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REPORT

PRELIMINARY HAZARD ANALYSIS

ORANA BATTERY ENERGY STORAGE SYSTEM

SSD-45242780

NGH PTY LTD

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ABBREVIATIONS

AC	Alternating Current
ADGC	Australian Dangerous Goods Code
APZ	Asset Protection Zone
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AS/NZS	Australian Standard/New Zealand Standard
BESS	Battery Energy Storage System
BMS	Battery Management System
CCTV	Closed Circuit Television
DA	Development Application
DC	Direct Current
DG	Dangerous Goods
DoP	Department of Planning
DPE	Department of Planning and Environment
DVC	Decisive Voltage Classification
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency
EMF	Electric and Magnetic Fields
EMS	Energy Management System
EP&A	Environmental Planning and Assessment
ESRG	Energy Safety Response Group
FDC	Fire Department Connection
FRNSW	Fire and Rescue NSW
HAZID	Hazard Identification
HIPAP	Hazardous Industry Planning Advisory Paper
HVAC	Heating Ventilation and Air Conditioning
Hz	Hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEC	International Electrotechnical Commission
IP	Ingress Protection
km	Kilometres
kV	Kilovolt

kV/m	Kilovolt per metre
kW	Kilowatt
kWh	Kilowatt hours
LFP	Lithium Iron Phosphate
LGA	Local Government Area
MV	Medium Voltage
MVA	Megavolt Amperes
MW	Megawatt
MWh	Megawatt hours
NEM	National Electricity Market
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NSW	New South Wales
O&M	Operations and Management
OH&S	Occupational Health & Safety
PCS	Power Conversion System
PHA	Preliminary Hazard Analysis
PPE	Personal Protective Equipment
REZ	Renewable Energy Zone
RFS	Rural Fire Safety
SDS	Safety Data Sheet
SEARs	(Planning) Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SSD	State Significant Development
T	Tesla
TMS	Thermal Management System
UI	User Interface
UL	Underwriters' Laboratories
V/m	Volt per metre

TERMINOLOGY

Term	Definition
Consequence	Outcome or impact of a hazardous incident, including the potential for escalation.
Development footprint	All areas that may be disturbed by the Project during construction, operation and decommissioning (including all activities, including temporary and permanent impact areas). This is considered a 'worst case' generous delineation to allow required flexibility, during detailed design.
Development footprint boundary	The perimeter of the development footprint
Non-associated residential dwellings (sensitive receptors)	Residential dwellings that are not associated with the project.
Off-site	Areas extending beyond the development footprint boundary.
Project	Orana Battery Energy Storage System
Proponent	Akaysha Energy Pty Ltd
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. EXECUTIVE SUMMARY

1.1. Background and context

Akaysha Energy Pty Ltd (Akaysha Energy) proposes to construct and operate the Orana Battery Energy Storage System (the project); a grid-scale Battery Energy Storage System (BESS) facility with capacity of up to 400 MW/1600 MWh and associated infrastructure including connection to the existing electricity transmission network. The project will be located in Montefiores, approximately 2 km north-east of Wellington within the Dubbo Regional Local Government Area (LGA).

The project is a State Significant Development (SSD) under the *State Environmental Planning Policy (Planning Systems) 2021* (Planning Systems SEPP) and requires an Environmental Impact Statement (EIS) to accompany the Development Application (DA) submission. Akaysha Energy has commissioned NGH Pty Ltd (NGH) to prepare the project EIS. NGH has engaged Sherpa Consulting Pty Ltd (Sherpa) to undertake a Preliminary Hazard Analysis (PHA) for the project.

1.2. PHA objective, methodology and findings

A preliminary risk screening was completed to determine whether the proposed development is considered as 'potentially hazardous' in the context of SEPP (Resilience and Hazards) 2021. The risk screening followed the *Applying SEPP 33* guideline and found that the project is not considered as 'potentially hazardous' with respect to storage and transportation of dangerous goods. However, notwithstanding the outcome of the preliminary risk screening, the Planning Secretary's Environmental Assessment Requirements (SEARs) for the project require a PHA to be undertaken.

A PHA was completed to identify the hazards and assess the risks associated with the proposed operations of the BESS at the planning stage to determine risk acceptability from land use safety planning perspective. The PHA was focused on the risk to surrounding land uses (off-site impacts) and assesses if the development is appropriate for the location. Off-site impact was determined based on potential to impact sensitive receptors (i.e. non-associated residential dwellings).

The PHA was completed following the methodology specified in Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 *Hazard Analysis* and the *Multi-Level Risk Assessment* guidelines for assessment against HIPAP No. 4 criteria. A Level 1 PHA (qualitative) was completed.

