# REPORT

# PRELIMINARY HAZARD ANALYSIS

# BATTERY ENERGY STORAGE SYSTEM

# WALLERAWANG BATTERY ENERGY STORAGE SYSTEM

# ARCADIS AUSTRALIA PACIFIC PTY LTD

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| **Title:**<br>**Report**<br>**Preliminary Hazard Analysis**<br>**Battery Energy Storage System**<br>**Wallerawang Battery Energy Storage System** | **QA verified:**<br>S. Chia<br><br>**Date:** 03-Nov-2021 |

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# ABBREVIATIONS

| | |
|---|---|
| ARPANSA | Australian Radiation Protection and Nuclear Safety Agency |
| AC | Alternating Current |
| AS | Australian Standard |
| BESS | Battery Energy Storage System |
| BMS | Battery Management System |
| CBD | Central Business District |
| CSS | Construction Safety Study |
| DA | Development Application |
| DC | Direct Current |
| DDR | Decommissioning, Demolition and Rehabilitation |
| DG | Dangerous Goods |
| DPIE | (NSW) Department of Planning, Industry and Environment |
| DVC | Decisive Voltage Classification |
| EIS | Environmental Impact Statement |
| ELF | Extremely Low Frequency |
| EMF | Electric and Magnetic Fields |
| ENA | Energy Networks Australia |
| EP&A | Environmental Planning and Assessment |
| EPS | Environmental Property Services (Australia) Pty Ltd |
| ESV | Energy Safe Victoria |
| FHA | Final Hazard Analysis |
| FRNSW | Fire and Rescue NSW |
| HAZID | Hazard Identification |
| HIPAP | Hazardous Industries Planning Advisory Paper |
| HV | High Voltage |
| HVAC | Heating Ventilation Air Conditioning |
| Hz | Hertz |
| ICNIRP | International Commission on Non-Ionizing Radiation Protection |
| kV | Kilovolt |
| LEP | Local Environmental Plan |
| LGA | Local Government Area |
| LV | Low Voltage |

| | |
|---|---|
| MLRA | Multi-Level Risk Assessment |
| MV | Medium Voltage |
| MW | Megawatt |
| MWh | Megawatt hours |
| NSW | New South Wales |
| OH&S | Occupational Health & Safety |
| NSW | New South Wales |
| PCE | Power Conversion Equipment |
| PHA | Preliminary Hazard Analysis |
| PPE | Personal Protective Equipment |
| REZ | Renewable Energy Zone |
| RFS | Rural Fire Service |
| RFI | Request For Information |
| SDS | Safety Data Sheet |
| SEARs | Secretary's Environmental Assessment Requirements |
| SEPP | State Environmental Planning Policy |
| SRD | State and Regional Development |
| SSD | State Significant Development |
| WHO | World Health Organisation |

## TERMINOLOGY

| Term | Definition |
|---|---|
| BESS | Battery Energy Storage System facility that includes battery enclosures, invertors and transformers located on the Project Site. Note: this has been denoted as "Invertors" on the supplied figures by Arcadis. |
| Project | The Wallerawang Battery Energy Storage System (Wallerawang 9 Battery Project). |
| Project Site | The area of the Greenspot 2845 Activity Hub on which the Project is to be located (associated with both construction and operational works). |
| Consequence | Outcome or impact of a hazardous incident, including the potential for escalation. |
| Off-site | Areas extending beyond the project operational boundary. |
| Operational area | The area of the Project Site which is to be utilised for the long-term operation of the Project. |
| 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

Greenspot Wallerawang Pty Ltd (Greenspot) proposes to construct, operate and maintain a large-scale Battery Energy Storage System (BESS) within the buffer lands of the decommissioned Wallerawang Power Station site. The battery will be known as the 'Wallerawang 9 Battery' (the Project).

The Project includes construction and operation of the BESS and associated civil and electrical infrastructures. A transmission line will be required to connect the project to the nearby TransGrid Wallerawang 330 kV substation. The Project also includes ancillary upgrades to the existing Wallerawang substation.

The Project would involve construction and operation of the following:

- BESS including battery enclosures, inverters and transformers
- 33/330 kV switchyard
- Overhead transmission line connection between the BESS and the TransGrid Wallerawang 330 kV substation
- Ancillary elements including site access from the Castlereagh Highway, internal access roads and parking, site office and amenities, stormwater and fire management infrastructure, utilities, signage, fencing, security systems and landscaping.

The Project is a State Significant Development (SSD) under the State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP) and requires an Environmental Impact Statement (EIS) to accompany the Development Application (DA) submission, in accordance with the Environmental Planning and Assessment (EP&A) Regulation.

Greenspot has commissioned Arcadis Australia Pacific Pty Ltd (Arcadis) to prepare an EIS for the Project. Arcadis has retained Sherpa Consulting Pty Ltd (Sherpa) to undertake a Preliminary Hazard Analysis (PHA) for the operation of the proposed BESS for input to the 'Hazards and Risks' section of the EIS.

## 1.2. Objectives

The overall study objective was to address the assessment requirement for the BESS including Electric and Magnetic Field (EMF) sources under the 'Hazards' component of the Secretary's Environmental Assessment Requirements (SEARs), issued on 18 March 2021 as follows:

- *A Preliminary Hazard Analysis prepared in accordance with Hazardous Industry Planning Advisory Paper No. 6 – Guideline for Hazard Analysis (DoP, 2011) and Multi-Level Risk Assessment (DoP, 2011).*

- *An assessment of potential hazards and risks including but not limited to bushfires, electromagnetic fields or 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.*

The objective of the PHA was to identify the hazards and assess the risks associated with the BESS including EMF in the operational phase at the Development Application (DA) stage to determine risk acceptability from land use safety planning perspective. The PHA is based on the operating phase of the BESS (i.e. excluded construction and commission related events) and is focused on events that could result in off-site impacts (i.e. consequences outside the boundary of the operational area).

This report documents the PHA undertaken for the Project to support the EIS development for submission to the relevant planning authority.

## 1.3. Scope

The scope of the study was to complete a PHA for the proposed BESS (the Project operational boundary was used to define and determine off-site impact), and an assessment against the ICNIRP guideline for potential EMF sources (i.e. substations, transformers, overhead transmission lines, BESS).

## 1.4. Exclusions and assumptions

The study exclusions and assumptions are summarised as follows:

1. State Environmental Planning Policy (SEPP) No. 33 *Hazardous and Offensive Development* risk screening. A risk screening is typically undertaken to determine whether (1) the Project is considered as ‘potentially hazardous’ in the context of SEPP 33 and hence (2) requirement for a PHA. The SEARs issued for this Project included requirement for a PHA to be carried out for the BESS without first applying the SEPP screening approach.
2. Transport route analysis. The SEARs issued for this Project does not include a requirement for a transport route analysis for the BESS to be carried out.
3. The scope of work is limited to the requirements under the ‘Hazards’ component of the SEARs. The study exclusions are summarised as follows:
   - Bushfire hazard assessment. Arcadis has advised Sherpa that a separate bushfire hazard assessment has been undertaken by other specialists for the EIS. Where applicable, identified controls have been referenced (i.e. fire management plan) in this study.
   - Construction safety study. This study does not constitute a Construction Safety Study (CSS). Requirement for a CSS at a later stage will be subject to the conditions of consent of the Project DA approval. For more information, refer to the HIPAP No. 7 Construction Safety, Ref [1].
4. Update of this PHA to Final Hazard Analysis (FHA), as per HIPAP requirements.

