APPENDIX N

Hazard and risk assessment

REPORT

PRELIMINARY HAZARD ANALYSIS

WELLINGTON SOUTH BATTERY ENERGY STORAGE SYSTEM

ENVIRONMENTAL IMPACT STATEMENT

EMM CONSULTING PTY LTD

DOCUMENT NO:	**21580-RP-001**
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Title: **Report** **Preliminary Hazard Analysis** **Wellington South Battery Energy Storage System** **Environmental Impact Statement**	**QA verified:** G. Peach **Date:** 02-Sep-2022

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TABLES

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ABBREVIATIONS

AC	Alternating Current
APZ	Asset Protection Zone
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AS	Australian Standard
BESS	Battery Energy Storage System
BMS	Battery Management System
DA	Development Application
DC	Direct current
DG	Dangerous Goods
DP	Deposited Plan
DPE	(NSW) Department of Planning and Environment
DVC	Decisive Voltage Classification
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency
EMF	Electric and Magnetic Fields
EMM	EMM Consulting Pty Limited
ENA	Energy Networks Australia
EP&A	Environmental Planning and Assessment
ESV	Energy Safe Victoria
FRNSW	Fire and Rescue NSW
HAZID	Hazard Identification
HIPAP	Hazardous Industry Planning Advisory Paper
HVAC	Heating Ventilation Air Conditioning
Hz	Hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
ISO	International Standards Organization
km	Kilometres
kV	kilovolt
LEP	Local Environmental Plan
MLRA	Multi Level Risk Assessment
MW	Megawatt

MWh	Megawatt hours
NEM	National Electricity Market
NSW	New South Wales
OH&S	Occupational Health & Safety
PCS	Power Conversion System
PHA	Preliminary Hazard Analysis
PPE	Personal Protective Equipment
RFS	Rural Fire Safety
SDS	Safety Data Sheet
SEARs	(Planning) Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SRD	State and Regional Development
SSD	State Significant Development
WHO	World Health Organization

TERMINOLOGY

Consequence	Outcome or impact of a hazardous incident, including the potential for escalation
Development area	Area within the project site boundary on which the project infrastructure will be located.
Development area boundary	The perimeter of the development area
Offsite	Areas extending beyond the development area boundary
Onsite	Areas within the development area boundary
Project	Wellington South Battery Energy Storage System (BESS)
Project site boundary	The perimeter of the project site area
Proponent	AMPYR Australia
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

AMPYR Australia Pty Ltd (AMPYR) proposes to construct and operate a major grid-scale Battery Energy Storage System (BESS) (the project) near Wellington, New South Wales (NSW). The project is located approximately 250 m south-east of the TransGrid Wellington Substation.

The project includes construction and operation of the BESS and associated civil and electrical infrastructures (e.g. transformers, inverters). The project will have an estimated discharge capacity of 500 megawatts (MW) with a two-hour energy storage. The electricity from the BESS will contribute and connect to the national electricity grid via either a 330 kilovolt (kV) underground or overhead transmission line.

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.

AMPYR 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 BESS and its proposed operation for input to the 'Hazards' section of the EIS.

1.2. Objectives

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

1. A Preliminary Hazard Analysis (PHA) must be prepared in accordance with *Hazardous Industry Planning Advisory Paper No. 6 – Guidelines for Hazard Analysis* (DoP, 2011) and *Multi-Level Risk Assessment* (DoP, 2011); and
2. An assessment of all potential hazards and risks including but not limited to bushfires, spontaneous ignition, 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*.

1.3. Scope

The scope of the study includes the following project infrastructures:

- A 500 MW BESS compound including battery enclosures and electrical conversion systems (e.g. inverters and transformers).
- An onsite substation.

- An aboveground or underground transmission line connecting the BESS and the adjoining TransGrid Wellington 330 kV substation.
- Upgrade of the existing TransGrid Wellington 330 kV substation, which may include an additional 330 kV switch bay with power transformers (which would be installed as an alternative to the transformer bays being located on the BESS site).
- A control and office building.
- Ancillary infrastructure (e.g. security fencing, lighting and closed-circuit television).

1.4. Exclusions and limitations

The study exclusions and limitations are 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 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 include a SEPP 33 risk screening, although notwithstanding the screening outcome a PHA should be undertaken. The requirement for a SEPP 33 risk screening is addressed in the EIS.
2. Bushfire hazard assessment. This study does not constitute a bushfire hazard assessment. Risk event associated with bushfire and the identified controls (i.e. fire management plan) have been included in this study to demonstrate that this event has been considered and assessed.
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 DA approval. For more information, refer to the Department of Planning and Environment (DPE) 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 BESS and associated infrastructure, and excluded specific hazards relating to construction, commissioning, and decommissioning. This approach is assumed appropriate for EIS assessment at the DA stage aimed to obtain approval for the project.
5. Design elements subject to change during detailed design. 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 and following contractor selection 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 Wellington South BESS (the project) will be on privately owned land, located approximately 0.5 km south of the existing intersection of Goolma Road and Twelve Mile Road. It will be located within Lot 32 DP 622471 and will incorporate either an overhead or underground transmission line in the adjoining TransGrid owned landholding (Lot 1 DP 1226751).