The PHA findings are as follows:

- A total of 12 hazardous events were identified.
- The worst-case consequence for the identified events is a BESS fire and/or explosion event which may result from causes such as battery thermal runaway, encroachment from off-site bushfire or a substation fire. However, the consequences from these events are not expected to result in significant off-site impacts (serious injury and/or fatality to the public or off-site population) as:

  - The proposed BESS will be situated in a rural area with the scattered residential dwellings. The nearest sensitive receptor is approximately 680 m from the proposed BESS.
  - The nearest township is Wellington, located approximately 2 km south-west of the proposed BESS.
- For each event, the risk to off-site population was qualitatively profiled using the AS/NZS 5139:2019 *Electrical installations – Safety of battery systems for use with power conversion equipment* risk matrix. All events were rated as 'Very Low' risks except for one 'Medium' risk event. This event is related to unauthorised person access to the proposed 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. In addition to the rural location of the site, the proposed BESS will be located in a secure area with fencing 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.
- All identified events are not expected to have significant off-site impacts. Based on the study risk acceptance criteria, the risk profile for the proposed BESS is considered to be tolerable.

1.3. Review of BESS separation distances

For this project, the SEARs also include a requirement for the PHA to demonstrate that the proposed BESS capacity would be able to fit within the land area designated for the BESS accounting for separation distances between the:

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

The assessment made in this PHA was based on the use of the Powin's Centipede battery energy storage platform which utilises Powin's Stack750E hardware (pre-assembled and pre-tested modular battery stacks in outdoor rated enclosures).

The review of BESS separation distances found that:

1. The proposed BESS has been tested to Underwriters' Laboratories (UL) 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems* and the results indicate that:
   - Module-to-module propagation was not observed, and
   - Unit level results show a fire does not propagate from one Stack750E to another.

   The result of the UL 9540A test (performed with clearances as specified by the BESS manufacturer) form a key parameter to determine clearances.

2. As the BESS installation manual was not available at the time of this study, Sherpa was unable to verify the manufacturer specified clearances. Sherpa assumed that the clearances included in the BESS concept layout reflect the manufacturer's specified clearances.
3. The designated land area can accommodate the proposed BESS units to meet the proposed capacity.
4. There is a considerable separation distance between the proposed BESS and the TransGrid substation (i.e. >100 m). The separation distance to the Operations & Management (O&M) and BESS substation will be better informed during detailed design.
5. The nearest sensitive receptor is approximately 680 m away from the proposed BESS. No off-site impact is expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.

1.4. Conclusions and recommendations

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 off-site impacts.
- The proposed BESS meets the HIPAP No. 4 qualitative risk criteria.

The following recommendations were identified:

1. Akaysha Energy to locate the O&M building at least 30.5 m away (100 feet) from the closest BESS enclosure. This clearance corresponds with the minimum safety perimeter in the event of an emergency specified in Powin's Battery Emergency Response Guide, Ref [1].
2. Akaysha Energy to review the investigation reports on the Victorian Big Battery Fire (occurred on 31 July 2021) and implement relevant findings for the project. The publicly available investigation reports include:
    - Energy Safe Victoria: Statement of Technical Findings on fire at the Victorian Big Battery.
    - Fisher Engineering and Energy Safety Response Group: Report of Technical Findings on Victorian Big Battery Fire.
3. Akaysha Energy to consult with Fire and Rescue NSW (FRNSW) to ensure that the relevant aspects of fire protection measures have been included in the design. These may include: (i) type of firefighting or control medium (ii) demand, storage and containment measures for the medium. The above aspects will form an input to the Fire Safety Study which may be required as part of the development consent conditions, for review and approval by FRNSW.

2. INTRODUCTION

2.1. Background

Akaysha Energy Pty Ltd (Akaysha Energy) proposes to construct and operate the Orana Battery Energy Storage System (the project); a grid-scale Battery Energy Storage System (BESS) facility with capacity of up to 400 MW/1600 MWh and associated infrastructure including connection to the existing electricity transmission network. The project will be located in Montefiores, approximately 2 km north-east of Wellington within the Dubbo Regional Local Government Area (LGA).

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

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

2.2. Objectives

The overall study objective was to address the 'Hazards' component of the Planning Secretary's Environmental Assessment Requirements (SEARs), Ref [2], which include:

1. A preliminary risk screening completed in accordance with the *State Environmental Planning Policy (Resilience and Hazards) 2021*.
2. A PHA must be prepared in accordance with Hazardous Industry Planning Advisory Paper (HIPAP) No. 6, 'Hazard Analysis' and Multi-Level Risk Assessment (DoP, 2011). The PHA must:
   - Consider all recent standards and codes; and
   - Verify that the area designated for the BESS, and separation distances to on-site and off-site receptors and between BESS sub-units, is sufficient to prevent fire propagation and compliance with HIPAP No. 4, 'Risk Criteria for Land Use Safety Planning' (DoP, 2011).
3. An assessment of potential hazards and risks including but not limited to bushfires, land contamination[1], spontaneous ignition, electromagnetic fields for the proposed grid connection infrastructure against the International Commission on Non-Ionizing Radiation Protection (ICNIRP) *Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields*.

[1] Sherpa's scope of work excludes assessment of existing and the potential for future land contamination.

