including reputable third party) in accordance with relevant procedures - Preventative maintenance (e.g. insulation, replacement of faulty equipment) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External assistance for firefighting (FRNSW & RFS)	-	No
4	Fire	BESS	BESS fire	- Faulty equipment - Arc flash - 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. fire from adjacent infrastructure) - Bushfire	- 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 located within the operational infrastructure area and there is a large separation distance to the nearest non-associated residential dwelling, the effects are not expected to have an offsite impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - Installation, operations and maintenance by trained personnel (including reputable third party) in accordance with relevant procedures - To minimise escalation between sub-units or other structures, 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) - BMS fault detection and shut-off function - BESS fire protection/suppression system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External assistance for firefighting (FRNSW & RFS)	-	No

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Controls	Other Comments	Significant offsite impact?
5	Fire	Substation	Substation fire	- Faulty equipment - Transformer oil leak - Arc flash - Vandalism - External fire (fire from adjacent infrastructure, e.g. BESS) - Bushfire	- Release of toxic combustion products - Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees As the substation will be located within the operational infrastructure area and there is a large separation distance to the nearest non-associated residential dwelling, the effects are not expected to have an offsite impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian 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 - To minimise escalation between sub-units or other structures, 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) - Electrical switch-in & switch-out protocol - Circuit breakers - Substation is locked with security fence - BESS fire protection/suppression system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External assistance for firefighting (FRNSW & RFS)	-	No
6	Fire	Operational infrastructure area	Bushfire	- Encroachment of offsite bushfire - Escalated event due to fire from other project infrastructure	- Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees As there is a large separation distance from the operational infrastructure area to the nearest non-associated residential dwelling, the effects are not expected to have an offsite impact.	- Fire Management Plan - Defendable boundary for firefighting will be established - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS) - Inclusion of APZ buffer - Use of appropriate PPE	-	No
7	Chemical	Gasoline storage	Loss of containment of gasoline from storage or during handling	- Mechanical failure - Human error during transfer	- Fire, if ignited. - Injury to onsite employees Based on the minor storage quantity, the effects will be localised and not expected to have an offsite impact.	- Storage will comply with Australian standards & guidelines (e.g. AS 1940) - Engagement of reputable suppliers - Independent certifiers/owner's engineers - Warning signs (flammable material) - Fire Management Plan - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS) - Use of appropriate PPE	Gasoline may be provided onsite for vehicle refueling. The amount stored will be under the SEPP 33[5] threshold.	No

[5] SEPP 33 has been consolidated into the new *SEPP (Resilience and Hazards) 2021*. It now forms Chapter 3 of the new Resilience and Hazards SEPP.

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Controls	Other Comments	Significant offsite impact?
8	Chemical	Construction ancillary facilities	Loss of containment of diesel from storage or during handling	- Mechanical failure - Human error during transfer	- Fire, if ignited. - Injury to onsite employees Based on the minor storage quantity, the effects will be localised and not expected to have an offsite impact.	- Equipment and systems will be designed and test to comply with Australian standards & guidelines (e.g. AS 1940) - Engagement of reputable suppliers - Independent certifiers/owner's engineers - Installation, operations and maintenance by trained personnel (e.g. reputable third party) in accordance with relevant procedures - Diesel is a combustible liquid and will be stored away from other flammable materials (e.g. gasoline) - Warning signs (combustible material) - Fire Management Plan - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS) - Use of appropriate PPE	Diesel may be provided for power generation during construction for use in the construction ancillary facilities. The amount stored will be under the SEPP 33[5] threshold.	No
9	Chemical	Construction ancillary facilities	Loss of containment of LPG from storage or filling point	- Mechanical failure - Human error during transfer	- Fire and/or explosion - Injury and/or fatality to onsite employees Based on the minor storage quantity, the effects will be localised and not expected to have an offsite impact.	- Equipment and systems will be designed and test to comply with Australian standards & guidelines (e.g. AS 1956) - Engagement of reputable suppliers - Independent certifiers/owner's engineers Installation, operations and maintenance by trained personnel (e.g. reputable third party) in accordance with relevant procedures - Warning signs (flammable material) - Fire Management Plan - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS) - Use of appropriate PPE	LPG may be provided for utility purposes during construction for use in the construction ancillary facilities. The amount stored will be under the SEPP 33[5] threshold.	No
10	Chemical	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 offsite 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)	-	No

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Controls	Other Comments	Significant offsite impact?
11	Chemical	BESS	Release of battery 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. fire from adjacent infrastructure)	- Release of flammable liquid electrolyte - Vapourisation 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 located within the operational infrastructure area and there is a large separation distance to the nearest non-associated residential dwelling, the effects are not expected to have an offsite impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - Installation, operations and maintenance by trained personnel (including reputable third party) in accordance with relevant procedures - To minimise escalation between sub-units or other structures, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Venting and containment requirements of the BESS manufacturer to be followed - Spill cleanup using dry absorbent material - BESS BMS fault detection and shut-off function - BESS fire protection/suppression system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External assistance for firefighting (FRNSW & RFS)	Vented gases are early indicator of a thermal runaway reaction	No
12	Chemical	BESS	BESS chiller unit or coolant leak	- Mechanical failure/damage - Incorrect maintenance	- Irritation/injury to onsite employee on exposure to leak (e.g. inhalation and skin contact) - Ingress of coolant to battery or other electrical components (battery enclosure) leading to short circuit and fire, resulting in injury and/or fatality to onsite employees. As the BESS will be located within the operational infrastructure area and there is a large separation distance to the nearest non-associated residential dwelling, the effects are not expected to have an offsite impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - Installation, operations and maintenance by trained personnel (including reputable third party) in accordance with relevant procedures - To minimise escalation between sub-units or other structures, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Battery cells are enclosed with external casing - Spill cleanup using dry absorbent material - BESS BMS fault detection and shut-off function - BESS fire protection/suppression system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External assistance for firefighting (FRNSW & RFS)	[Containerised BESS]: Wall or roof mounted reverse cycle HVAC unit with enclosed refrigerant, e.g. R407C or equivalent to Australian Standards [Outdoor/Indoor Rack]: Coolant is 50% ethylene glycol aqueous solution	No