5. The study identified and assessed credible hazards associated with proposed operations of the BESS, and excluded specific hazards relating to construction, commissioning and decommissioning. This approach is appropriate for EIS assessment at the DA stage aimed to obtain approval for the Project.
6. At the time of this study, Greenspot has not made a final decision on the BESS supplier. As advised by Arcadis, the assessment made in this PHA was based on:
   - A Tesla style battery for the BESS, and
   - Associated Safety Data Sheet (SDS) and Emergency Response Guide.
7. As agreed by Arcadis and Greenspot, Sherpa used a simplified risk matrix suitable for this facility type to carry out the qualitative risk assessment.

# 2. PROJECT DESCRIPTION

## 2.1. Location and Project Site

The Project is located south of Wallerawang Power Station site and 320 metres east of the TransGrid Wallerawang 330 kV substation (at its closest point) within the Lithgow Local Government Area (LGA) in the Central West region of NSW.

The Project Site has a total footprint of approximately 50 hectares, of which the operational BESS will require approximately 10 hectares. The proposed Project Site and the Project's operational layout is shown in Figure 2.1 and Figure 2.2.

## 2.2. Surrounding land use

The Project Site and surrounding areas comprise a combination of land use zoned IN3 Heavy Industrial and SP2 (Infrastructure) electricity generating works in the western half, and RU1 Primary Production on the eastern half under the Lithgow Local Environmental Plan (LEP) 2014. See Figure 2.3 for the land use zoning map.

The Project Site and surrounding areas are largely rural in nature and comprise undeveloped grasslands, plantations and several forestry areas. Areas around the Coxs River and Lake Wallace and surrounds to the west are used recreationally for camping and fishing.

The following potential commercial and residential receivers in proximity to the BESS were identified as follows:

- Goodearth Landscape and Building Supplies (700 m south)
- Black Gold Motel (1.6 km north-west)
- Industrial and commercial businesses along Main Street, Wallerawang (2 km north-west)
- Approximately six residential receivers located on Springvale Lane (650 m south-east of the nearest BESS enclosure)
- A residential area within the suburb of Wallerawang (1.5 km south-west).

Other nearby industrial developments include:

- Wallerawang Power Station site, owned by Greenspot (1.3 km north-east)
- Centennial Coal Springvale Coal Mine site (1.3 km east)
- Wallerawang Power Station Ash Repository and associated lands, owned and operated by Generator Property Management Pty Ltd (about 2.2 km north).

The local context of the Project Site is shown in Figure 2.4.

## Figure 2.1: Project Site location

**Figure 2.2: Project operational footprint**

## Figure 2.3: Land use zoning map

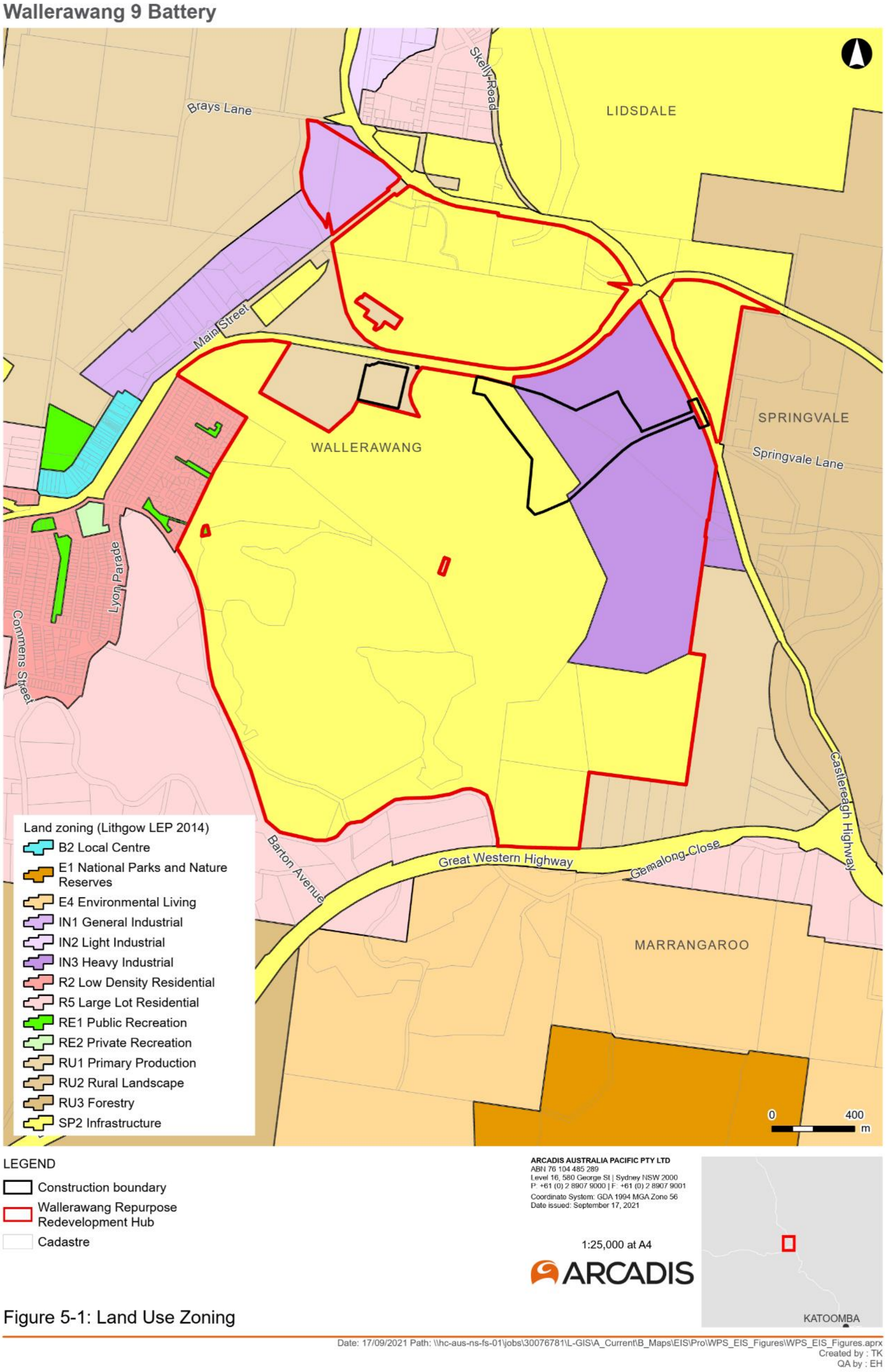
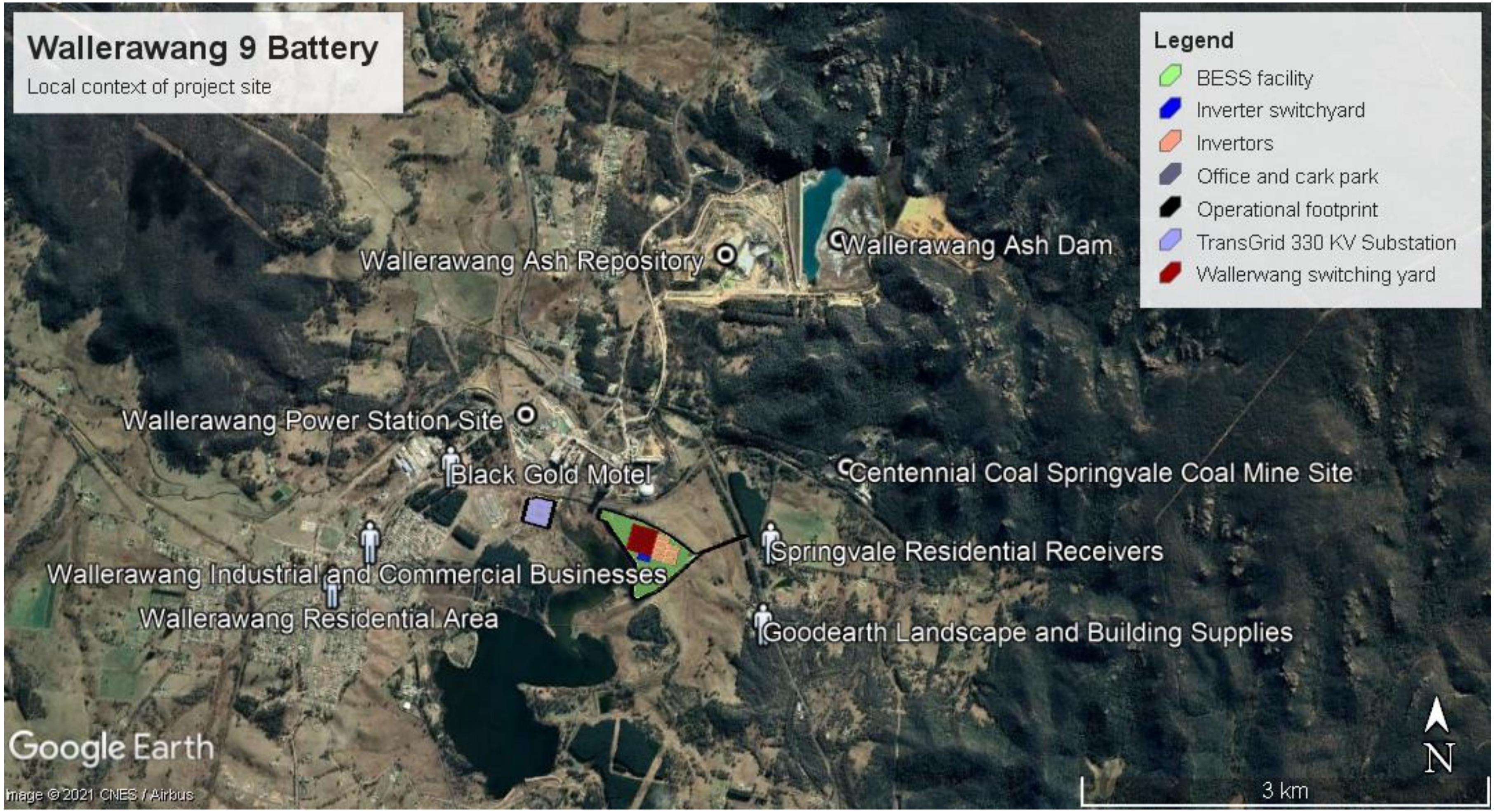