The development boundary of the project will occupy an area of approximately 13 hectares (ha) and the disturbance boundary associated with the project will occupy an area of approximately 19 ha.

The project will include an upgrade and relocation to the existing site access (currently at the intersection of Goolma Road and Twelve Mile Road) to facilitate safer connection to roadway network and entry of larger construction vehicles.

The location of the project including the development and disturbance boundaries is shown in Figure 2.1. The general layout of the project is shown in Figure 2.2.

2.2. Surrounding land use

The site for the proposed BESS is zoned RU1 – Primary Production under the Wellington Local Environmental Plan (LEP) 2012 and is currently used for farming, grazing and other agriculture purposes. These existing uses will continue with minimal interruption from the project's operation. The TransGrid site is zoned SP2 Electricity Generating Works.

The surrounding land is used for farming and generation of renewable energy, including the Wellington Solar Farm and Wellington North Solar Farm.

The nearest township to the project will be Wellington, located approximately 2.2 km south-west of the development area boundary.

The closest involved residential dwelling (project participating landowner) is located approximately 700 m south of the proposed BESS (i.e. R23). The closest non-involved residential dwelling (non-project residential receiver) is located approximately 800 m north-east of the proposed BESS (i.e. R1). The locations of the residential dwellings in the vicinity of the project site are shown in Figure 2.1.