2.3. Scope

The study scope includes the following project infrastructure:

- A 400 MW/1600 MWh BESS compound including battery enclosures and electrical conversion systems (e.g. inverters and transformers).
- An onsite substation, switch room and control room.
- An aboveground or underground transmission line connecting the BESS and the adjoining TransGrid Wellington 330 kV substation.
- An Operations & Management (O&M) building.
- Ancillary infrastructure (e.g. security fencing, access roads).

2.4. Exclusions and limitations

The study exclusions and limitations are summarised in Table 2.1.

Table 2.1: Exclusions and limitations

No.	Item	Exclusions and limitations
1	Design elements for the BESS	Design elements for the BESS may be subject to change prior to construction. Sherpa noted that the selection of the BESS supplier and layout of the BESS units will be finalised during detailed design. Detailed design will be conducted upon project approval.
2	Hazards associated with proposed operations	The PHA 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 assumed to be appropriate for assessment at the DA stage aimed to obtain approval for the project.
3	Indicative BESS layouts	Verification that the areas designated for the BESS would be sufficient for the proposed capacity, taking into account separation distances between BESS sub-units, was based on the nominated BESS design (i.e. make and model) adopted. One indicative BESS layout drawing reflecting the configuration was assessed. This is shown in Figure 8.1.
4	Bushfire hazard assessment	The PHA does not constitute a bushfire hazard assessment (outside of the study scope). Risk events associated with bushfire and the relevant controls (e.g. fire management plan) have been included in the PHA to demonstrate that this event has been considered.
5	Land contamination	The PHA excludes assessment of potential hazards and risks of land contamination for the project. A separate assessment is completed for the EIS in line with the requirement of Chapter 4 of the Resilience and Hazards SEPP.

No.	Item	Exclusions and limitations
6	Construction Safety Study	The PHA does not constitute a Construction Safety Study. Requirement for a Construction Safety Study will be subject to the conditions of consent of the project approval. For more information, refer to HIPAP No. 7 *Construction Safety*.
7	Fire Safety Study	The PHA does not constitute a Fire Safety Study. Requirement for a Fire Safety Study will be subject to the conditions of consent of the project approval. For more information, refer to HIPAP No. 2 *Fire Safety Study*.

3. FACILITY DESCRIPTION

3.1. Location and project site

The project will be located at 6945 Goolma Road, Montefiores NSW 2080, approximately 2 km north-east of Wellington, within the Dubbo Regional LGA. The project will be located within the Central-West Orana Renewable Energy Zone (REZ).

The project site covers an area of approximately 41 hectares. Of this, the development footprint[2] will occupy an area of approximately 14.8 hectares including the transmission line, access roads and bushfire Asset Protection Zone (APZ). The project site comprises privately owned farmland, and the development footprint would be subdivided and purchased by the proponent.

The location of the project site and indicative development footprint are shown in Figure 3.1 and Figure 3.2, respectively.

3.2. Surrounding land use

The project site is situated approximately 200 m south of the existing TransGrid Wellington substation. Also in the vicinity are the Wellington Solar Farm (in operation), the Wellington North Solar Farm (approval granted) and the Wellington South BESS (300 m east of the site; DA assessment underway).

The development footprint is zoned SP2 Infrastructure and RU1 Primary Production (intersecting the access track only) under the Dubbo Regional Local Environmental Plan 2022. While the site has been utilised predominantly for grazing, its zoning is appropriate for the project (i.e. BESS).

The nearest town centre is Wellington, located approximately 2 km south-west of the project site.

There are 10 residential dwellings within 1.5 km of the project. Of these, there are nine non-associated residential dwellings[3] (R1-R8, R10) and one associated residential dwelling (R9). These dwellings are located on rural properties outside of the Wellington township. The surrounding residential dwellings are visually presented in Figure 3.3.

[2] All areas that may be disturbed by the Project during construction, operation and decommissioning (including all activities, including temporary and permanent impact areas). This is considered a 'worst case' generous delineation to allow required flexibility, during detailed design.

[3] Residential dwellings that are not associated with the project.