**Figure 2.4: Local context of Project Site**



## 2.3. Proposed Project components

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

**Table 2.1: Indicative proposal component and specification**

| Component | Feature | Specification |
|---|---|---|
| Electrical connections and transmission lines | On-site substations | There is an existing TransGrid Wallerawang 33/330 kV substation on the western side of the Cox's River. |
| | Switchyard | A Switchyard (330 kV) including up to four High Voltage (HV) transformers and HV switchgear and associated control building will be provided to convert Medium Voltage (MV) power produced by the BESS facility to HV power to enable connection to the grid. |
| | Overhead transmission line (grid connection) | An overhead transmission line will be provided to connect the Project 330 kV switchyard and the nearby TransGrid Wallerawang 330 kV substation. The connection will be approximately 600 m long and include a transmission line corridor of 60 m. |
| Battery storage | BESS | The BESS will be made up of a number of units (yet to be determined) with up to 500 MW and would provide up to 1,000 Megawatt hours (MWh) of battery storage capacity or up to 2 hours of storage duration. The BESS will be located adjoining the Project switchyard. Further information provided in Section 2.4. |
| Access roads | Access to site and turbines | Access to the Project Site will be via the access road off the Castlereagh Highway. |
| Operations and maintenance buildings | Site office and/or building(s) | Control, admin, amenities, and stores buildings (prefabricated building modules) will be provided adjacent to the BESS. |

## 2.4. Battery Energy Storage System

The purpose of the BESS will be to provide a dispatchable capability to Greenspot's energy generation profile and provide enabling infrastructure for expanding the renewable energy industry in NSW, particularly in the Central-West Orana Renewable Energy Zone (REZ). Indicatively, the proposed BESS will have up to 500 MW, and would provide up to 1,000 Megawatt hours (MWh) of battery storage capacity or up to 2 hours of storage duration. The BESS will be located adjoining the Project switchyard.

At the time of this study, Greenspot has not made a final decision on the BESS supplier. In agreement with Greenspot and Arcadis, the study assumed a lithium ion battery similar to the Tesla battery system will be installed. This PHA is based on the use of the

Tesla Megapack battery system for the Project. The Tesla Megapack is a pre-assembled and pre-tested integrated system which includes the battery modules, inverters, thermal management system, circuit breakers and other controls.

The Tesla Megapack battery system enclosure is assumed to be outdoor rated cabinet mounted on concrete pads, with security fencing. The total Project Site area would cover up to 18 hectares (including BESS, switchyard, ancillary development and buffer) and 3.6 hectares for the overhead transmission line corridor, a total of approximately 21.6 hectares.

Major components for a BESS typically include and assumed in this study are:

- Battery modules – it is anticipated that between approximately 266 Megapacks will be installed to provide the required 500 MW/1000 MWh capacity (each with up to 3 MWh energy capacity).
- Transformers – within the BESSs, there may be two types of transformers, namely (1) a Low Voltage (LV) to MV transformer and (2) a MV to HV transformer. The configuration of the transformers will be subject to the type of batteries used and the BESS configuration.
- Battery Management System (BMS) – 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).
- Thermal management system/Heating, Ventilation and Air Conditioning (HVAC) – the system that provides temperature control for the batteries. The Tesla battery system includes a sealed liquid thermal management system with a dual coolant and refrigerant loop system that runs through battery modules and inverters.
- Power Conversion Equipment (PCE), e.g. inverters are electrical devices that convert Direct Current (DC) to Alternating Current (AC).
- Fire protection. The Tesla battery system are designed to meet fire and safety codes and standards requirements (NFPA 855 and IFC 2018/2021). By design, the cabinet facilities minimise risk of a fire spreading from one cabinet to another Ref [2].

The components described will be similar for the BESS structures likely to be constructed as part of the Project. As noted, the specific design details for the BESS will only be confirmed at the completion of the detailed design stage of the Project.

## 2.5. Operations

The operational life of the Project is proposed to be from 2023, to at least January 2043 (i.e. minimum operational lifespan of 20 years). The estimated life of the initial BESS equipment is 15 – 20 years. It is expected that replacement of the batteries would be undertaken, extending the life of the BESS to 30 - 40 years.

# 3. METHODOLOGY

## 3.1. Overview

This study was carried out in accordance with the requirements of HIPAP No. 6 *Hazard Analysis*, Ref [3], and included the following steps:

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

The PHA assessed the events associated with proposed operation of the BESS (i.e. excluded construction related events). The Project operational boundary was used to define and determine off-site impact (i.e. impact extending outside of the Project operational boundary).

## 3.2. Context

A risk screening is typically undertaken to determine whether (1) the Project is considered as 'potentially hazardous' in the context of SEPP 33 and hence (2) requirement for a PHA. The SEARs issued for this Project included requirement for a PHA to be carried out for the BESS without first applying the SEPP screening approach.