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Controls	Other Comments	Significant offsite impact?
13	Explosive Gas	BESS	Generation of explosive gas Note: also refer to item 10 (release of vented gas)	- Thermal runaway - Bushfire - External fire (e.g. 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 located within the operational infrastructure area and there is a large separation distance to the nearest non-associated residential dwelling, the effects are not expected to have an offsite 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 certifiers/owner's engineers - Installation, operations and maintenance by trained personnel (including reputable third party) in accordance with relevant procedures - To minimise escalation between sub-units or other structures, 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 protection/suppression system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External assistance for firefighting (FRNSW & RFS)	-	No
14	Reaction	BESS	Thermal runaway in battery	Elevated temperature - Bushfire - External fire (e.g. fire from adjacent infrastructure) Electrical failure - Short circuit - Excessive current/voltage - Imbalance charge across cells Mechanical failure - Internal cell defect - Damage (crush/penetration/puncture) Systems failure - BMS failure - Venting failure	- Fire in the battery cell and enclosure - Escalation to the entire BESS - Injury and/or fatality to onsite employees As the BESS will be located within the operational infrastructure area and there is a large separation distance to the nearest non-associated residential dwelling, the effects are not expected to have an offsite impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards and guidelines. - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - Installation, operations and maintenance by trained personnel (including reputable third party) in accordance with relevant procedures - To minimise escalation between sub-units or other structures, 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 (minimise runaway) - BESS BMS fault detection and shut-off function - BESS fire protection/suppression system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External assistance for firefighting (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.	No

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Controls	Other Comments	Significant offsite impact?
15	EMF	PV panels Solar arrays cable network Electrical conversion systems (i.e. inverters, transformers) BESS Substation Transmission line	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) - Injury to onsite employees EMF created from the project will not exceed the ICNIRP reference level for exposure to the general public. Additionally, the strengths of electric and magnetic fields attenuate rapidly away from the source. Impact to the general public in surrounding land uses will be negligible (refer to Section 5).	- 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 relevant international and/or Australian 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 [13]. No established evidence that Extremely Low Frequency (ELF) EMF is associated with long term health effects (ARPANSA), Ref [14].	No
16	External factors	Electrical conversion systems (i.e. inverters, transformers) BESS Substation	Water ingress	- Rain - Flood	- Electrical fault/short circuit - Fire - Injury and/or fatality to onsite employees As the BESS and substation will be located within the operational infrastructure area and there is a large separation distance to the nearest non-associated residential dwelling, the effects are not expected to have an offsite 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 - Substation and switchroom will be housed in a dedicated building and constructed in accordance to relevant standards - Drainage system - Preventative maintenance (check for leaks) - To minimise escalation between sub-units or other structures, 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 protection/suppression system (battery system specific features, refer to Table 2.1) - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External assistance for firefighting (FRNSW & RFS)	-	No

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Controls	Other Comments	Significant offsite impact?
17	External factors	PV panels and solar arrays Electrical conversion systems (i.e. inverters, transformers) BESS Substation	Vandalism	Unauthorised personnel access Trespassing Deliberate damage to project infrastructure	- Asset damage - Equipment failure - Fire - Potential hazard to unauthorised person/ trespasser and injury (e.g. electrocution) Effects to unauthorised person are expected to be localised and not expected to have an offsite impact. The impact is to a member of public but occurs onsite. For a fire event at the operational infrastructure area (e.g. BESS and substation), the effects are not expected to have an offsite impact as there is a large separation distance to the nearest non-associated residential dwelling.	- The project will be located in a rural location - The project infrastructure will be located within a secure area and will be fenced - Warning signs (i.e. trespassers and onsite hazards) - Security cameras will be provided at the operational infrastructure area (e.g. substation, BESS) - Onsite security protocol - Presence of staff during operational hours	-	No
18	External factors	Operational infrastructure area	Lightning strike	Lightning storm	- Fire - Injury and/or fatality to onsite employees As there is a large separation distance from the operational infrastructure area to the nearest non-associated residential dwelling, the effects are not expected to have an offsite impact.	- Earthing - Lightning protection mast - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - Inclusion of APZ buffer - External assistance for firefighting (FRNSW & RFS)	-	No

5. ELECTRIC AND MAGNETIC FIELDS

5.1. Overview

EMF are naturally present in the environment. They are present in the earth's atmosphere as electric fields, while static magnetic fields are created by the earth's core. EMF are also produced wherever electricity or electrical equipment is in use (e.g. household appliances, powerlines), Ref [13].

Electric fields are created where there is flow of electricity. Electric fields are related to and directly proportional to voltage (i.e. higher the voltage higher the electric field). Electric fields are often described in terms of their strength and commonly expressed in volts per metre (V/m) or kilovolts per metre (kV/m).

Magnetic fields are created whenever electric current flows. Magnetic fields are directly proportional to the current (i.e. higher the current higher the magnetic field). Magnetic fields are often described in terms of their flux density and commonly measured in either Tesla (T) or Gauss (G).

Electric and magnetic fields are strongest closest to source and their strength attenuates rapidly away from the source. The strength of electric fields is weakened due to shielding effect from common materials (i.e. buildings, walls), whereas magnetic fields are not.

Use of electricity means that people are exposed to EMF as part of daily life. The background electric and magnetic fields in a typical home is around 20 V/m and 0.1 µT, respectively. These may vary depending on the number and type of appliances, configuration and positioning and distances to the other sources (e.g. powerlines). Typical EMF strengths for common household electrical appliances (at distance of 30 cm) are shown in Table 5.1, Ref [15].

EMF associated with the generation, distribution and use of electricity power systems in Australia which have a frequency of 50 Hertz (Hz) are classified by Energy Networks Australia[6] as Extremely Low Frequency[7] (ELF) EMF, Ref [13].

Table 5.1: Typical EMF strengths for household appliances

Electric appliance	Electric field strength (V/m)	Magnetic field density (µT)
Refrigerator	120	0.01 – 0.25
Iron	120	0.12 – 0.3
Hair dryer	80	0.01 – 7
Television	60	0.04 – 2
Vacuum cleaner	50	2 – 20
Electric oven	8	0.15 – 0.5

[6] Energy Networks Association is the peak national body representing gas distribution and electricity transmission and distribution businesses throughout Australia.

[7] ELF EMF occupy the lower part of the electromagnetic spectrum in the frequency range 0-3000 Hz.

5.2. Effects of exposure to EMF

5.2.1. Acute effect

Studies have been conducted to determine the effects of EMF exposure. There have been a number of well-established acute effects on the nervous system due to exposure to high levels of EMF. These include direct stimulation of the nerve and muscle tissue, and induction of retinal phosphene (i.e. sensation of ring or spot of light on eye ball). However, it should be noted that exposure to high levels of EMF is not normally found in everyday environment from electrical sources. There is also indirect scientific evidence that EMF can transiently affect visual processing and motor coordination. For certain occupational instances, the ICNIRP considered that with appropriate training, it is reasonable for workers to voluntarily experience transient effects such as retinal phosphene and minor changes in brain function since these are not believed to result in long term or pathological health effects, Ref [16].