Figure 3.1: Project site location

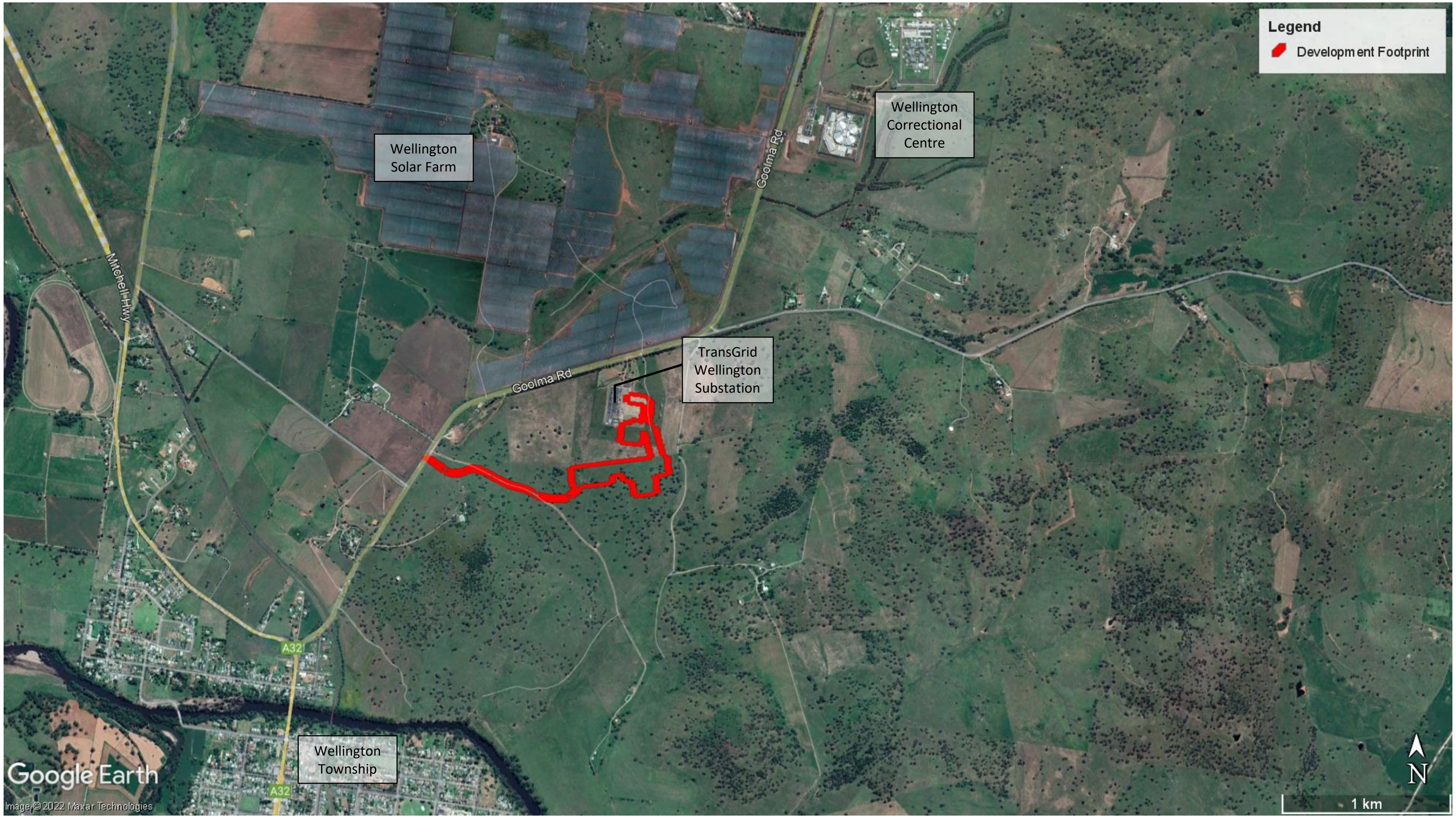


Figure 3.2: Indicative development footprint and infrastructure layout

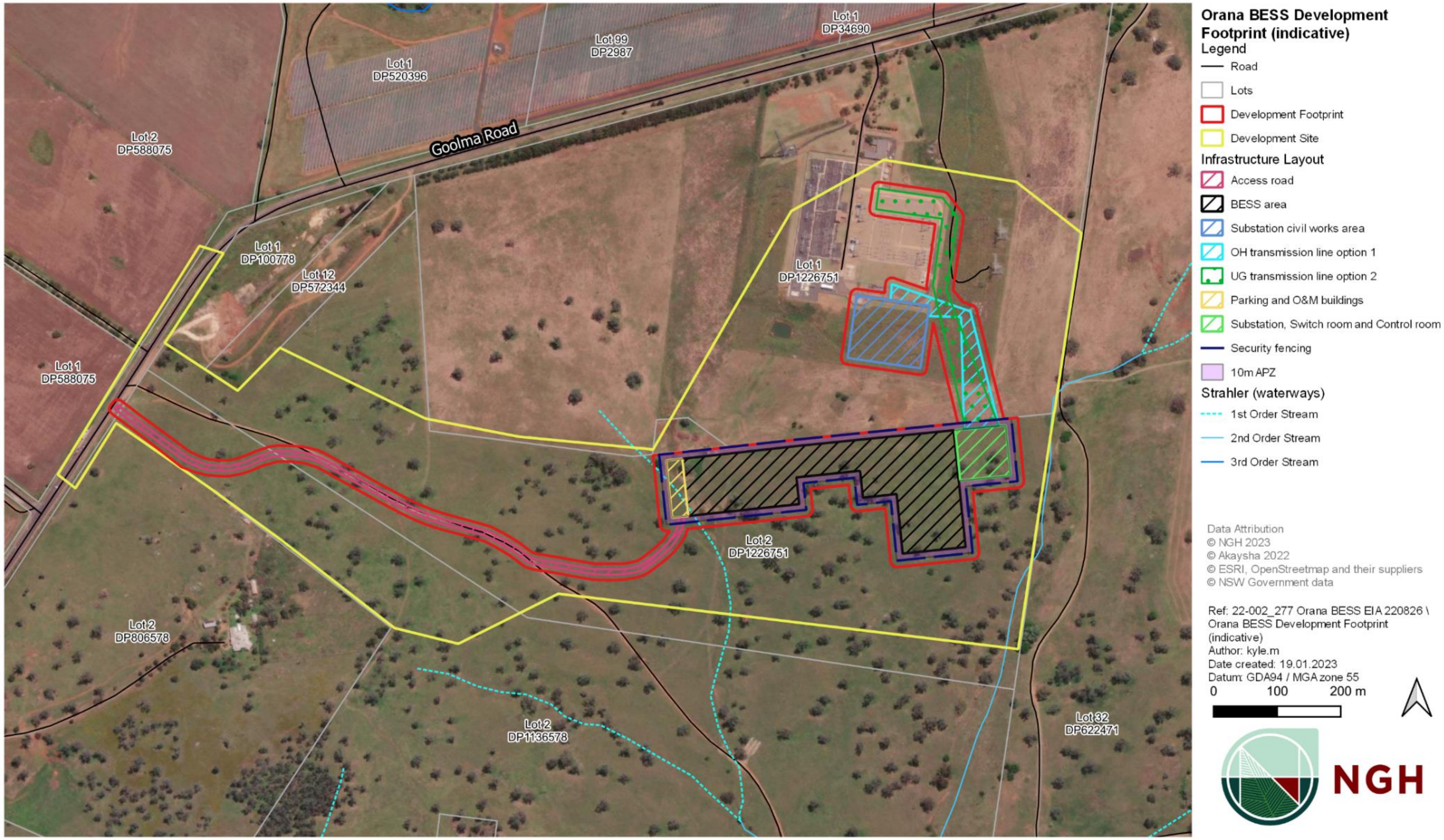


Figure 3.3: Residential dwellings in the surrounding area

3.3. Project key infrastructure

3.3.1. Battery Energy Storage System

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

The BESS would store excess energy during peak production periods to later transmit into the grid when required (e.g. peak demand periods) and support stabilising the supply of electricity to the National Electricity Market (NEM). Indicatively for this project, the proposed BESS will have a capacity of up to 400 MW/1600 MWh and make use of lithium-ion technology.

At the time of this study, Sherpa was advised by Akaysha Energy that the conceptual design for the project is based on the Powin battery system. Assessment made in this study was based on the use of the Powin's Centipede battery energy storage platform; a fully modular design, complete with pre-integrated segments containing batteries, thermal management equipment, and essential safety systems, Ref [3].

The Powin Centipede platform including its major equipment and features are shown in Figure 3.4. Major components and specific features of the battery system are described in Table 3.1, Ref [4]. The concept BESS layout is provided in Figure 8.1.

The selection of the BESS supplier and layout of the BESS units within the development footprint will be finalised during detailed design. Detailed design will be conducted upon project approval. The following were assumed for the PHA:

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

Figure 3.4: Powin Centipede Platform with Stack750E

(a) Illustration of multiple centipede segments

(b) Overview of components for each centipede segment

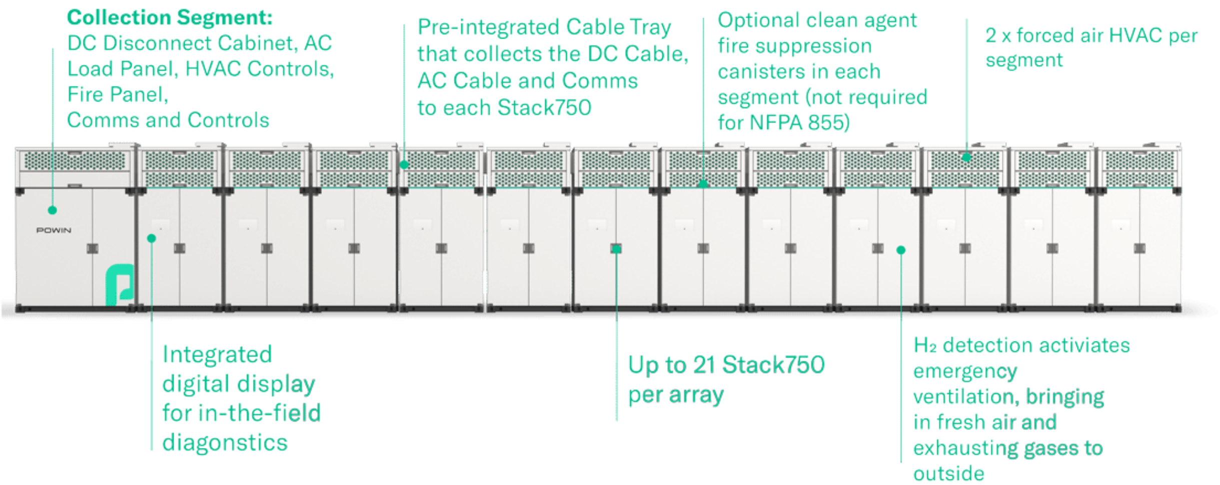


Table 3.1: BESS components

Component	Description
Overview	The Centipede battery energy storage platform is a modular BESS which integrates batteries, power distribution, thermal management and safety systems. It is a turnkey product solution by Powin, LLC. The Centipede platform utilises Powin's Stack750E hardware (pre-assembled and pre-tested modular battery stacks enclosed in outdoor rated enclosures) and StackOS software platform.
Enclosure	The enclosure for Stack 750E is rated to NEMA 4 and IP 56, suited for outdoor use. The dimension of each stack is approximately (D) 2.5 m x (W) 1.6 m x (H) 3.4 m.
Battery system	Stack750E utilises Lithium Iron Phosphate (LFP) battery cells, manufactured by CATL and EVE. Each centipede segment: • Comprises up to 21 units of Stack750E. • Connects to a DC collection segment that is joined to the start of the segment. • Connects to a single Power Conversion System (PCS) with multiple inverter modules. The PCS dimension will be (D) 1.7 m x (W) 5.3 m x (H) 2.5 m. The BESS configuration for the project (Figure 8.1) will be as follows: • There will be 69 centipede arrays. • Each array consists of two centipede segments (18 units of Stack750E per segment), with two PCS connected to one 7.3 MVA Medium Voltage (MV) transformer for stepping up to 33 kV. • MV transformers are grouped via ring main units, from which 33 kV cables connect to the 33 kV switchroom. For the proposed capacity, it is anticipated that there will be 2484 BESS stacks, 69 MV transformers and 12 ring main units.
Battery Management System (BMS)	Powin's BESS utilises StackOS which includes an all-encompassing: • 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). • Energy Management System (EMS): the interface between the BESS, its operators and the grid, providing full control and visibility of all the system components through the Command Center User Interface (UI). • Thermal Management System (TMS): which constantly monitors individual cell statuses and uses algorithmic control of Heating, Ventilation and Air Conditioning (HVAC) units and stack level fans to optimize the thermal performance of the system. These monitoring systems include (1) telemetry reporting to the onsite control room and off-site operations and maintenance facility, and (2) manual and automated safety protection systems e.g. power shut down and disconnection.

Component	Description
Heating and cooling	Two forced-air HVAC units with humidity control are provided for each Centipede segment.
Fire suppression system	The fire suppression system includes: • Addressable fire panel • Smoke & heat detectors • Heat activated sprinkler system with remote Fire Department Connection (FDC) dry standpipe connection • Fire rated insulation • Strobes and horn • Optional clean agent fire suppression cannisters for each segment.
Explosion prevention and mitigation system	Off-gas detection (hydrogen) with dedicated, fail-safe active and passive ventilation systems (i.e. bringing in fresh air and exhausting gases to outside).
Codes and compliance	The Centipede platform is compliant with the following standards and codes[4], Ref [4]: • UL 1642 – Standard for Lithium Batteries • UL 1973 – Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail Applications • UL 9540 – Standard for Energy Storage Systems and Equipment • UL 9540A – Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems • NFPA 1 – Fire Code • NFPA 69 – Standard on Explosion Prevention Systems • NFPA 855 – Standard for the Installation of Stationary Energy Storage Systems • IEC 62619 – Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications • IEC 6100-6-2 – Electromagnetic compatibility - Part 6-2: Generic standards - Immunity standard for industrial environments • IEC 62477 – Safety requirements for power electronic converter systems and equipment • UN3480 – Transporting lithium batteries • UN38.3 – Certification for Lithium Batteries

[4] The specific release edition or revision was not included in the datasheet. Sherpa assumed that the BESS will be compliant with the latest edition of these Standards and Codes.

3.3.2. BESS substation and grid connection

A switchyard and an onsite BESS substation will be established to convert electricity between the BESS (33 kV) and the TransGrid substation (330 kV). The BESS will connect to the BESS substation via underground or above ground 33 kV cables.

The project is proposing to connect into the adjoining TransGrid Wellington substation via a new underground or overhead transmission line. Options include:

- Option 1: A 330 kV overhead line from the BESS to the southern portion of the Wellington Substation. This option includes two 45 m tall transmission poles with a 60 m wide clear easement corridor.
- Option 2: A 330 kV underground line from the BESS to the northern portion of the Wellington substation. This option would include a 20 m wide cable corridor.

To facilitate this connection, the required upgrade works within the TransGrid site will include:

- Minor expansion beyond the current yard to extend the 330 kV bus bar and provision of additional 330 kV connection bays.
- Provision of 330 kV/33 kV power transformers connecting the BESS to the TransGrid substation.
- Provision of a connection tower (approximately 40-50 m high) on the TransGrid connection point.

3.3.3. Supporting infrastructure

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

1. Access road from Goolma Road and parking facility.
2. O&M building.
3. Control room.
4. Electrical switch room.
5. Security fencing around the perimeter with Closed Circuit Television (CCTV) cameras.
6. Fire water tank(s) providing supply to fire water ring mains and fire hydrants around the BESS.