## 3.3. Level of analysis

The Multi-Level Risk Assessment (MLRA), Ref [4], sets out three levels of risk analysis that may be appropriate for a PHA, as shown in Table 3.1. This guidance document was consulted to determine the level of analysis required for this study.

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

**Table 3.1: Level of analysis**

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

## 3.4. 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 [5], appropriate for the level of analysis determined (based on guidance outlined in Table 3.1).

## 3.5. ICNIRP Considerations

The SEARs for 'Hazards and Risks' include a requirement to assess potential hazards and risks associated with exposure to EMF against the ICNIRP guidelines. This assessment considers the EMF exposures from the Project components (i.e. PCE, substations and transformers, transmission lines, BESS) and compares it against the ICNIRP time varying electric and magnetic fields reference levels (general public and occupational). Details on EMF exposure and assessment is presented in Section 8.

## 4. HAZARD IDENTIFICATION

### 4.1. Overview

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

The HAZID process was completed using the following input:

1. Review of the battery Safety Data Sheet (SDS)/emergency response guide, Ref [2], for potential hazardous events and controls provided.
2. Review of AS/NZS 5139:2019 *Electrical installations – Safety of battery systems for use with power conversion equipment*, Ref [6].
3. Literature research of past incidents[1] involving similar BESS systems.
4. Previous risk assessments for similar BESS systems.
5. Consultation and feedback from Greenspot and Arcadis.

### 4.2. Identified hazards and events

The following factors were considered to identify the hazards:

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

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

The identified hazards and events for the proposal are presented in Table 4.1.

**Table 4.1: Identified hazards and events**

| Hazard | Event |
|---|---|
| Electrical | Exposure to voltage |
| Energy | Release of energy (i.e. arc flash) |

[1] During the preparation of this EIS, a fire involving two Tesla Megapacks occurred at the Victorian Big Battery site at Moorabool, Victoria on July 30 2021. Incident investigations are ongoing and the Energy Safe Victoria (regulator) investigation advised that the fire was "most likely" caused by a leak in the Megapack cooling system. This in turn lead to a short circuit and fire in the electronic components, thermal runaway and a fire involving a second battery. The fire lasted 4 days and was localised around the battery facility.

| Hazard | Event |
|---|---|
| Fire | Infrastructure fire, exposure to overhead transmission lines |
| 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, loss of containment from firewater tank), loss of containment from Wallerawang Power Station Ash Repository and Dam |

In this study, bushfire was considered as a cause of fire resulting from encroachment of an off-site bushfire impacting the BESS. A separate bushfire assessment will be completed for input to the EIS, to meet the SEARs. However, identified controls have been referenced (i.e. fire management plan) in the hazards and risks assessment study where applicable.

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

**Table 4.2: Hazards by BESS component**

| | **BESS Components** | | | |
|---|---|---|---|---|
| **Hazard** | **Battery modules** | **Battery Management System (BMS)** | **Thermal management system/HVAC** | **PCE (e.g. inverters)** |
| Electrical | ✓ | ✓ | - | ✓ |
| Energy (arc flash) | ✓ | ✓ | - | ✓ |
| Fire | ✓ | ✓ | ✓ | ✓ |
| Chemical | ✓ | ✓ | ✓ | - |
| Explosive gas | ✓ | - | ✓ | - |
| Reaction | ✓ | - | - | - |
| EMF | ✓ | ✓ | - | ✓ |
| External factors | ✓ | ✓ | ✓ | ✓ |

### 4.2.1. Other hazardous materials

Arcadis has advised Sherpa that no other hazardous materials or dangerous goods apart from the battery components are expected to be stored or present on site. Firewater is stored in a 20,000 L tank at the BESS facility area, located approximately 70 m away from the site boundary and 60 m from the closest BESS enclosure. The firewater tank is not expected to be a hazard source affecting the BESS facility in terms of offsite impact. Firewater storage and the Wallerawang Power Station Ash Repository and Dam were considered a potential hazard source in terms of flooding the site's BESS facility. The Wallerawang Power Station Ash Repository and Dam is located over 1.2 km away from the Project operational boundary. Arcadis has advised that the ash dam is currently being decommissioned and rehabilitated as part of the DDR (decommissioning, demolition, and rehabilitation) project, it is highly unlikely that a breach would occur once the water is removed.

## 4.3. HAZID register

The HAZID register is provided in Table 4.3.

## 4.4. Findings

The findings are as follows:

- A total of 13 hazardous events were identified.
- The nearest BESS enclosure to the site boundary will be located approximately 27 m away from the operational area boundary. The nearest residential receiver (Springvale Lane residents) is approximately 650 m away from the nearest BESS enclosure, no events with the potential for significant off-site impact (i.e. serious injury and/or fatality) to the public or off-site receptors were identified.

**Table 4.3: HAZID register - BESS**

| ID | Hazard | BESS component | Event | Cause | Consequence | Controls | Other Comments | Significant Off-site Impact? |
|---|---|---|---|---|---|---|---|---|
| 1. | Electrical | Battery modules<br>BMS<br>PCE (e.g. inverters) | Exposure to voltage | <u>Short circuit/electrical connection failure</u><br>- Faulty equipment<br>- Incorrect installation<br>- Incorrect maintenance<br>- Human error during maintenance<br>- Safety device/circuit compromised<br>- Battery casing/enclosure damage<br><br><u>Earth potential rise (exposure to step and touch potentials)</u><br>- Electrical faults | - Electrocution<br>- Fire<br>- Injury and/or fatality to on-site employees<br>- Injury and/or fatality to member of public due to touch and step potential (e.g. transferred through fences).<br><br>This has been considered in the ICNIRP.<br><br>As the BESS will be situated in a remote area and there is a large separation distance from the nearest BESS enclosure to the nearest residential dwelling (650 m), the effects are not expected to have an impact at this location. | - Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS 5139) and guidelines.<br>- Decisive Voltage Classification (DVC) followed and equipment marked accordingly.<br>- Warning signs (electrical hazards, arc flash)<br>- Engagement of reputable contractors<br>- Installation and maintenance will be undertaken by trained personnel<br>- Independent certifiers/owner's engineers<br>- Electrical switch-in & switch-out protocol<br>- BMS fault detection and safety shut-off<br>- Earthing study (mitigate touch and step potentials)<br>- Earthing as per manufacturer and standards requirements<br>- Emergency Response Plan<br>- External firefighting assistance (FRNSW & RFS) from nearby fire stations (i.e. Wallerawang, Lithgow, Lithgow West)<br>- Use of appropriate PPE<br>- Rescue kits (i.e. insulated hooks) | - | No |
| 2. | Energy | Battery modules<br>BMS<br>PCE (e.g. inverters) | Arc flash | - Incorrect procedure (i.e. installation/maintenance)<br>- Faulty equipment (e.g. corrosion on conductors)<br>- Faulty design<br>- Human error during maintenance<br>- Insufficient isolation/insulation to applied voltage<br>- Mechanical damage<br>- Vibration | - Arc blasts and resulting heat, may result in fires and pressure waves<br>- Burns<br>- Exposure to intense light and noise<br>- Injury and/or fatality to on-site employees<br><br>Localised effects, the effects are not expected to have an off-site impact. | - Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS 5139) and guidelines<br>- Warning signs (arc flash boundary)<br>- Engagement of reputable contractors<br>- Installation and maintenance will be undertaken by trained personnel as per manufacturer's instruction<br>- Independent certifiers/owner's engineers<br>- Site induction/substation training (i.e. high voltage areas)<br>- Maintenance procedure (e.g. deenergize equipment)<br>- Preventative maintenance (insulation)<br>- Emergency Response Plan<br>- External firefighting assistance (FRNSW & RFS) from nearby fire stations (i.e. Wallerawang, Lithgow, Lithgow West)<br>- 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 [6].<br><br>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.<br><br>Arc flash may result in rapid rise in temperature and pressure in the air between electrical conductors, causing an explosion known as an arc blast. | No |