Figure 2.1: Project site location

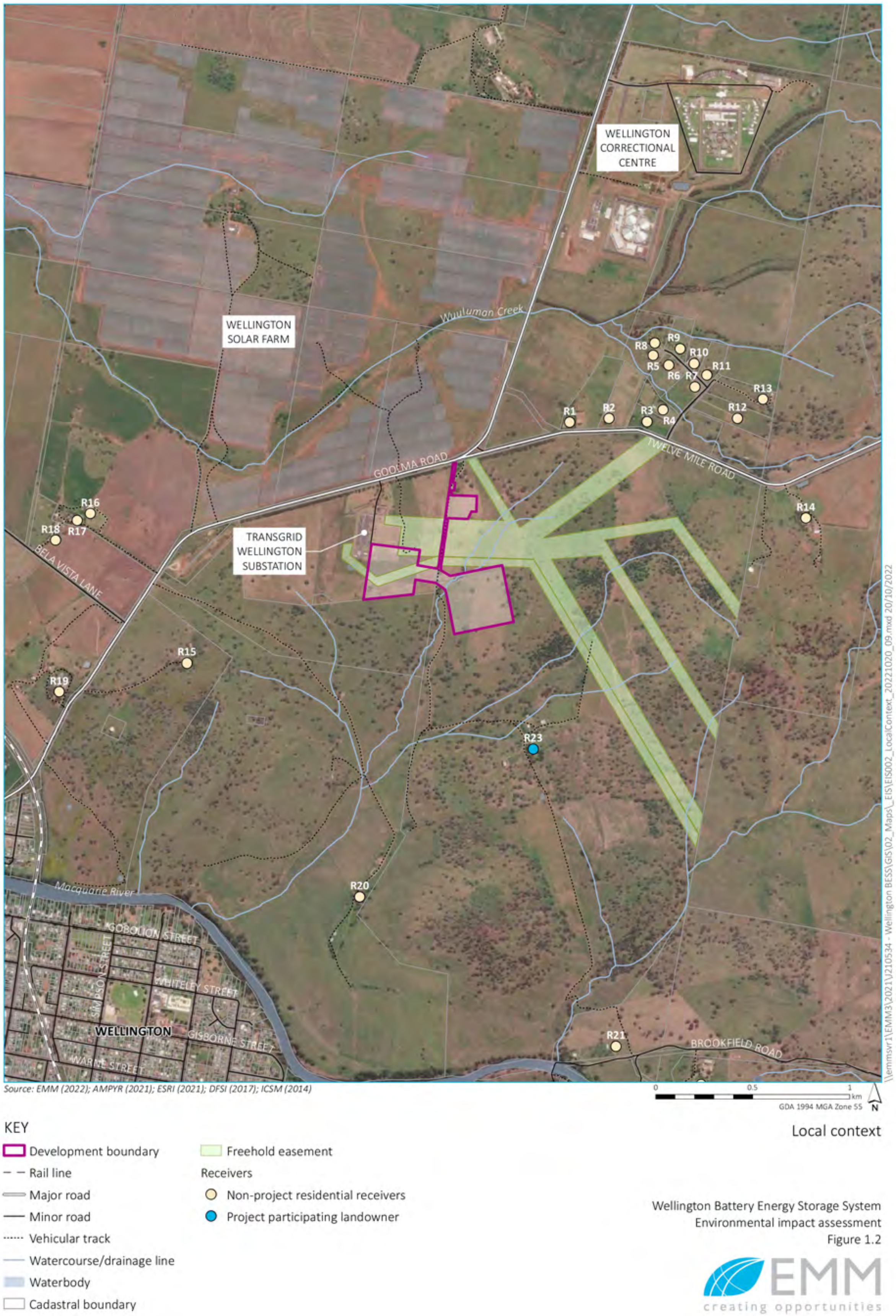
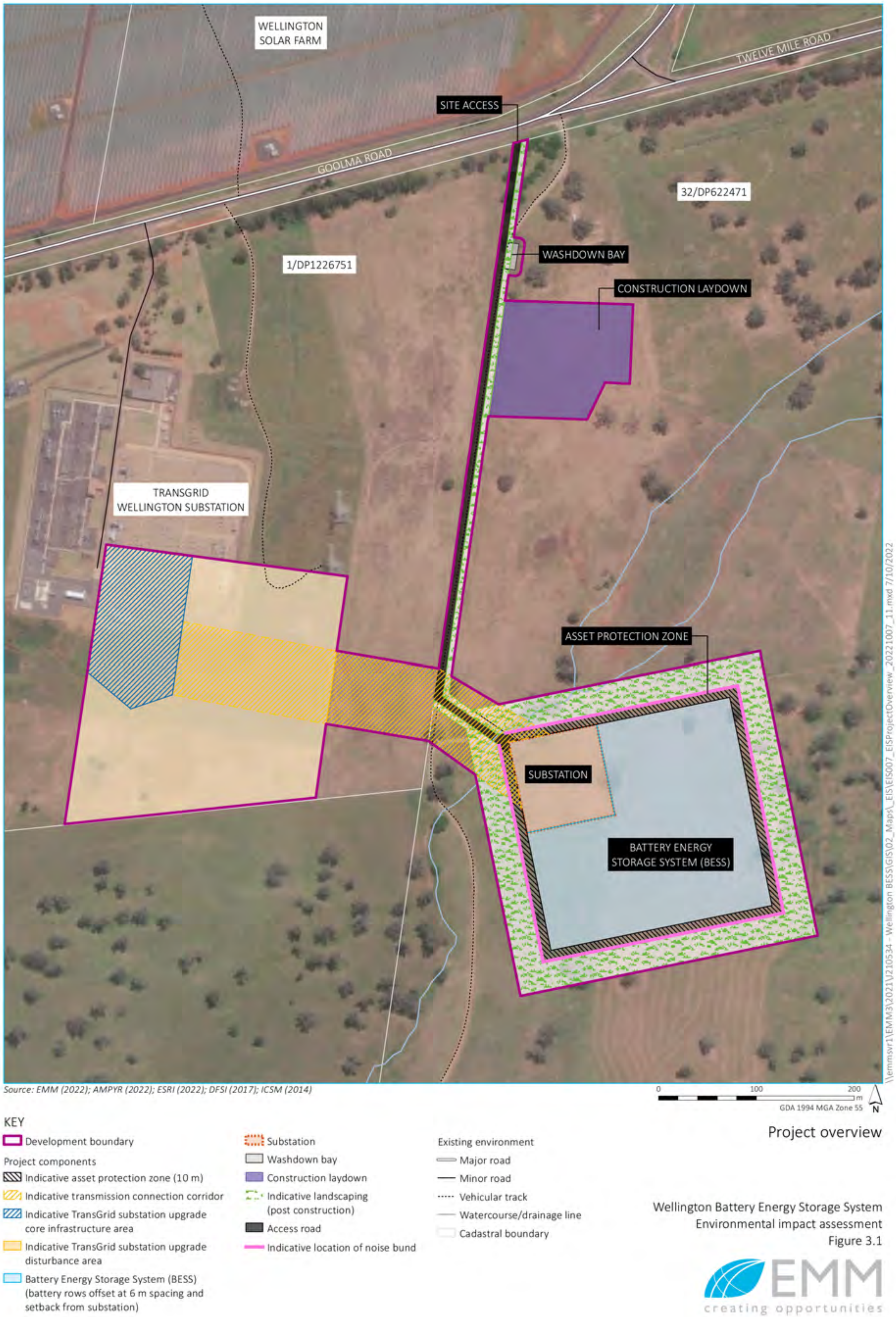


Figure 2.2: General layout of the project



2.3. Project key infrastructure

2.3.1. Battery Energy Storage System

The proposed BESS will have a capacity of 500 MW/1000 MWh (allowing a two-hour energy storage) and make use of lithium-ion technology. The BESS will be adjacent to a dedicated BESS substation. Security fencing will be provided around the perimeter of the BESS compound.