The control room and switch room will be located within the same compound as the BESS substation.

3.4. Construction

Construction is expected to take approximately 9-12 months and would involve the following activities:

- Construction of concrete hardstands
- Construction of internal access tracks
- Delivery of infrastructure components to the site
- Assembly of the BESS containerised units and associated 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.

3.5. Operations

The expected project operational life is approximately 40 years.

The BESS will operate 24 hours per day, seven days per week, 365 days per year and will be normally unmanned (i.e. remote operation).

During the operations phase, there will be up to 4 staff members to support ongoing operations and maintenance activities.

3.6. Decommissioning

Once the project reaches the end of its operational life, the project infrastructure will be decommissioned.

Decommissioning would involve removal of all built infrastructure from site and the site would be rehabilitated to a safe, stable and non-polluting state, consistent with future land use requirements.

4. PRELIMINARY RISK SCREENING

4.1. Overview

The objective of the preliminary risk screening was to determine whether the proposed development is considered as 'potentially hazardous' in the context of *SEPP (Resilience and Hazards) 2021*.

SEPP (Resilience and Hazards) 2021, Ref [5], defines potentially hazardous industry as follows:

> 'Potentially hazardous industry' means a development for the purposes of any industry which, if the development were to operate without employing any measures (including, for example, isolation from existing or likely future development on other land) to reduce or minimise its impact in the locality or on the existing or likely future development on other land, would pose a significant risk in relation to the locality:
>
> (a) to human health, life or property, or
>
> (b) to the biophysical environment,
>
> and includes a hazardous industry and a hazardous storage establishment.

Development proposals that are classified as 'potentially hazardous' industry must undergo a PHA as per the requirements set in HIPAP No. 6 *Guidelines for Hazard Analysis*, Ref [6], to determine the risk to people, property and the environment. If the residual risk exceeds the acceptability criteria, the development is considered as a 'hazardous industry' and may not be permissible within NSW.

To determine whether a proposed development is potentially hazardous, the NSW Department of Planning and Environment (DPE) *Applying SEPP 33* guideline[5], Ref [7], is used to undertake the risk screening process. The risk screening process considers the type and quantity of hazardous materials to be stored on site, distance of the storage area to the nearest site boundary, as well as the expected number of transport movements.

'Hazardous materials' are defined within the guideline as substances that fall within the classification of the Australian Dangerous Goods Code (ADGC), i.e. have a Dangerous Goods (DG) classification. Detail of the DG classification is typically obtained from the materials' Safety Data Sheet (SDS).

The *Applying SEPP 33* guideline is based on the 7th edition of ADGC, Ref [8], and refers to hazardous chemicals by their DG classification. Risk screening is undertaken by comparing the storage quantity and the number of road movements of the hazardous materials with the screening threshold specified in the guideline. The screening threshold presents the quantities below which it can be assumed that significant off-site risk is unlikely.

[5] SEPP No. 33 *Hazardous and Offensive Development* has been consolidated into SEPP (Resilience and Hazards). It now forms Chapter 3 of the Resilience and Hazards SEPP. The SEPP states that supporting documents such as *Applying SEPP 33* should still be followed.

4.2. Risk screening

A summary of the expected hazardous materials to be stored and handled on site for the project, transport movements and the relevant SEPP screening threshold is presented in Table 4.1.

Other materials considered as part of the SEPP risk screening include transformer oil and herbicide/pesticide. Generally, these are not classified as dangerous goods and are excluded from the risk screening. Additionally, these materials will not be stored with other flammable materials and hence not considered to be potentially hazardous under the SEPP. The Powin BESS utilises forced-air HVAC system (i.e. non DG) and also excluded from the risk screening.

4.3. Other risk factors

Appendix 2 of *Applying SEPP 33* outlines other risk factors for consideration to identify hazards outside the scope of the risk screening method.

A review of these risk factors was completed, and it was noted that the project would <u>not</u> involve:

- Storage or transport of incompatible materials (i.e. hazardous and non-hazardous). Hazardous materials will be stored in dedicated areas and storage protocols in accordance with standard and guidelines will be followed.
- Generation of hazardous waste.
- Possible generation of dusts within confined areas.
- Type of activities involving the hazardous materials with potential to cause significant off-site impacts.
- Incompatible, reactive or unstable materials and process conditions that could lead to uncontrolled reaction or decomposition.
- Storage or processing operations involving high (or extremely low) temperature and/or pressures.
- Hazardous materials and processes with known past incidents (or near misses) that resulted in significant off-site impacts at similar BESS developments.

4.4. Industries that may fall within the Resilience and Hazards SEPP

Appendix 3 of *Applying SEPP 33* provides a list of industries that may be potentially hazardous. It is noted that this list is illustrative rather than exhaustive. The current edition of the guideline does not include BESS facilities in the example industry listings that may fall within the Resilience and Hazards SEPP or considered as potentially hazardous.