| ID | Hazard | BESS component | Event | Cause | Consequence | Controls | Other Comments | Significant Off-site Impact? |
|---|---|---|---|---|---|---|---|---|
| 3. | Fire | Battery modules<br>BMS<br>HVAC<br>PCE (e.g. inverters) | BESS fire | - Faulty equipment<br>- Arc flash<br>- Damage or failure of battery case (e.g. overload, insulation breakdown, connection failures)<br>- Battery thermal runaway (e.g. short circuit, overheating, overcharge)[2]<br>- External fire (e.g. substation fire)<br>- Bushfire (e.g. encroachment of off-site bushfire, escalated event due to fire from other proposal infrastructure) | - Release of toxic and/or explosive combustion products<br>- Escalation to the entire BESS<br>- Injury and/or fatality to on-site employees<br>- Potential damage to overhead power transmission lines<br><br>As the BESS will be situated in a remote area and there is a large separation distance from the nearest BESS enclosure to the nearest residential dwelling (650 m), the effects are not expected to have an impact at this location | - Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS 5139) and guidelines<br>- Equipment will be procured from reputable supplier<br>- Independent certifiers/owner's engineers<br>- Installation, operations and maintenance by trained personnel (e.g. reputable third party) in accordance with relevant procedures<br>- Preventative maintenance (e.g. insulation, replacement of faulty equipment)<br>- The Tesla battery system/cabinet facilities inherent design minimises risk of a fire spreading from one cabinet to another<br>- Emergency Response Plan<br>- Activation of emergency shutdown<br>- Fire Management Plan (e.g. establishing defendable fire-fighting boundary)<br>- External firefighting assistance (FRNSW & RFS) from nearby fire stations (i.e. Wallerawang, Lithgow, Lithgow West)<br>- As per site layout the battery storage is not underneath and 130 m from the overhead transmission lines corridor | **Recommendation:**<br>Greenspot Energy to review the ESV investigation report into the Victoria Tesla battery fire[2] (when made publicly available) for implementing findings (e.g. 'battery isolation loss', inspection for coolant leaks before on site testing) as appropriate. | No[2] |
| 4. | Chemical | Battery modules<br>BMS<br>HVAC | Release of electrolyte (liquid/ vented gas) from the battery cell | <u>Mechanical failure/damage</u><br>- Dropped impact (e.g. during installation/ maintenance)<br>- Damage (e.g. crush/ penetration/puncture)<br><br><u>Abnormal heating/elevated temperature</u><br>- Thermal runaway<br>- Bushfire<br>- External fire (e.g. substation) | - Release of flammable liquid electrolyte<br>- Vapourisation of liquid electrolyte<br>- Release of vented gas from cells<br>- Fire and/or explosion in battery enclosure<br>- Release of toxic combustion products<br>- Injury and/or fatality to on-site employees<br><br>As the BESS will be situated in a remote area and there is a large separation distance from the nearest BESS enclosure to the nearest residential dwelling (650 m), the effects are not expected to have an impact at this location | - Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS 5139) and guidelines<br>- Equipment will be procured from reputable supplier<br>- Independent certifiers/owner's engineers<br>- Engagement of reputable contractors<br>- Installation and maintenance by trained personnel<br>- BMS fault detection and shut-off function<br>- Each enclosure compartment has the capacity to contain liquid from a large number of cells.<br>- Layers of battery case (pod and external casing)<br>- Spill clean-up using dry absorbent material<br>- Emergency Response Plan<br>- Activation of emergency shutdown<br>- Fire Management Plan (e.g. establishing defendable fire-fighting boundary)<br>- External firefighting assistance (FRNSW & RFS) from nearby fire stations (i.e. Wallerawang, Lithgow, Lithgow West)<br>- Venting and containment requirements of the BESS manufacturer to be followed | Vented gases are early indicator of a thermal runaway reaction | No |

[2] The Victorian Big Battery Moorabol site fire (30-Jul-21) was caused by a short circuit (a coolant leak from the cooling system leading to a fire in an electronic component) and subsequent overheating (thermal runaway). The fire involved 2 battery packs and was locally confined to the area. ESV reported that the battery was offline and the monitoring and protection systems not being available, allowed the initial fault to go undetected.

| ID | Hazard | BESS component | Event | Cause | Consequence | Controls | Other Comments | Significant Off-site Impact? |
|---|---|---|---|---|---|---|---|---|
| 5. | Chemical | Battery modules<br>BMS<br>HVAC | Coolant leak (Tesla Battery System) | - Mechanical failure/damage<br>- Incorrect maintenance | Irritation/injury to on-site employees on exposure (inhalation)<br><br>Potential for short circuit (see HAZID 3) and fire in the worst case<br><br>Localised effects – not expected to have an off-site impact. | - Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS 5139) and guidelines<br>- Equipment will be procured from reputable supplier<br>- Independent certifiers/owner's engineers<br>- Engagement of reputable contractors<br>- Maintenance will be undertaken by trained personnel<br>- BMS fault detection and shut-off function<br>- Inspection of cooling system prior to start up<br>- Layers of battery case (pod and external casing)<br>- PPE and spill clean-up using dry absorbent material | For the Tesla system, the coolant is 50/50 mixture of ethylene glycol and water (DG Class 9, environmentally hazardous substance). The fluid does not emit a strong odour.<br><br>A Megapack contains about 540 L of coolant.<br>See HAZID 3 for remarks on the Big Battery fire (Moorabool, 30-Jul-21). | No |
| 6. | Chemical | Battery modules<br>BMS<br>HVAC | Refrigerant leak (Tesla Battery System) | - Mechanical failure/damage<br>- Incorrect maintenance | Irritation/injury to on-site employees on exposure (skin contact)<br><br>Localised effects - not expected to have an off-site impact. | - Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS 5139) and guidelines<br>- Equipment will be procured from reputable supplier<br>- Independent certifiers/owner's engineers<br>- Engagement of reputable contractors<br>- Maintenance will be undertaken by trained personnel<br>- BMS fault detection and shut-off function<br>- Layers of battery case (pod and external casing)<br>- PPE and spill clean-up using dry absorbent material | The Tesla thermal management system is in a sealed system.<br><br>Mechanical damage could result in a release of the refrigerant. Such a release would appear similar to the emission of smoke. | No |
| 7. | Explosive Gas | Battery modules | Generation of explosive gas (e.g. hydrogen)<br><br><u>Note</u>: also refer to Item 4 (release of vented gas) | - Thermal runaway<br>- Bushfire<br>- External fire (e.g. substation) | - Fire and/or explosion in battery enclosure<br>- Release of toxic combustion products<br>- Injury and/or fatality to on-site employees<br><br>As the BESS will be situated in a remote area and there is a large separation distance from the nearest BESS enclosure to the nearest residential dwelling (650 m), the effects are not expected to have an impact at this location | - Equipment and systems will be designed and tested to comply with the relevant international and Australian standards (e.g. AS 5139) and guidelines<br>- Equipment will be procured from reputable supplier<br>- Independent certifiers/owner's engineers<br>- BMS fault detection and shut-off function<br>- Ventilation requirements as per manufacturer's instruction<br>- The Tesla battery system/cabinet facilities inherent design minimises risk of a fire spreading from one cabinet to another<br>- Emergency Response Plan<br>- Activation of emergency shutdown<br>- Fire Management Plan (e.g. establishing defendable fire-fighting boundary)<br>- External firefighting assistance (FRNSW & RFS) from nearby fire stations (i.e. Wallerawang, Lithgow, Lithgow West) | - | No |