At the time of this study, AMPYR has not made a final decision on the BESS supplier. Two options currently being considered include the (1) CATL and (2) Tesla Megapack battery systems.

Major components for the proposed BESS and specific features for the battery systems being considered are shown in Table 2.1.

Table 2.1: Potential BESS options for the development

Component	CATL	Tesla
Description	The assessment made in this study was based on the use of the following system/configuration: • Battery modules: CATL • Battery rack: CATL Enerone (O852280-E, outdoor rated enclosure) • Inverter: Power Electronics (FREEMAQ PCSK / HEMSK) • Integrator: Power Electronics.	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 an outdoor rated cabinet, typically mounted on concrete pads.
Battery modules	The exact number of battery modules and/or enclosures required to achieve the intended 500 MW/1000 MWh capacity will be subject to the technology provider selected. Each CATL battery rack consists of eight battery modules. Each rack is rated for 372.7 kWh, Ref [4]. Each Tesla Megapack is rated for up to 3 MWh, Ref [3].	
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.	
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 [4].	
Thermal management system	The CATL battery enclosure includes a sealed liquid cooling system (8 kW chiller) using a 50% ethylene glycol aqueous solution as the coolant, Ref [4].	The Tesla Megapack includes a sealed liquid thermal management system with a dual coolant and refrigerant loop system that runs through battery modules and inverters. For the Tesla system, the coolant is also a 50% ethylene glycol aqueous solution.
Fire protection system	The CATL battery enclosure has a built-in fire protection/suppression system which includes a smoke detector, heat detector and aerosol spray, Ref [5].	The Tesla Megapack does not contain built-in smoke, gas, or fire detection or suppression features. The Tesla Megapack inherent design minimises risk of a fire spreading from one cabinet to another. Validated large-scale fire testing has shown that in the event of a fire, the Megapacks perform in a safe and controlled manner, consuming themselves slowly without explosive bursts, deflagrations, or unexpected hazards, and without propagating to neighbouring enclosure units, Ref [6]. Water spray has been deemed safe as an agent for use on exposed Megapacks and water is considered the preferred agent for suppressing lithium-ion battery fires, Ref [6].

2.3.2. BESS substation and grid connection

A BESS substation will be established within the site to convert electricity between the high voltage transmission network and medium voltage BESS compound. Indicatively, the substation footprint will be approximately 130 m x 130 m and established on a concrete pad. The BESS substation will connect to BESS infrastructure via underground 33 kV cables and will be separated from the BESS compound infrastructure by security fencing and an Asset Protection Zone (APZ).

The on-site substation will comprise:

- Two 330 kV transformer switch bays; and
- 33 kV indoor switchgear housed in portable substation containers.

The transformer bays will be bunded and subject to separation distances in accordance with manufacturer requirements.

An underground or overhead 330 kV transmission line, approximately 500 m in length from the BESS substation to the existing TransGrid Wellington substation, will provide connection point to the National Electricity Market (NEM). A 60 m wide easement will be established for the transmission line.

2.3.3. Supporting infrastructure

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

1. A control and office building – The control and office building will be a prefabricated building comprising a lunchroom, office and ablutions room. The building will be equipped with a fire detection and fire suppressant systems.
2. Electrical switchroom and connection to utilities.
3. Parking facilities and internal access roads.
4. Security fencing, lighting and closed-circuit television.
5. Temporary compound for construction and decommissioning.

Security fencing will be installed to restrict public access to the project infrastructure.

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

The project is proposing to connect into the existing, neighbouring TransGrid switchyard. The required upgrade works on the TransGrid site are subject to detailed design, but may include the connection of overhead or underground conductors and an additional 330 kV switch bay with power transformers (which would be installed as an alternative to the transformer bays being located on the BESS site) and may be installed in stages to coincide with the staged construction of the BESS should a staged approach be adopted. The work may include:

- Switchyard bench extension to the south of the existing bench;
- Relocation of security fencing;
- Provision of a new switch bay with transformers and associated infrastructure; and
- Overhead or underground cables as required for the new 330 kV switch bay.

2.4. Construction

Construction is expected to commence in May 2023 (subject to approvals and market conditions). The project will be constructed and commissioned in line with battery supply availability, labour and equipment availability and increasing demand in the network. This may occur in a single stage over a period of 12 – 18 months. Alternatively, it is considered likely that it may occur over two stages as follows:

- Stage 1 – construction commencement May 2023 and operation May 2024
- Stage 2 – construction commencement November 2024 and operation November 2025.