5.2.2. Chronic effect

Numerous studies have been conducted to understand the effects of long-term exposure to EMF. Some studies have linked prolonged exposure of EMF to increased rates of childhood leukemia. Based largely on limited evidence, the International Agency for Research on Cancer has classified ELF magnetic fields as ‘possibly carcinogenic to humans. The ICNIRP views that the current existing scientific evidence is too weak to ascertain a causal relationship that prolonged exposure to ELF magnetic fields is related with increased risk of childhood leukemia, Ref [16].

5.2.3. Advice from public authority

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is a federal government agency assigned with the responsibility for protecting the health and safety of people and the environment from EMF, Ref [13].

ARPANSA advises that:

- *“The scientific evidence does not establish that exposure to ELF EMF found around the home, the office or near powerlines and other electrical sources is a hazard to human health.”*
- *“There is no established evidence that ELF EMF is associated with long term health effects. There is some epidemiological research indicating an association between prolonged exposure to higher-than-normal ELF magnetic fields (which can be associated with residential proximity to transmission lines or other electrical supply infrastructure, or by unusual domestic electrical wiring), and increased rates of childhood leukaemia. However, the epidemiological evidence is weakened by various methodological problems such as potential selection bias and confounding. Furthermore this association is not supported by laboratory or animal studies and no credible theoretical mechanism has been proposed.”*

5.3. Study approach

Although the adverse health impacts have not been established, the possibility of impact due to exposure to EMF cannot be ruled out. As part of a precautionary approach, the study will assess the typical exposure levels to EMF for the proposed project infrastructure.

A task group assembled by the World Health Organisation to assess any potential health risks from exposure to ELF EMF in the frequency range of 0 to 100,000 Hz found that there are no substantive health issues related to ELF electric fields at levels generally encountered by the general public, Ref [17]. Therefore, the information presented in the following sections address predominantly the effects of exposure to ELF magnetic fields.

5.4. Guidelines for limiting EMF exposure

The ICNIRP has produced a publication to establish guidelines for limiting EMF exposure to assist in providing protection against adverse health effects. Separate guidance is given for general public and occupational exposure within the guideline.

The guideline has defined general public and occupational exposures as follows:

- General public – individuals of all ages and of varying health status which might increase the variability of the individual susceptibilities.
- Occupational exposure – adults exposed to time-varying EMF from 1 Hz to 10 MHz at their workplaces, generally under known conditions, and as a result of performing their regular or assigned job.

The ICNIRP reference levels for exposure to EMF at 50 Hz is presented in Table 5.2, Ref [16]. The guideline adopted more stringent exposure restrictions compared to occupational exposures recognising that in many cases general public are unaware of their exposure to EMF.

Table 5.2: Reference levels for EMF levels at 50 Hz

Exposure	ICNIRP Reference Levels	
	Electric field (V/m)	Magnetic field (μT)
General public	5,000	200
Occupational	10,000	1,000

5.5. Project infrastructure EMF

5.5.1. PV panels, solar arrays and PCSs

A field study was undertaken to characterise the EMF between the frequencies of 0-3 GHz at two large scale solar facilities operated by the Southern California Edison Company in Porterville and San Bernardino, Ref [18].

The field study findings were adopted to estimate the EMF measurements for the project (i.e. large scale solar development and power generating facilities). The findings are as follows:

- There is no evidence of magnetic fields created from the PV modules. For conservatism, it is assumed that the magnetic fields from the PV module do not exceed the background static magnetic field observed at Porterville and San Bernardino (i.e. 52-62 µT).
- The highest DC magnetic fields were measured adjacent to the inverter (277 µT) and transformer (258 µT). These fields were lower than the ICNIRP's occupational exposure limit.
- The highest AC magnetic fields were measured adjacent to the inverter (110 µT) and transformer (177 µT). These fields were lower than the ICNIRP's occupational exposure limit.
- The strength of the magnetic field attenuated rapidly with distance (i.e. within 2-3 metres away, the fields drop to background levels).
- Electric fields were negligible to non-detectable. This is mostly likely attributed to the enclosures provided for the electricity generating equipment.

5.5.2. Underground cable

A typical 33 kV underground cable will produce a maximum magnetic field of approximately 1 µT at one metre above ground level. The magnetic field density will be indistinguishable from the background magnetic field at distances greater than 20 m away from the source, Ref [19].

5.5.3. Substation and grid connection

Main sources of magnetic fields within a large substation (e.g. transmission substation) include transformer secondary terminations, cable runs to the switch room, capacitors, reactors, bus-bars, and incoming and outgoing feeders. For the majority of the cases, the highest magnetic fields at the boundary come from the incoming and outgoing transmission lines.

Generally, the application of electrical safety standards and codes (e.g. fence, enclosure, distance) will result in exclusion of general public exposures from these sources. This is consistent with the measurement of typical magnetic field reported which ranges between 1-8 µT at substation fence, Ref [14].

5.5.4. Transmission lines

The magnetic field from transmission lines will vary with configuration, phasing and load. The typical magnetic fields near overhead transmission lines measured at one metre above ground level range between 1-20 µT (directly underneath) and 0.2-5 µT (at the edge of easement), Ref [14].

5.5.5. BESS

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

5.6. Controls to limit exposure to EMF

The following controls were identified to limit exposure to EMF:

- The design, selection and procurement of electrical equipment for the project will comply with relevant international and Australian standards.
- Location selection for the project infrastructure (i.e. accounts for separation distance to surrounding land uses including neighbouring properties and agricultural operations) and fencing within the project boundary will assist to limit the exposure to EMF for the general public.
- Exposure to EMF (specifically magnetic fields) from electrical equipment will be localised and the strength of the field attenuates rapidly with distance.
- Duration of exposure to EMF for personnel onsite will be transient.

5.7. Conclusion

Based on the review completed in the preceding sections, the study concludes that:

- EMF created from the project will not exceed the ICNIRP occupational exposure reference level.
- As the strengths of EMF attenuate rapidly with distance, the study determined that the ICNIRP reference level for exposure to the general public will not be exceeded and impact to the general public in surrounding land uses will be negligible.
- For the risk assessment, consequence from exposure to EMF was assumed to result in no or minor injury (‘Insignificant’) in reference to the consequence impact rating shown in Table 8.2.

6. BESS SEPARATION DISTANCES

6.1. Overview

As per the SEARs, the PHA for this project also includes requirement to '*consider all recent standards and codes and verify separation distances to onsite and offsite receptors to prevent fire propagation'*. Based on clarification with the Department of Planning and Environment, this additional requirement (to that of a conventional PHA) is intended to ensure that fire risks from the BESS[8] have been considered in designing the project.