| ID | Hazard | BESS component | Event | Cause | Consequence | Controls | Other Comments | Significant Off-site Impact? |
|---|---|---|---|---|---|---|---|---|
| 8. | Reaction | Battery modules | Thermal runaway in battery | Elevated temperature<br>- Bushfire<br>- External fire (e.g. substation)<br><br>Electrical failure<br>- Short circuit (HAZID item 3)<br>- Excessive current/voltage<br>- Imbalance charge across cells<br><br>Mechanical failure<br>- Internal cell defect<br>- Damage (crush/ penetration/puncture)<br><br>Systems failure<br>- BMS failure<br>- Thermal management system/HVAC failure | - Fire and/or explosion in battery enclosure<br>- Escalation to the entire BESS<br>- Injury and/or fatality to on-site employees<br><br>As the BESS will be situated in a remote area and there is a large separation distance from the nearest BESS enclosure to the nearest residential dwelling (650 m), the effects are not expected to have an impact at this location | - Equipment and systems will be designed and tested to comply with the relevant international and Australian standards (e.g. AS 5139) and guidelines<br>- Equipment will be procured from reputable supplier<br>- Independent certifiers/owner's engineers<br>- Battery Management System (BMS)<br>* Voltage control<br>* Charge-discharge current control<br>* Temperature monitoring<br>* Safety shut-off function<br>- Thermal management system<br>- Cell chemistry selection (minimise runaway)<br>- BESS is located in designated area<br>- The Tesla battery system/cabinet facilities inherent design minimises risk of a fire spreading from one cabinet to another<br>- Emergency Response Plan<br>- Activation of emergency shutdown<br>- Fire Management Plan (e.g. establishing defendable fire-fighting boundary)<br>- External firefighting assistance (FRNSW & RFS) from nearby fire stations (i.e. Wallerawang, Lithgow, Lithgow West) | 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 |
| 9. | EMF | BESS (overall) | 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)<br>- Injury to on-site employees<br><br>As the BESS will be situated in a remote area and there is a large separation distance from the nearest BESS enclosure to the nearest residential dwelling (650 m), the effects are not expected to have an impact at this location | - Location siting and selection (i.e. separation distance to sensitive receptors)<br>- Optimising equipment layout and orientation<br>- Reducing conductor spacing<br>- Balancing phases and minimising residual current<br>- Incidental shielding (i.e. BESS enclosure)<br>- Equipment and systems will be designed and tested to comply with international standards and guidelines<br>- Exposure to personnel is short duration in nature (transient)<br>- Warning signs<br>- Commercial power generation facilities comply with ICNIRP occupational exposure limits (i.e. EMF). See Section 8 of this report. | Adverse health effects from EMF have not been established based on findings<br>of science reviews conducted by credible authorities, Ref [7].<br><br>No established evidence that Extremely Low Frequency (ELF) EMF is associated with long term health effects (ARPANSA). | No |
| 10. | External factors | BESS (overall) | Fire | Water ingress (e.g. rain, flood)<br><br>Water ingress or inundation from rupture of firewater tank<br><br>Inundation from collapse of Wallerawang Power Station Ash Repository and dam | - Electrical fault/short circuit<br>- Fire and/or explosion in battery enclosure<br>- Injury and/or fatality to on-site employees<br><br>As the BESS will be situated in a remote area and there is a large separation distance from the | - Location siting (i.e. outside of flood prone area)<br>- Wallerawang Power Station Ash Repository and Dam is located on far side of the power station (approximately 2.2 km away from the closest BESS enclosure) and batteries are not downstream. Arcadis has also advised that the ash dam is currently being decommissioned and rehabilitated as part of the DDR (decommissioning, demolition, and rehabilitation) project. It is highly unlikely that a breach would occur once the water is removed. | An estimate of the impact zone (equivalent to a radius of 5 m) of the firewater tank indicates that the released water may only minimally affect the switchyard and will not have off-site impacts. | No |

| ID | Hazard | BESS component | Event | Cause | Consequence | Controls | Other Comments | Significant Off-site Impact? |
|---|---|---|---|---|---|---|---|---|
| | | | | | nearest BESS enclosure to the nearest residential dwelling (650 m), the effects are not expected to have an impact at this location. | - Releasable amount of water from the firewater tanks is not significant (20 $m^3$) and is located approximately 70 m away from the site boundary and 60 m from the closest BESS enclosure. There will be minimal impact to BESS units<br>- BESS will be housed in dedicated enclosure which will be constructed in accordance with relevant standards<br>- The Tesla battery system enclosures are outdoor rated<br>- Drainage system<br>- Preventative maintenance (check for leaks)<br>- Emergency Response Plan<br>- Activation of emergency shutdown<br>- Fire Management Plan (e.g. establishing defendable fire-fighting boundary)<br>- External firefighting assistance (FRNSW & RFS) from nearby fire stations (i.e. Wallerawang, Lithgow, Lithgow West) | | |
| 11. | External factors | BESS (overall) | Vandalism | Unauthorised personnel access<br>Trespassing<br>Deliberate damage to BESS (e.g. using firearms) | - Asset damage<br>- BESS failure/fire<br>- Potential hazard to unauthorised person (e.g. electrocution)<br>- Injury and/or fatality to trespasser<br><br>Effects to unauthorised person are expected to be localised and not expected to have an off-site impact. The impact is to a member of public but occurs on-site.<br><br>For a fire event, the effects are not expected to have an off-site impact as the BESS will be situated in a remote area and there is a large separation distance from the nearest BESS enclosure to the nearest residential dwelling (650 m), the effects are not expected to have an impact at this location. | - Proposed development is located in remote location<br>- Proposed development infrastructure is located in a secure area and will be fenced<br>- Warning signs (i.e. trespassers and on-site hazards)<br>- Security cameras will be provided at the substation and in vicinity of the BESS.<br>- On-site security protocol<br>- Presence of staff during operational hours | - | No |
| 12. | External factors | BESS (overall) | Lightning strike | Lightning storm | - Fire<br>- Injury and/or fatality to on-site employees<br><br>As the BESS will be situated in a remote area and there is a large separation distance from the nearest BESS enclosure to the nearest residential dwelling | - Lightning protection mast (substation)<br>- Earthing as per manufacturer and standards requirements<br>- PPE | - | No |

| ID | Hazard | BESS component | Event | Cause | Consequence | Controls | Other Comments | Significant Off-site Impact? |
|---|---|---|---|---|---|---|---|---|
| | | | | | (650 m), the effects are not expected to have an impact at this location | | | |
| 13. | Escalation to on-site substation | BESS (overall) | Escalation from the BESS to adjacent on-site substation | BESS fire | Escalation to adjacent substation resulting in potential off-site impacts.<br><br>As the BESS and substation will be situated in a remote area and there is a large separation distance from the nearest BESS enclosure to the nearest residential dwelling (650 m), the effects are not expected to have an impact at this location. | - The Tesla cabinet facilities inherent design minimises risk of a fire spreading from one cabinet to another. This will minimise escalation of battery fire to the overall BESS and subsequently the onsite substation.<br>- Separation distance between the BESS facility and the substation (600 m). | | No |

# 5. LEVEL OF ANALYSIS DETERMINATION

## 5.1. Level of analysis

The HAZID found that for all identified events the resulting consequences are not expected to have significant off-site impacts (i.e. injury/fatality). Assessment of off-site impacts was determined based on the following:

- The distance between the proposed location of the nearest BESS enclosure to the nearest residential receiver on Springvale lane is approximately 650 m away and 1.5 km away to the Wallerawang residential area. Hazardous events (e.g. thermal runaway) resulting in potential fire and explosion are expected to be localised with no potential for significant off-site consequences.
- Provision of controls under the Battery Management System (BMS) provides protection against overheating, overcharging and thermal runaway. Design of the battery may also contain fires within the modular units and prevent escalation.