Construction of the project, or each stage of it, would be undertaken in four phases, as follows:

1. Enabling works (site establishment): approximately 2-4 months
2. Construction works (civil, structural and electrical works): approximately 5-8 months
3. Commissioning: approximately 4-5 months
4. Demobilisation: approximately 1 month.

For the staged construction scenario, Stage 1 would likely include 300 MW installed discharge capacity, all civil and enabling works, installation of batteries, one transformer and switchgear and associated structural, mechanical and electrical works, and connection to the substation. Stage 2 would consist of 200 MW, including installation of a second transformer and associated switchgear and batteries.

Project components (e.g. batteries, enclosures, PCS components and substation components) will be transported to the site from Sydney/Newcastle via the Mitchell Highway and Goolma Road, an approved B-double route.

2.5. Operations

The BESS is expected to commence operation in 2024 for a period of approximately 20 years. The BESS will operate 24 hours per day, seven days per week, 365 days per year and normally unmanned (i.e. remote operation). The BESS is expected to undergo one to two full cycles of charging and discharging per day.

During the operations phase, the project will employ a workforce of up to 2 full time employees. Operation of the project would involve:

1. Maintenance and cleaning of equipment
2. General office activities; and
3. Waste removal.

2.6. Decommissioning

Once the project reaches the end of its investment and operational life, the project infrastructure will either be replaced, upgraded or decommissioned.

Decommissioning would involve removal of the built infrastructure from site and the development footprint returned to its pre-existing land use, suitable for farming, grazing of sheep and cattle or another land use as agreed by the project owner and the landholder at that time.

3. METHODOLOGY

3.1. Overview

This study was carried out in accordance with the requirements of HIPAP No. 6 *Hazard Analysis*, Ref [7], 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 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 the identified events with offsite impact (*Risk Analysis*).
6. Assessment of the estimated risks from identified events against risk criteria to determine acceptability (*Risk Assessment)*.

These above steps are also in line with the risk management process outlined in AS ISO 31000 *Risk Management Guidelines,* Ref [8].

This study assessed the events associated with proposed operation of the BESS (i.e. excluded construction related events). The development area boundary was used to define and determine offsite impact (i.e. impact extending outside of the development area boundary).

3.2. Level of analysis

The NSW DPE *Multi-Level Risk Assessment* guidelines, Ref [9], 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 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 [10], appropriate for the level of analysis determined (based on guidance outlined in Table 3.1).

4. HAZARD IDENTIFICATION

4.1. Overview

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

The HAZID process was completed using the following input:

1. Review of the CATL battery system's product brochure, Ref [11], product specifications, Ref [4], and fire safety design, Ref [5], for controls provided.
2. Review of the Tesla Megapack battery system's emergency response guide, Ref [6].
3. Review of AS/NZS 5139:2019 *Electrical installations – Safety of battery systems for use with power conversion equipment*, Ref [12].
4. Literature research of past incidents involving similar BESS systems.
5. Previous risk assessments for similar BESS systems completed by Sherpa.
6. Consultation and feedback from AMPYR.

At the time of this study, the CATL specific battery Safety Data Sheet (SDS) and/or emergency response guide was 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 similar. 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:

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

The types of hazards and associated events considered were informed from AS/NZS 5139, Ref [12]. The identified hazards and events for the project are presented in Table 4.1.

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

Table 4.1: Identified hazards and events

Hazard	Event
Electrical	Exposure to voltage
Energy	Release of energy (i.e. arc flash)
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 BESS. Identified controls have been referenced in this study (i.e. fire management plan), where applicable.

AMPYR has confirmed that no other hazardous materials or dangerous goods apart from the battery components are expected to be stored or present on site (i.e. source of fire escalation to the BESS).

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

Table 4.2: Hazards by BESS component

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

4.3. Exposure to EMF

The SEARs for 'Hazards' 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. HAZID register

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

- A total of 14 hazardous events were identified.
- The BESS and substations will be located close to the development area boundary. Some hazardous events (i.e. fires) may extend beyond this boundary (i.e. off-site impact in the context of HIPAP No. 6). However, as the BESS and substations will be situated in a rural area and the nearest non-project residential receiver is located 800 m away, no events with potential for significant off-site impact (i.e. serious injury and/or fatality to the public or off-site population) were identified.

Note: as per the study scope, mentions of the TransGrid substation in the HAZID register refer to the relevant proposed upgrade works only (i.e. excluded the existing substation and infrastructure).