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

- BESS 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 offsite 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 offsite receptors.

6.2. Separation distances between BESS sub-units

A review of NFPA 855 *Standard for the Installation of Stationary Energy Storage Systems*, Ref [20], was undertaken by Entura as part of the Birriwa BESS Design Considerations study, Ref [4]. 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[9]. As such, the result of the UL 9540A test (performed with

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

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

clearances as specified by the BESS manufacturer) results form a key parameter to determine clearances.

The following clearances for the BESS components were identified by Entura, Ref [4]:

- 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 6.1. These clearances form an input to the concept layouts produced for the project.

The conceptual BESS layouts for all three enclosure options, Ref [4], showing the separation distances are shown in:

- Figure 6.1 – Containerised
- Figure 6.2 – Outdoor racks
- Figure 6.3 – Indoor racks within a building.

Table 6.1: Summary of clearances for BESS[10]

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 two 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 two surveyed manufacturers. • AS 3000:2018 accessibility requirement.
Integrated Power Conversion Unit	Any other equipment	2 m	2-4 m	-	• OEM specifications from three surveyed manufacturers.
Inverter or switchgear	Any other equipment	2 m	2-4 m	-	• OEM specifications from three 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	10-16m	May include clearance required for adjacent equipment.	• Entura experience. • Austroads turning templates.