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

- The nearest school (Pied Piper Preschool) and hospital (Lithgow Medical Clinic) is located approximately 1.7 km and 10.5 km away from the BESS location.

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 6.

## 5.2. Qualitative risk criteria

The HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [5], recommends that the following qualitative criteria/principles be adopted concerning the land use safety acceptability of a development:

a) *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.*

b) *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.*

c) *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.*

d) *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.*

The risk assessment against HIPAP No. 4 criteria is provided in Section 7.

## 6. RISK ANALYSIS

### 6.1. 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 was qualitatively determined from the resulting severity and likelihood rating pair using the study risk matrix, shown in Figure 6.1.

The acceptance criteria used to assess the risk for off-site population are as follows:

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

### 6.2. Severity rating

For each event, the severity rating was qualitatively assigned based on the consequence description identified in the HAZID register (Table 4.3) using the category scale shown in Figure 6.1.

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

### 6.3. Likelihood rating

The likelihood of an event was estimated using the category scale shown in Figure 6.1. The likelihood ratings were assigned based on knowledge of historical incidents in the industry. The likelihood ratings were assigned accounting for the initiating causes and the resulting consequences with controls (prevention and mitigation) in place.

**Figure 6.1: Qualitative risk matrix**

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

### Risk Acceptance Criteria

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

## 6.4. Risk results and analysis findings

The qualitative risk results for the identified events are shown in Table 6.1.

The risk analysis findings are as follows:

- **Consequence**: The worst-case consequence for the identified events is a fire and/or explosion event which may result from a variety of causes (e.g. battery thermal runaway, encroachment from off-site bushfire, substation fire). The study found that for all events the impacts will be localised and not expected to have off-site safety impacts. This was assessed based on the proposed controls and separation distance between the proposed BESS and sensitive receptors (i.e. residential dwellings).
- **Likelihood**: The highest likelihood rating for the identified events is 'Very Unlikely' (i.e. heard of in the industry, but not expected to occur).
- **Risk analysis**: A total of 13 hazardous events were identified. The breakdown of these events according to their risk ratings are as follows:
  - 'Medium' risk event: 1

    This event relates to unauthorised person access to the proposed BESS area resulting in vandalism/asset damage to the infrastructure, with no significant off-site impact expected. Severity rating of 'Major' was assigned to account for the trespasser potentially injuring themselves in the act. The PHA noted that the controls for this event are well understood and the likelihood was rated as 'Very Unlikely'.
  - 'Low' risk events: 12

    Most of these events relate to fire and/or explosion events, with no significant off-site impact expected (i.e. more likely to affect on-site 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 were rated as 'Very Unlikely'.

**Table 6.1: Risk results**

| Hazard | Event | Consequence (safety) | Off-site consequence | Significant off-site impact? | Risk and public impact) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Severity | Likelihood | Risk |
| Electrical | Exposure to voltage | - Electrocution<br>- Fire<br>- Injury and/or fatality to on-site employees | No off-site impact expected as the BESS will be situated in a remote area and there is a large separation distance to the nearest residential dwelling. | No | Insignificant | Very Unlikely | Low |
| Energy | Arc flash | - Arc blasts and resulting heat, may result in fires and pressure waves<br>- Burns<br>- Exposure to intense light and noise<br>- Injury and/or fatality to on-site employees | Localised effects, the effects are not expected to have an off-site impact. | No | Insignificant | Very Unlikely | Low |
| Fire | BESS fire | - Release of toxic and/or explosive combustion products<br>- Escalation to the entire BESS<br>- Injury and/or fatality to on-site employees | No off-site impact expected as the BESS will be situated in a remote area and there is a large separation distance to the nearest residential dwelling. | No | Insignificant | Very Unlikely | Low |
| Chemical | Release of electrolyte from the battery cell (liquid/vented gas) | - Release of flammable liquid electrolyte<br>- Vapourisation of liquid electrolyte<br>- Release of vented gas from cells<br>- Fire and/or explosion in battery enclosure<br>- Release of toxic combustion products<br>- Injury and/or fatality to on-site employees | No off-site impact expected as the BESS will be situated in a remote area and there is a large separation distance to the nearest residential dwelling. | No | Insignificant | Very Unlikely | Low |
| | Coolant leak | Irritation/injury to on-site employees on exposure (inhalation) | Localised effects - not expected to have an off-site impact. | No | Insignificant | Very Unlikely | Low |
| | Refrigerant leak | Irritation/injury to on-site employees on exposure (skin contact) | Localised effects - not expected to have an off-site impact. | No | Insignificant | Very Unlikely | Low |
| Explosive gas | Generation of explosive gas | - Fire and/or explosion in battery enclosure<br>- Release of toxic combustion products<br>- Injury and/or fatality to on-site employees | No off-site impact expected as the BESS will be situated in a remote area and there is a large separation distance to the nearest residential dwelling. | No | Insignificant | Very Unlikely | Low |

| Hazard | Event | Consequence (safety) | Off-site consequence | Significant off-site impact? | Risk and public impact) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Severity | Likelihood | Risk |
| Reaction | Thermal runaway in battery | - Fire and/or explosion in battery enclosure<br>- Escalation to the entire BESS<br>- Injury and/or fatality to on-site employees | No off-site impact expected as the BESS will be situated in a remote area and there is a large separation distance to the nearest residential dwelling. | No | Insignificant | Very Unlikely | Low |
| EMF | Exposure to EMF | - High level exposure (i.e. exceeding the reference limits) may affect function of the nervous system (i.e. direct stimulation of nerve and muscle tissue and the induction of retinal phosphenes)<br>- Injury to on-site employees | No off-site impact expected as the BESS will be situated in a remote area and there is a large separation distance to the nearest residential dwelling. | No | Insignificant | Extremely Unlikely | Low |
| External factors | Water ingress (e.g. rain, flood)<br><br>Water ingress or inundation from rupture of firewater tank<br><br>Inundation from collapse of Wallerawang Power Station Ash Repository and dam | - Electrical fault/short circuit<br>- Fire and/or explosion in battery enclosure<br>- Injury and/or fatality to on-site employees | No off-site impact expected as the BESS will be situated in a remote area and there is a large separation distance to the nearest residential dwelling. | No | Insignificant | Very Unlikely | Low |
| | Vandalism due to unauthorised personnel access and deliberate damage to the BESS | - Asset damage<br>- BESS failure/fire<br>- Potential hazard to unauthorised person (e.g. electrocution)<br>- Injury and/or fatality to trespassing person | Effects to unauthorised person are expected to be localised and not expected to have an off-site impact. The impact is to a member of public but occurs on-site.<br><br>For a fire event, the effects are not expected to have an off-site impact as the BESS will be situated in a remote area and there is a large separation distance to the nearest residential dwelling. | No | Major | Very Unlikely | Medium |
| | Lightning strike | - Fire<br>- Injury and/or fatality to on-site employees | No off-site impact expected as the BESS will be situated in a remote area and there is a large separation distance to the nearest residential dwelling. | No | Insignificant | Very Unlikely | Low |

| Hazard | Event | Consequence (safety) | Off-site consequence | Significant off-site impact? | Risk and public impact) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Severity | Likelihood | Risk |
| Escalation risk | Escalation from the BESS to adjacent on-site substation | - Escalation to adjacent substation resulting in potential off-site impacts | No off-site impact expected as the BESS will be situated in a remote area and there is a large separation distance to the nearest residential dwelling. | No | Insignificant | Very Unlikely | Low |

# 7. RISK ASSESSMENT

## 7.1. Assessment against company risk acceptance criteria

Using the study risk matrix, the identified hazardous events were qualitatively risk profiled. Of the 13 events identified, all were rated as Low risk except for one Medium risk event. This event is related to unauthorised person access to the BESS area, resulting in vandalism/asset damage to the infrastructure with the potential for self-injury during the act. The PHA noted that the controls for this event are well understood and will be implemented accordingly. It is anticipated that the proposed BESS will be located in a secure area with fencing and cameras, and warning signs will be provided. Mitigation measures would also include on-site 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 'Very Unlikely'.