Table 4.3: HAZID register

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant offsite impact?
1	Electrical	Battery modules BMS Inverters	Exposure to voltage	Short circuit/electrical connection failure - Faulty equipment - Incorrect installation - Incorrect maintenance - Human error during maintenance - Safety device/circuit compromised - Battery casing/enclosure damage Earth potential rise (exposure to step and touch potentials) - Electrical faults	- Electrocution - Fire - Injury and/or fatality to onsite employees - Injury and/or fatality to member of public due to touch and step potential (e.g. transferred through fences). As the BESS will be situated in a rural area and there is a large separation distance to the nearest 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. - 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 - Site induction/substation training (i.e. high voltage areas) - Electrical switch-in & switch-out protocol - BESS BMS fault detection and safety shut-off - Earthing study (mitigate touch and step potentials) - Earthing as per manufacturer and standards requirements - Emergency Response Plan - External firefighting assistance (FRNSW & RFS) - Use of appropriate PPE - Rescue kits (i.e. insulated hooks)	-	No
2	Energy	Battery modules BMS Inverters	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 standard 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 [12]. Arc flash occurs when electrical current passes through the air between electrified conductors when there is insufficient isolation or insulation to withstand the applied voltage. Arc flash may result in rapid rise in temperature and pressure in the air between electrical conductors, causing an explosion known as an arc blast.	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant offsite impact?
3	Fire	Battery modules BMS HVAC Inverters	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. substation fire, 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 situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an offsite impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS 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. These may include clearances (1) between the units (2) from combustible objects/structures (3) from means of egress, buildings and public ways. - 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 Asset Protection Zone buffer - External assistance for firefighting (FRNSW & RFS)	-	No
4	Fire	BESS substation TransGrid substation (proposed upgrade works only)	Substation fire	- Faulty equipment - Transformer oil leak - Arc flash - Vandalism - External fire (e.g. fire escalation from adjacent BESS) - Bushfire	- Release of toxic combustion products - Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees As the BESS and substations will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an 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 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. These may include clearances (1) between the units (2) from combustible objects/structures (3) from means of egress, buildings and public ways. - 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 Asset Protection Zone buffer - External assistance for firefighting (FRNSW & RFS)	-	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant offsite impact?
5	Fire	BESS BESS substation TransGrid substation (proposed upgrade works only)	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 the BESS and substations will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an offsite impact.	- Fire Management Plan - Defendable boundary for firefighting will be established - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS) - Inclusion of Asset Protection Zone buffer - Use of appropriate PPE	-	No
6	Chemical	Battery modules BMS HVAC	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 - Contamination of the Development Area As the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an offsite impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS 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. These may include clearances (1) between the units (2) from combustible objects/structures (3) from means of egress, buildings and public ways. - Venting and containment requirements of the BESS manufacturer to be followed - Spill cleanup using dry absorbent material - Each enclosure compartment has the capacity to contain liquid from a large number of cells - Layers of battery case (pod and external casing) - 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 Asset Protection Zone buffer - External assistance for firefighting (FRNSW & RFS)	Vented gases are early indicator of a thermal runaway reaction	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant offsite impact?
7	Chemical	Battery modules BMS HVAC	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 situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an 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. These may include clearances (1) between the units (2) from combustible objects/structures (3) from means of egress, buildings and public ways. - Battery cells are enclosed with external casing - Spill cleanup using dry absorbent material - 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 - External assistance for firefighting (FRNSW & RFS)	[CATL]: Coolant is 50% ethylene glycol aqueous solution (CATL Enerone) [Tesla]: For the Tesla system, the coolant is 50/50 mixture of ethylene glycol and water. A Megapack contains about 540 L of coolant.	No
8	Chemical	Battery modules BMS HVAC	Refrigerant leak (if applicable)	- Mechanical failure/damage - Incorrect maintenance	Irritation/injury to on-site employees on exposure (skin contact) 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 - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - Engagement of reputable contractors - Maintenance will be done by trained personnel - BMS fault detection and shut-off function - Layers of battery case (pod and external casing) - PPE and spill clean-up using dry absorbent material	The Tesla thermal management system is in a sealed system. Mechanical damage could result in a release of the refrigerant. Such a release would appear similar to the emission of smoke.	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant offsite impact?
9	Explosive Gas	Battery modules	Generation of explosive 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 situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an offsite impact.	- Equipment and systems will be designed and tested to comply with the relevant international and Australian standards (e.g. AS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - 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. These may include clearances (1) between the units (2) from combustible objects/structures (3) from means of egress, buildings and public ways. - 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 Asset Protection Zone buffer - External assistance for firefighting (FRNSW & RFS)	-	No
10	Reaction	Battery modules	Thermal runaway in battery	<u>Elevated temperature</u> - Bushfire - External fire (e.g. fire from adjacent infrastructure) <u>Electrical failure</u> - Short circuit - Excessive current/voltage - Imbalance charge across cells <u>Mechanical failure</u> - Internal cell defect - Damage (crush/penetration/puncture) <u>Systems failure</u> - 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 situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an 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 - 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. These may include clearances (1) between the units (2) from combustible objects/structures (3) from means of egress, buildings and public ways. - Battery Management System (BMS), including temperature monitoring, fault detection and shut-off function - Cell chemistry selection - 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 Asset Protection Zone 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	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant offsite impact?
11	EMF	BESS BESS substation Transmission line TransGrid substation (proposed upgrade works only)	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 As the BESS and substations will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an offsite impact.	- Location siting and selection (i.e. separation distance to sensitive receptors) - Optimising equipment layout and orientation - Reducing conductor spacing - Balancing phases and minimising residual current - Incidental shielding (i.e. BESS enclosure) - Equipment and systems will be designed and tested to comply with 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).	No
12	External factors	BESS BESS substation TransGrid substation (proposed upgrade works only)	Water ingress	- Rain - Flood	- Electrical fault/short circuit - Fire - Injury and/or fatality to onsite employees As the BESS and substations will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an offsite impact.	- Location siting (i.e. outside of flood prone area) - [CATL]: BESS enclosure is outdoor rated with water ingress protection (IP 56 rated) [applies to BESS only] - [Tesla]: The Tesla battery system enclosure is outdoor rated with water ingress protection (IP 66 rated) [applies to BESS only] - BESS will be housed in dedicated enclosure which will be constructed in accordance with relevant standards [applies to BESS only] - 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. These may include clearances (1) between the units (2) from combustible objects/structures (3) from means of egress, buildings and public ways [applies to BESS only]. - Drainage system - Preventative maintenance (check for leaks) - BESS BMS fault detection and shut-off function [applies to BESS only] - BESS fire protection/suppression system (battery system specific features, refer to Table 2.1) [applies to BESS only] - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS)	-	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant offsite impact?
13	External factors	BESS BESS substation TransGrid substation (proposed upgrade works only)	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, the effects are not expected to have an offsite impact. As the BESS and substations will be situated in a rural area and there is a large separation distance to the nearest 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 substations and in vicinity to the BESS - Onsite security protocol - Presence of staff during operational hours	-	No
14	External factors	BESS BESS substation TransGrid substation (proposed upgrade works only)	Lightning strike	Lightning storm	- Fire - Injury and/or fatality to onsite employees As the BESS and substations will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an offsite impact.	- Earthing - Lightning protection mast - Activation of emergency shutdown - Fire Management Plan - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS)	-	No