10 Reproduced from Table 3.2 of the Birriwa BESS Design Considerations report, Ref [4].

Figure 6.1: Concept BESS layout – Containerised

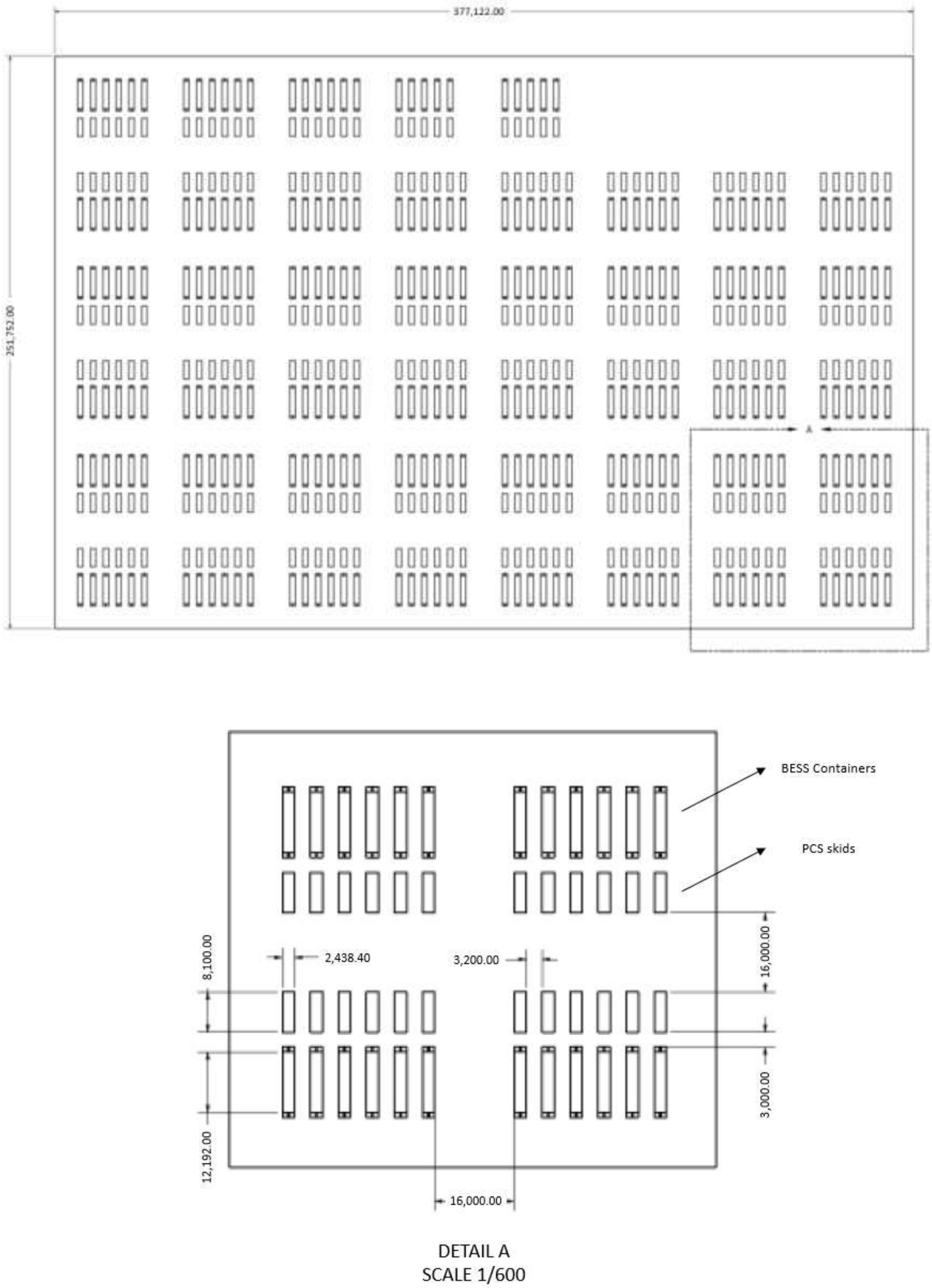


Figure 6.2: Concept BESS layout – Outdoor racks

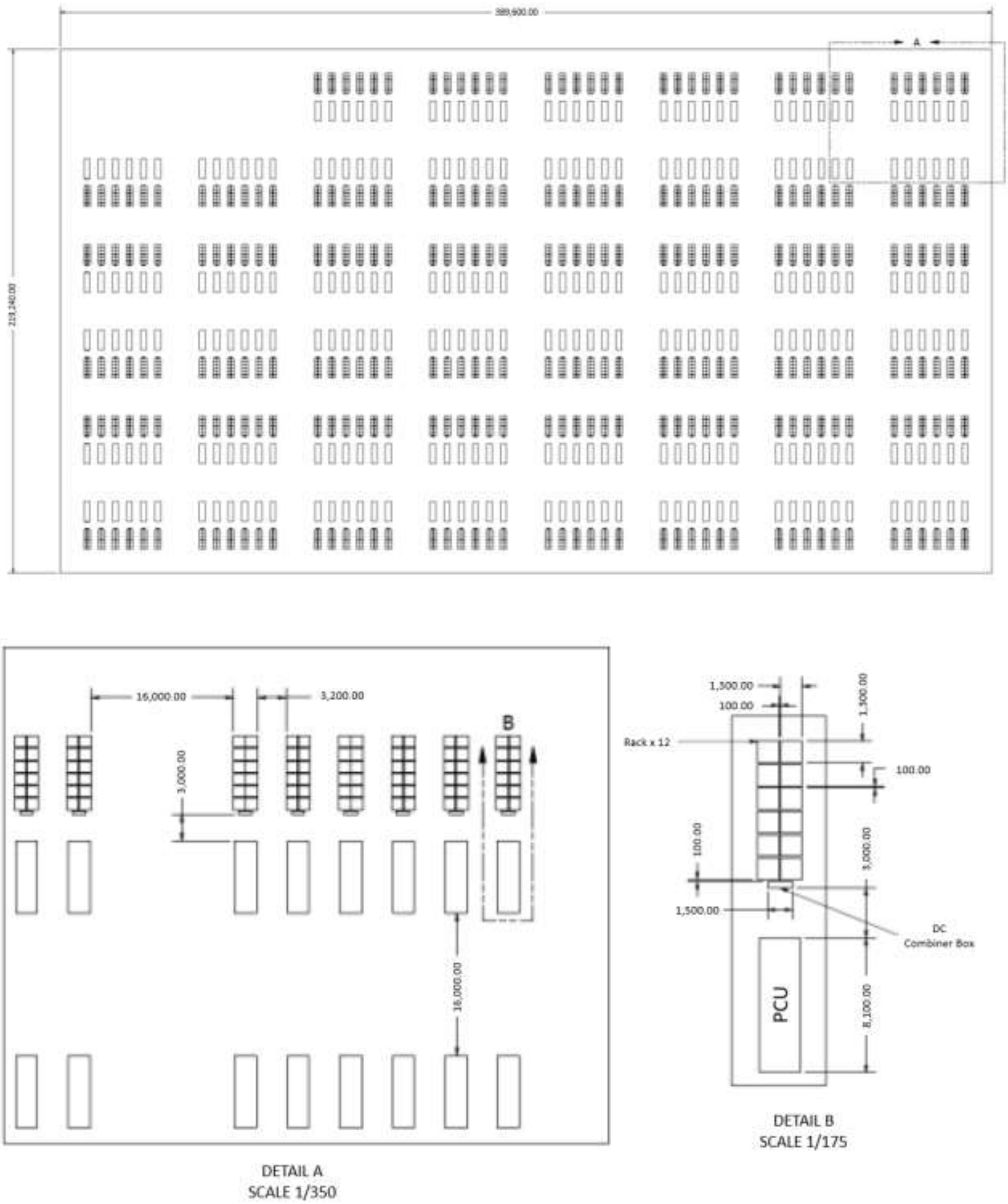
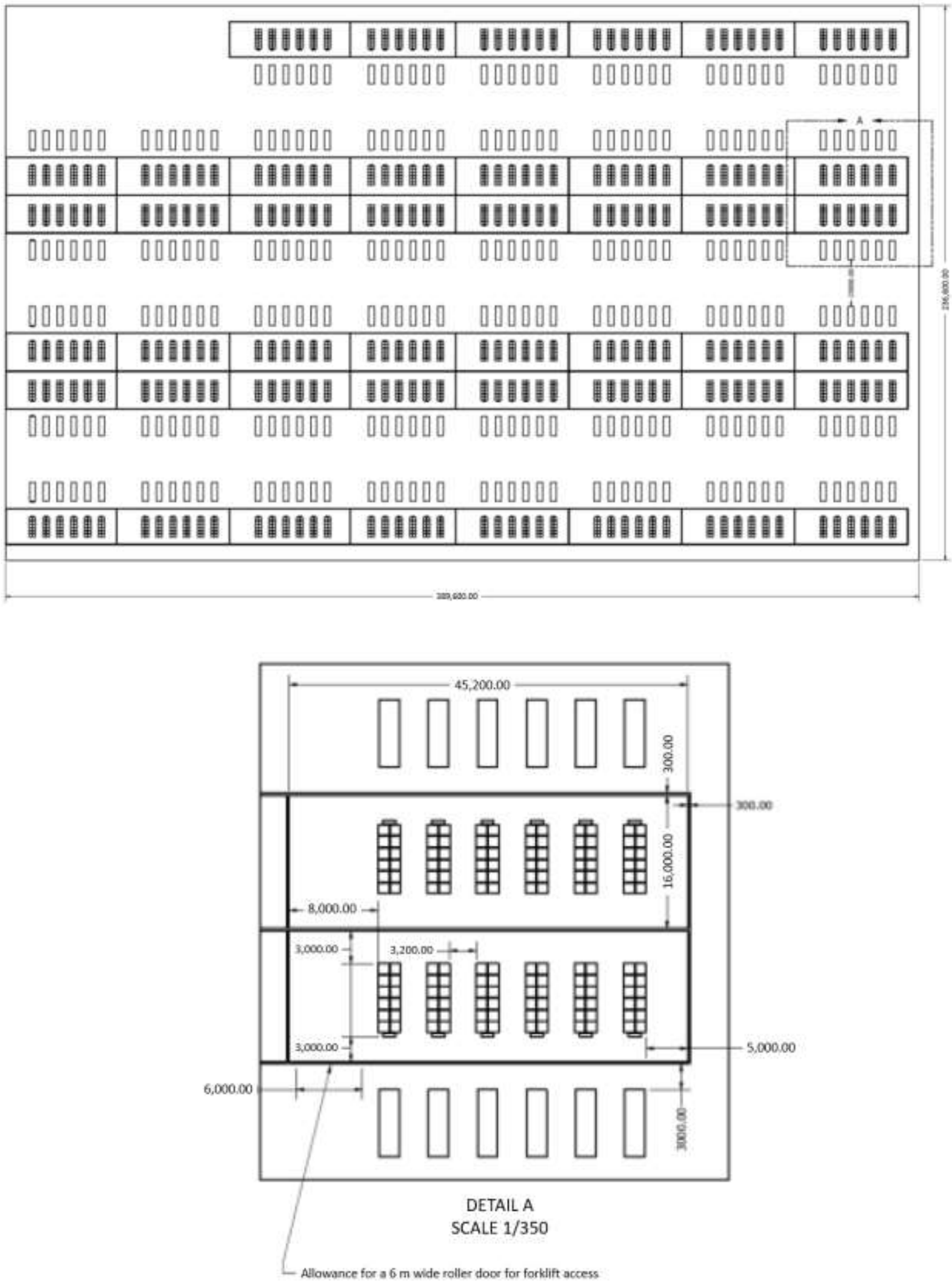


Figure 6.3: Concept BESS layout – Indoor racks within building

(each building is separated into 25 MW zones by internal fire walls)



6.3. Land area designated for the BESS

The land area required for all three BESS enclosure types considered were determined in the Birriwa BESS Design Considerations study, Ref [4], and summarised in Table 6.2.