All events are expected to have no significant off-site impact. Based on the study risk acceptance criteria, the risk profile for the Project is considered to be tolerable.

## 7.2. Assessment against HIPAP 4 criteria

Assessment against the HIPAP 4 qualitative land use planning risk criteria is provided in Table 7.1.

**Table 7.1: 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.* | The PHA has identified hazardous events and assessed the inherent risks associated with the proposed operations of the BESS.<br>The BESS location is suited for the proposed operation, situated in a relatively remote area with considerable separation distance to sensitive receptors to avoid off-site risks. | Yes |

| HIPAP 4 qualitative criteria | Remarks | Complies? |
|---|---|---|
| *The risk from a major hazard should be reduced wherever practicable, irrespective of the numerical value of the cumulative risk level from the whole installation. In all cases, if the consequences (effects) of an identified hazardous incident are significant to people and the environment, then all feasible measures (including alternative locations) should be adopted so that the likelihood of such an incident occurring is made very low. This necessitates the identification of all contributors to the resultant risk and the consequences of each potentially hazardous incident. The assessment process should address the adequacy and relevancy of safeguards (both technical and locational) as they relate to each risk contributor.* | Based on the separation distance to sensitive receptors, consequence impacts from the identified hazardous events are not expected to have significant off-site impacts. | Yes |
| *The consequences (effects) of the more likely hazardous events (i.e. those of high probability of occurrence) should, wherever possible, be contained within the boundaries of the installation.* | Based on the separation distance to sensitive receptors, consequence impacts from the identified hazardous events are not expected to have significant off-site impacts. | Yes |
| *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.* | The proposed BESS will be located within the Project operational boundary. There will be no other additional hazardous developments in the vicinity (Arcadis has advised that the nearby Wallerawang power station is currently being demolished). | Yes |

## 7.3. Conclusion and Recommendation

A PHA has been completed for the BESS in accordance with the DPIE HIPAP No. 6 and Multi Level Risk Assessment guidance. A Level 1 PHA (qualitative) was conducted for the BESS. The PHA concluded that:

- There are no events with the potential for significant off-site impact associated with the operation of the BESS and the BESS meets the HIPAP No.4 qualitative risk criteria.
- The BESS is suitably located and minimises the risk to neighbouring land uses and on-site substation(s).

The PHA has made one recommendation and

- Greenspot to review the Energy Safe Victoria (ESV) investigation report into the Moorabol Big Battery site fire (30-Jul-21) (when publicly available) and implement findings as appropriate to their facility.

# 8. ICNIRP CONSIDERATIONS

## 8.1. Overview

This section of the report presents an assessment against the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields. The section considers the potential for public and occupational personnel to be exposed to EMF generated from Project components and is set out as follows:

- Description of EMF
- Potential effects of EMF to humans
- Approach to risk assessment
- Project EMF sources
- Proposed controls to limit exposure
- Assessment and conclusion.

## 8.2. Description of EMF

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 [7].

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 kilo volts 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 effects 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 EMF 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 presented in Table 8.1, Ref [8].

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[3] (ENA) as Extremely Low Frequency[4] (ELF) EMF, Ref [7].

**Table 8.1: 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 |

## 8.3. Effects of human exposure to EMF

### 8.3.1. 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 [9].

### 8.3.2. 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 Extremely Low Frequency (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 [9].

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

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

### 8.3.3. 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 [7].

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".*

## 8.4. Study approach for risk assessment

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 considered the typical EMF exposure levels from the proposed Project components.

A task group assembled by the World Health Organisation (WHO) 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 [10]. Therefore, the information presented in the following sections address predominantly the effects of exposure to ELF magnetic fields.

## 8.5. Guidelines for EMF exposure

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 (frequency of distribution and use of electricity power systems) is presented in Table 8.2, Ref [9]. The guideline adopted more stringent exposure restrictions for the general public compared to occupational exposures, recognising that in many cases general public are unaware of their exposure to EMF.

**Table 8.2: 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 |

## 8.6. EMF of proposed Project BESS infrastructure

### 8.6.1. Power Conversion Equipment (PCE)

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 [11].

The field study findings were adopted to estimate the EMF measurements for the project. The findings are as follows:

- 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.

### 8.6.2. Substations and transformers

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 [12].

#### 8.6.3. 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 [12].

#### 8.6.4. 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 given the proposed designs which include dedicated housing (e.g. enclosures/large building) (refer to Section 2.4). 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.

### 8.7. Controls to limit exposure to EMF

The following controls were identified to limit exposure to EMF for the Wallerawang BESS:

- 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. The distance between the proposed location of the nearest BESS enclosure to the nearest residential receiver at Springvale lane is approximately 650 m away.
- Occupied buildings are located well away from the BESS and proposed components.
- Exposure to EMF (specifically magnetic fields) from electrical equipment will be localised and the strength of the field attenuates rapidly with distance.
- There is incidental shielding (i.e. the BESS enclosure, substation) and warning signs will be placed within the site and surrounds.
- Duration of exposure to EMF for Greenspot personnel on-site will be transient.

### 8.8. Assessment and 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 (Refer to section 8.6).
- 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 (Refer to section 8.6).
- For the risk assessment, the risk was determined to be 'Low' (in reference to the study matrix shown in Figure 6.1) for the following reasons:
  - Consequence from exposure to EMF was assumed to be 'Insignificant' (the lowest level in the matrix). Given the remote location of the BESS and associated infrastructure, the Project is not expected to have off-site impact.
  - Likelihood of EMF exposure to the general public was assumed to be 'Extremely Unlikely'. For onsite personnel, likelihood of EMF exposure is 'Very Unlikely' provided that controls (section 2.4) are adhered and avoidance of exposure is practiced (assuming temporary and short-term occupation of Project locations).

# 9. REFERENCES

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[3] NSW Department of Planning, “HIPAP No.6 - Guidelines for Hazard Analysis,” 2011.

[4] NSW Department of Planning, “Assessment Guideline: Multi-Level Risk Assessment,” 2011.

[5] NSW Department of Planning, “HIPAP No.4 - Risk Criteria for Land Use Planning,” 2011.

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[7] Energy Networks Association, “EMF Management Handbook,” 2016.

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[11] R. A. Tell, C. Hooper, G. G. Sias, G. Mezei, P. Hung and R. Kavet, “Electromagnetic Fields Associated with Commercial Solar Photovoltaic Electric Power Generating Facilities,” *Journal of Occupational Environmental Hygiene,* pp. 795-803, 2015.

[12] ARPANSA, “Measuring magnetic field,” [Online]. Available: https://www.arpansa.gov.au/understanding-radiation/radiation-sources/more-radiationsources/measuring-magnetic-fields.