5. ELECTRIC AND MAGNETIC FIELDS (EMF)

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 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 the source and their strength attenuates rapidly away from the source. The strength of electric fields are 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 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 shown in Table 5.1, Ref [14].

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[1] (ENA) as Extremely Low Frequency[2] (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

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

[2] 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 [15].

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 [15].

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 (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 [16]. 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 [15]. 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. 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 [17].

5.5.2. 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 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.

5.5.3. PCS or inverters

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's infrastructures. 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.

5.5.4. Substation and grid connection

The project will include a BESS substation, grid connection and TransGrid Wellington substation upgrade. 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 [19].

5.5.5. 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 [19].

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 7.2.

6. LEVEL OF ANALYSIS DETERMINATION

6.1. Level of analysis

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

- The project site will be situated in a rural area.
- The distance between the closest development area boundary and the nearest non-project residential receiver is approximately 800 m (i.e. R1). Hazardous events resulting in potential fire and/or explosion are not expected to have significant offsite impacts.

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

- The project site will be situated in a rural area with the scattered residential dwellings. The nearest non-project residential receiver is approximately 800 m away (i.e. R1).
- The nearest township will be Wellington, which is located approximately 2.2 km south-west of the development 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 7.

6.2. Qualitative risk criteria

The HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [10], 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 8.2.

7. RISK ANALYSIS

7.1. Overview

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

For each identified event, the risk to offsite population was qualitatively determined from the resulting severity and likelihood rating pair using the risk matrix shown in Table 7.1. In the absence of a suitable company risk matrix, the risk matrix provided in AS/NZS 5139, Ref [12], was used for the study as agreed by AMPYR. 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 7.1: 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

7.2. Severity rating

For each event, the severity rating was qualitatively assigned based on the consequence description identified in the HAZID register using the category scale shown in Table 7.2 which was reproduced from AS/NZS 5139, Ref [12].

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 an ‘Insignificant’ rating to indicate minimal impact to offsite population.

Table 7.2: 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

7.3. Likelihood rating

The likelihood of an event was estimated using the category scale shown in Table 7.3 which was reproduced from AS/NZS 5139, Ref [12].

Table 7.3: 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 accessed 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 AMPYR. The likelihood ratings were assigned accounting for the initiating causes, resulting consequences with controls (prevention and mitigation) in place.