The BESS will be located within the operational infrastructure area. Two location options are considered for the operational infrastructure area (as shown in Figure 2.1). The land areas for Options A and B are 25 ha and 39.5 ha, respectively.

At the time of this study, the layout of the operational infrastructure 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 operational infrastructure area (expressed in % coverage).

The battery container solution has the largest footprint of the three enclosure types and represents a more conservative case for the verification. As shown in Table 6.2, the battery containers will cover approximately 38% (Option A) or 24% (Option B) of the operational infrastructure area. Both location options for the operational infrastructure area were determined as adequate to fit the required land for the BESS as well as other project infrastructure to be developed within the area.

Table 6.2: Land area required for the BESS

	BESS enclosure		
	Containerised	**Outdoor rack**	**Indoor rack within a building**
Dimension	380 m x 250 m	390 m x 220 m	390 m x 240 m
Required land area	9.5 ha	8.6 ha	9.4 ha
% of operational infrastructure area	(Option A) 38% (Option B) 24%	(Option A) 34% (Option B) 22%	(Option A) 38% (Option B) 24%
Fits the designated land area for the BESS (Y/N)?	(Option A) Yes (Option B) Yes	(Option A) Yes (Option B) Yes	(Option A) Yes (Option B) Yes

6.4. Onsite receptors

The BESS will be located within the operational infrastructure area. The closest onsite receptors will be other project infrastructure located within the operational infrastructure area, including:

- An onsite substation (500 or 330 kV)
- Staff office, amenities and meeting facilities
- Operations and control room

- Workshop and spare parts storage facility.

At the time of this study, the layout of the operational infrastructure 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 minimum of 10 m APZ will be provided for all structures and associated buildings/ infrastructure[11], Ref [3].

6.5. Offsite receptors

For the PHA, the non-associated residences or occupied areas are considered as sensitive receivers for determination of offsite impact. The nearest township to the project is Birriwa, located approximately 2 km west.

For fire events involving the BESS and/or substation the separation distance from the operational infrastructure area boundary to the non-associated residences was used to determine offsite impact. This is conservative as the operational infrastructure area layout/configuration has not yet been determined.

A review of the separation distances to offsite receptors is shown in Figure 6.4. The separation distances to the nearest non-associated residence(s) are as follows:

- From the <u>development footprint</u> boundary: 60 m (R3)
- From the <u>operational infrastructure area</u> boundary:
  - Option A: 1730 m (R5)
  - Option B: 1285 m (R12).

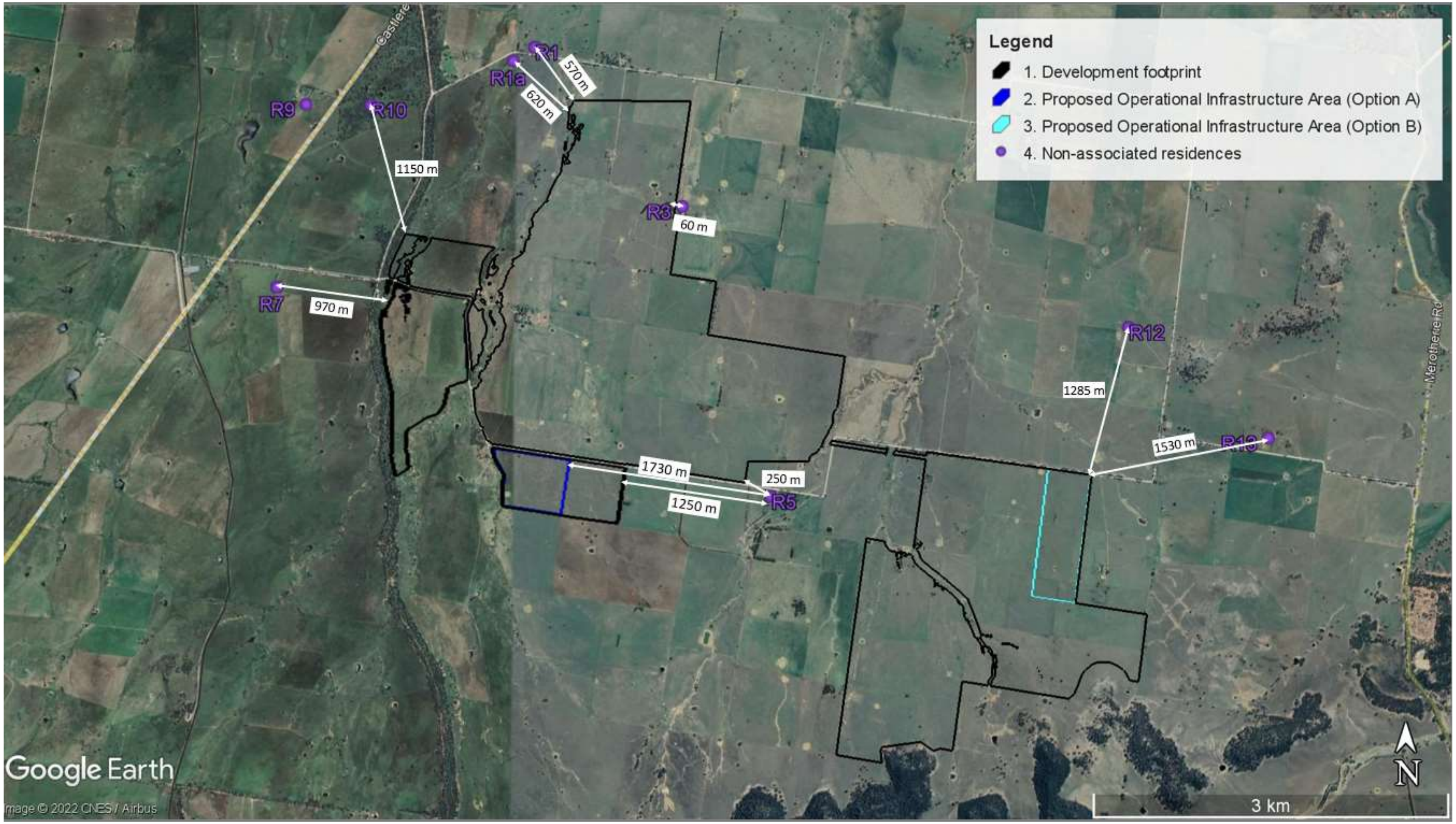
6.6. Review findings

The review of the BESS separation distances found that:

- The BESS concept layouts for all three options included clearances between the sub-units that would meet the minimum and/or recommended separation distances specified by the manufacturer to minimise risks of fire propagation. Additionally, the selected BESS would also be tested for certification to UL 9540A.
- Both location options for the operational infrastructure area can accommodate the required land for the BESS including the separation distances between the sub-units.
- For both operational infrastructure area location options, the closest non-associated residence is located at least 1.2 km away. No offsite impact is expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling.

[11] Excludes road access, power easements or other services to the site and associated fencing.

Figure 6.4: Separation distance to offsite receptors



7. LEVEL OF ANALYSIS DETERMINATION

7.1. Level of analysis

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

- The project will be situated in a rural area.
- The nearest non-associated residences is located approximately 60 m from the closest development footprint boundary (R3).
- For both operational infrastructure area locations considered (Options A and B) where the proposed BESS and substation will be located, the closest non-associated residence is located at least 1.2 km away (R12 or R5).

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

- The project site will be situated in a rural area with scattered residential dwellings.
- The nearest township is Birriwa, which is located approximately 2 km west of the study area.

Based on the above findings and the MLRA 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 8.

7.2. Qualitative risk criteria

The HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [9], 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 9.

8. RISK ANALYSIS

8.1. 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 offsite population was qualitatively determined from the resulting severity and likelihood rating pair using the risk matrix shown in Table 8.1. In the absence of a suitable company risk matrix, the risk matrix provided in AS/NZS 5139 was used for the study. In line with AS/NZS 5139, events with risks greater than "Low" should be discussed with the system owner and operator and anyone involved in the installation of the system.

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

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

Table 8.1: Risk matrix

Consequence	Likelihood				
	Rare	Unlikely	Possible	Likely	Almost Certain
Catastrophic	Medium	High	High	Extreme	Extreme
Major	Medium	Medium	High	High	Extreme
Moderate	Low	Medium	Medium	High	High
Minor	Very Low	Low	Medium	Medium	Medium
Insignificant	Very Low	Very Low	Low	Medium	Medium

8.2. 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 8.2 which was reproduced from AS/NZS 5139.

For this study, the severity scale was used to assess impact for offsite population. For example, an event with consequence outcome identified as "localised effects" or "effects are not expected to have an offsite impact", was assigned a 'Insignificant' rating to indicate minimal impact to offsite population.

Table 8.2: Consequence rating

Consequence rating	Rating definition
Catastrophic	Any fatality of staff, contractor or public
Major	Non-recoverable occupational illness or permanent injury Injury or illness requiring admission to hospital
Moderate	Injury or illness requiring medical treatment by a doctor Dangerous/reportable electrical incident
Minor	Injury requiring first aid Circumstances that lead to a near miss
Insignificant	No or minor injury

8.3. Likelihood rating

The likelihood of an event was estimated using the category scale shown in Table 8.3 which was reproduced from AS/NZS 5139.

Table 8.3: Likelihood rating

Likelihood rating	Rating definition
Almost certain	Probability of occurrence: greater than 90%
	Expected to occur whenever system is accessed or operated
	The event is expected to occur in most circumstances
Likely	Probability of occurrence: 60% - 89%
	Expected to occur when system is accessed or operated under typical circumstances
	There is a strong possibility the event may occur
Possible	Probability of occurrence: 40% - 59 %
	Expected to occur in unusual instances when the system is access or operated
	The event may occur at some time
Unlikely	Probability of occurrence: 20% - 39%
	Expected to occur in unusual instanced for non-standard access or non-standard operation
	Not expected to occur, but there is a slight possibility it may occur at some time
Rare	Probability of occurrence: 1%-19%
	Highly unlikely to occur in any instance related to coming in contact with the system or associated systems
	Highly unlikely, but it may occur in exceptional circumstances, but probably never will

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.

8.4. Risk results and analysis findings

The qualitative risk results for the identified events are shown in Table 8.4.

The risk analysis findings are as follows:

- **Consequence**: The worst-case consequence for the identified events is a fire and/or explosion event at the operational infrastructure area which may result from a variety of causes (e.g. battery thermal runaway, substation fire). The study found that for all events the consequence impacts are not expected to have significant offsite impacts. This was assessed based on the location of the project site (i.e. rural area) and separation distance between the closest operational infrastructure area boundary and sensitive receptors (i.e. non-associated residential dwellings).
- **Likelihood**: The highest likelihood rating for the identified events is 'Unlikely' (i.e. not expected to occur, but there is a slight possibility it may occur at some time).
- **Risk analysis**: A total of 18 hazardous events were identified. The breakdown of these events according to their risk ratings are as follows:
  - <u>'Medium' risk event: 1</u>

    This event relates to unauthorised person access to the project site/development footprint resulting in vandalism/asset damage to the infrastructure, with no significant offsite impact expected. Severity rating of 'Major' was assigned to account for the trespasser potentially injuring themselves in the act. This study noted that the controls for this event are well understood and the likelihood was rated as 'Unlikely'.
  - <u>'Very Low' risk events: 17</u>

    Most of these events relate to fire and/or explosion events, with no significant offsite 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 'Unlikely'.

Table 8.4: Risk results

Hazard	Event	Consequence	Offsite consequence	Significant offsite impact?	Risk analysis (offsite 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 offsite impact expected for member of the public	No	Insignificant	Unlikely	Very Low
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 offsite impact.	No	Insignificant	Unlikely	Very Low
Fire	Fire on electrical conversion system equipment	- Localised fire - Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees	Localised effects, the effects are not expected to have an offsite impact.	No	Insignificant	Unlikely	Very Low
	BESS fire	- 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 located within the operational infrastructure area and there is a large separation distance to the nearest non-associated residential dwelling, the effects are not expected to have an offsite impact.	No	Insignificant	Unlikely	Very Low
	Substation fire	- Release of toxic combustion products - Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees	As the substation will be located within the operational infrastructure area and there is a large separation distance to the nearest non-associated residential dwelling, the effects are not expected to have an offsite impact.	No	Insignificant	Unlikely	Very Low
	Bushfire	- Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees	As there is a large separation distance from the operational infrastructure area to the nearest non-associated residential dwelling, the effects are not expected to have an offsite impact.	No	Insignificant	Unlikely	Very Low
Chemical	Loss of containment of gasoline from storage or during handling	- Fire, if ignited. - Injury to onsite employees	Localised effects (minor storage quantity), the effects are not expected to have an offsite impact.	No	Insignificant	Unlikely	Very Low
	Loss of containment of diesel from storage or during handling	- Fire, if ignited. - Injury to onsite employees	Localised effects (minor storage quantity), the effects are not expected to have an offsite impact.	No	Insignificant	Unlikely	Very Low