7.4. Risk results and analysis findings

The qualitative risk results for the identified events are shown in Table 7.4. The context of the risk event and offsite consequence are provided in the HAZID register (Table 4.3).

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, substation fire, encroachment from offsite bushfire). The study found that for all events the impacts are not expected to have significant offsite impacts. This was assessed based on the location of the development (i.e. rural area), proposed controls and separation distance between the proposed BESS and sensitive receivers (i.e. 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 14 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 or development area 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'.
  - 'Very Low' risk events: 13

    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 7.4: Risk results

Hazard	Event	Consequence	Offsite consequence	Significant offsite impact?	Risk analysis (offsite and public impact)		
					Severity	Likelihood	Risk
Electrical	Exposure to voltage	- Electrocution - Fire - 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 as the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling(s).	No	Insignificant	Unlikely	Very Low
Energy	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	Rare	Very Low
Fire	BESS fire	- Release of toxic and/or explosive combustion products - Escalation to the entire BESS - Injury and/or fatality to onsite employees	No offsite impact expected due to provision of fire protection/suppression system for the BESS. The BESS will also be situated in a rural area and there is a large separation distance to the nearest dwelling(s).	No	Insignificant	Unlikely	Very Low
	Substation fire	- Release of toxic combustion products - Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees	No offsite impact expected as the BESS and substations will be situated in a rural area and there is a large separation distance to the nearest dwelling.	No	Insignificant	Unlikely	Very Low
	Bushfire	- Escalation to adjacent infrastructure - Injury and/or fatality to onsite employees	No offsite impact expected as the BESS and substations will be situated in a rural area and there is a large separation distance to the nearest dwelling(s), including presence of an Asset Protection Zone.	No	Insignificant	Unlikely	Very Low
Chemical	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	No offsite impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest dwelling(s).	No	Insignificant	Unlikely	Very Low
	BESS chiller unit or coolant leak	- Irritation/injury to onsite employee on exposure to leak - Ingress of coolant to battery or other electrical components (battery enclosure)	No offsite impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest dwelling(s).	No	Insignificant	Unlikely	Very Low

Hazard	Event	Consequence	Offsite consequence	Significant offsite impact?	Risk analysis (offsite and public impact)		
					Severity	Likelihood	Risk
		leading to short circuit and fire, resulting in injury and/or fatality to onsite employees.					
Chemical	Refrigerant leak (Tesla Battery System)	Irritation/injury to on-site employees on exposure (skin contact)	Localised effects - not expected to have an off-site 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	No offsite impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest dwelling(s).	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	No offsite impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest dwelling(s).	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	No offsite impact expected as the BESS and substations will be situated in a rural area and there is a large separation distance to the nearest dwelling(s).	No	Insignificant	Unlikely	Very Low
External factors	Water ingress (e.g. rain, flood)	- Electrical fault/short circuit - Fire - Injury and/or fatality to onsite employees	No offsite impact expected as the BESS and substations will be situated in a rural area and there is a large separation distance to the nearest dwelling(s).	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 an unauthorised person is 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, the effects are not expected to have an offsite impact as the BESS and substations will be situated in a rural area and there is a large separation distance to the nearest residential dwelling(s).	No	Major	Unlikely	Medium

Hazard	Event	Consequence	Offsite consequence	Significant offsite impact?	Risk analysis (offsite and public impact)		
					Severity	Likelihood	Risk
External factors	Lightning strike	- Fire - Injury and/or fatality to onsite employees	No offsite impact expected as the BESS and substations will be situated in a rural area and there is a large separation distance to the nearest dwelling(s).	No	Insignificant	Unlikely	Very Low

8. RISK ASSESSMENT

8.1. 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 14 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 proposed BESS/development area, 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.

8.2. Assessment against HIPAP 4 criteria

Assessment against the HIPAP 4 qualitative land use planning risk criteria is provided in Table 8.1.

Table 8.1: 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. The BESS location is suited for the proposed operation, situated in rural area with considerable separation distance to sensitive receptors to avoid off-site 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 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.	This study found that for all events the impacts are expected to be localised and contained within the boundaries of the installation with no significant off-site impacts.	Yes
Where there is an existing high risk from a hazardous installation, additional hazardous developments should not be allowed if they add significantly to that existing risk.	There is no other additional hazardous development in the vicinity.	Yes

8.3. Conclusion and recommendation

A PHA was completed to identify the hazards and assess the risks associated with the proposed BESS and its operations 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 BESS, 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. AMPYR to consult with Fire and Rescue NSW (FRNSW) during detailed design of the facility 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.
2. AMPYR 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 (ESV): Statement of Technical Findings on fire at the Victorian Big Battery.
   - Fisher Engineering (FEI) and Energy Safety Response Group (ESRG): Report of Technical Findings on Victorian Big Battery Fire.

9. REFERENCES

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