Hazard	Event	Consequence	Offsite consequence	Significant offsite impact?	Risk analysis (offsite and public impact)		
					Severity	Likelihood	Risk
	Loss of containment of LPG from storage or filling point	- Fire and/or explosion - Injury or fatality to onsite employees	Localised effects (minor storage quantity), the effects are not expected to have an offsite impact.	No	Insignificant	Unlikely	Very Low
	Exposure to hazardous material (herbicide/ pesticide)	Irritation/injury for personnel on exposure.	Localised effects, the effects are not expected to have an offsite impact.	No	Insignificant	Unlikely	Very Low
	Release of battery electrolyte (liquid/vented gas) from the battery cell	- Release of flammable liquid electrolyte - Vapourisation 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 located within the operational infrastructure area and there is a large separation distance to the nearest non-associated residential dwelling, the effects are not expected to have an offsite impact.	No	Insignificant	Unlikely	Very Low
	BESS chiller unit or coolant leak	- Irritation/injury to onsite employee on exposure to leak (e.g. inhalation and skin contact) - Ingress of coolant to battery or other electrical components (battery enclosure) leading to short circuit and fire, resulting in injury and/or fatality to onsite employees.	As the BESS will be located within the operational infrastructure area and there is a large separation distance to the nearest non-associated residential dwelling, the effects are not expected to have an offsite impact.	No	Insignificant	Unlikely	Very Low
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	As the BESS will be located within the operational infrastructure area and there is a large separation distance to the nearest non-associated residential dwelling, the effects are not expected to have an offsite impact.	No	Insignificant	Unlikely	Very Low
Reaction	Thermal runaway in battery	- Fire in the battery cell and enclosure - Escalation to the entire BESS - Injury and/or fatality to onsite employees	As the BESS will be located within the operational infrastructure area and there is a large separation distance to the nearest non-associated residential dwelling, the effects are not expected to have an offsite impact.	No	Insignificant	Unlikely	Very Low
EMF	Exposure to electric and magnetic fields	- 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 project will not exceed the ICNIRP reference level for exposure to the general public. Impact to the general public in surrounding land uses will be negligible.	No	Insignificant	Rare	Very Low

Hazard	Event	Consequence	Offsite consequence	Significant offsite impact?	Risk analysis (offsite and public impact)		
					Severity	Likelihood	Risk
External factors	Water ingress (e.g. rain, flood)	- Electrical fault/short circuit - Fire - Injury and/or fatality to onsite employees	As the BESS and substation will be located within the operational infrastructure area and there is a large separation distance to the nearest non-associated residential dwelling, the effects are not expected to have an offsite impact.	No	Insignificant	Unlikely	Very Low
	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 offsite impact. The impact is to a member of public but occurs onsite. For a fire event at the operational infrastructure area (e.g. BESS and substation), the effects are not expected to have an offsite impact as there is a large separation distance to the nearest non-associated residential dwelling.	No	Major	Unlikely	Medium
	Lightning strike	- Fire - Injury and/or fatality to onsite employees	As there is a large separation distance from the operational infrastructure area to the nearest non-associated residential dwelling, the effects are not expected to have an offsite impact.	No	Insignificant	Unlikely	Very Low

9. RISK ASSESSMENT

9.1. Assessment against study risk acceptance criteria

Using the study risk matrix referenced from AS/NZS 5139, the identified hazardous events were qualitatively risk profiled. Of the 18 events identified, all were rated as "Very Low" 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 during operational hours. 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 'Unlikely'.

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

9.2. Assessment against HIPAP 4 criteria

Assessment against the HIPAP 4 qualitative land use planning risk criteria is provided in Table 9.1.

Table 9.1: Assessment against HIPAP qualitative risk criteria

HIPAP 4 qualitative criteria	Remarks	Complies?
All 'avoidable' risks should be avoided. This necessitates the investigation of alternative locations and alternative technologies, wherever applicable, to ensure that risks are not introduced in an area where feasible alternatives are possible and justified.	This study has identified hazardous events and assessed the inherent risks associated with the proposed operations of the project. The project location is suited for the proposed operation, situated in a rural area with considerable separation distance to sensitive receptors to avoid offsite risks.	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 offsite 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.	This study found that for all events the impacts are expected to be contained within the boundaries of the installation with no significant offsite 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 other additional hazardous developments in the vicinity of the project site. The project will be situated within a designed REZ suitable for the project.	Yes

9.3. Conclusion and recommendations

A PHA was completed to identify the hazards and assess 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.

The PHA was completed following 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) was completed for the project.

The PHA concluded that:

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

The following recommendations were identified:

1. ACEN to consider and/or implement the relevant recommendations outlined in the Entura BESS Design Considerations report for the selected BESS design and enclosure type during detailed design of the project. Of highlight:
    - Requirement that the units are certified to UL 9540A and installed in accordance with the manufacturer's instructions for best practice to mitigate fire propagation.
    - Requirement for manufacturers to provide a deflagration hazard study in accordance with UL 9540 or include explosion control measures such as passive safe ventilation of flammable gases under pressure.
    - Requirement for a minimum one-hour fire rating for containerised BESS.
    - For indoor BESS installed within a purpose-built structure, considerations for (i) compartmentalisation, (ii) occupancy and means of egress, (iii) fire barriers, (iv) exhaust and ventilation system, (v) sprinkler system and required water volume, and (vi) containment system for the expected fire protection system discharge.
    - Requirement to meet National Construction Code and regulated Australian standards and codes for indoor BESS within dedicated use buildings (e.g. fire rating of materials, fire detection systems).
2. ACEN to review the investigation reports on the Victorian Big Battery Fire (occurred on 31 July 2021) and implement relevant findings for the project. The publicly available investigation reports include:
    - Energy Safe Victoria: Statement of Technical Findings on fire at the Victorian Big Battery.
    - Fisher Engineering and Energy Safety Response Group: Report of Technical Findings on Victorian Big Battery Fire.

3. ACEN to consult with Fire and Rescue NSW (FRNSW) during detailed design of the project to ensure that the relevant aspects of fire protection measures have been included. 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.
4. ACEN to install security fencing, cameras, warning signs and implement onsite security protocol to deter trespassers and minimise unauthorised person access resulting in vandalism/asset damage to the infrastructure with the potential for self-injury during the act.

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