Table 4.1: Preliminary risk screening summary

Material	DG Class	Category	Storage threshold	Transport threshold		Project storage quantities and applicable SEPP screening	Exceed threshold?
				Movements	Quantities		
Gasoline	3 PG II	Flammable liquids	5 tonnes	>750 (annual) >45 (weekly)	3-10 tonnes	Minor quantity to be stored on site not exceeding threshold. Number of movements will not be exceeded based on the amount stored on site.	No
Diesel	C1	Combustible liquids	N/A	N/A	N/A	No applicable SEPP screening threshold	No
BESS battery (Lithium ion)	9	Miscellaneous dangerous goods	N/A	>1000 (annual) >60 (weekly)	No limit	No applicable SEPP screening threshold and excluded from risk screening. Transport movement threshold will not be exceeded. Movements are expected to occur during construction only and minimal during operation and maintenance (e.g. battery replacement).	No
StatX fire suppression agent (part of the Stack750E)	9	Miscellaneous dangerous goods	N/A	>1000 (annual) >60 (weekly)	No limit	No applicable SEPP screening threshold and excluded from risk screening. Transport movement threshold will not be exceeded. Movements are expected to occur during construction only and minimal during operation and maintenance (e.g. battery replacement).	No

4.5. Conclusions

The preliminary risk screening found that the project is not considered as 'potentially hazardous' within the meaning of Resilience and Hazards SEPP and does not require a PHA.

The main findings of the preliminary risk screening are summarised as follows:

- The storage and transport of hazardous materials for the project will not exceed the relevant risk screening threshold.
- There are no other risk factors identified that could result in significant off-site impacts.
- The project is not considered as 'potentially hazardous' with respect to DG storage and transportation and does not require a PHA.

5. HAZARDS AND RISK ASSESSMENT

5.1. Overview

Notwithstanding the outcome of the preliminary risk screening, the *Hazards* assessment requirements of the SEARs require (1) a PHA and (2) an assessment of hazards and risks for the project to be undertaken. The objective of these assessments was to identify the hazards and assess the risks associated with the project at the planning stage of the DA and determine risk acceptability from a land use safety planning perspective.

To address the above requirements, a PHA was completed following the methodology specified in HIPAP No. 6 *Guidelines for Hazard Analysis*, Ref [6], which is focused on off-site impacts.

The HIPAP No. 6 methodology included the following steps:

1. Establishment of the study context.
2. Identification of hazards resulting from the project operations 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). At the DA stage, the PHA is focused on the risk to surrounding land uses (i.e. off-site impacts) and assesses if the development is appropriate for the location.

The development footprint boundary was used to define and determine off-site impact (i.e. impact extending outside of the development footprint boundary). Off-site impact was determined based on potential to impact sensitive receptors (i.e. non-associated residential dwellings).

5.2. Level of analysis

The 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 5.1. 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 5.1: 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.

5.3. 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 5.1).

6. HAZARD IDENTIFICATION

6.1. 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 system product datasheet, Ref [4], emergency response guide, Ref [1], and fire and off-gas emergency procedure, Ref [11], 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 [12].
3. Literature research of past incidents involving similar BESS systems.
4. Previous risk assessments for similar BESS systems completed by Sherpa.
5. Consultation and feedback from Akaysha Energy for review and acceptance.

6.2. Identified hazards and events

The following factors were considered to identify the hazards:

- BESS component and type of equipment.
- Hazardous substances/DG present.
- Proposed operation and maintenance activities.
- BESS incident history
- 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 types of hazards and associated events considered were informed from AS/NZS 5139. The identified hazards and events are presented in Table 6.1.

Table 6.1: Identified hazards and events

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

In this study, bushfire was considered as a cause of fire resulting from encroachment of an off-site bushfire impacting the BESS. A bushfire assessment was completed for the project as part of the EIS. Identified controls have been referenced in this study (i.e. APZ requirement, fire management plan), where applicable.

A summary of the hazard present at/applicable to the BESS is provided in Table 6.2.

Table 6.2: Hazards by BESS component

	BESS Components			
Hazard	**Battery modules**	**BMS**	**Thermal management system/HVAC**	**PCS (inverters)**
Electrical	✓	✓	-	✓
Energy (arc flash)	✓	✓	-	✓
Fire	✓	✓	✓	✓
Chemical	✓	✓	✓	-
Explosive gas	✓	-	✓	-
Reaction	✓	-	-	-
EMF	✓	✓	-	✓
External factors	✓	✓	✓	✓

6.3. 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 7.

6.4. Separation distances to off-site receptors

To inform whether the consequence of a hazardous event has the potential to impact off-site receptors, separation distances from the development footprint boundary to the nearest non-associated residential dwellings were reviewed. This review is provided in Section 8.

6.5. HAZID register

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

The HAZID register is provided in Table 6.3. The findings are as follows:

- A total of 12 hazardous events were identified.
- The proposed BESS is located approximately 12 m from its closest point to the development footprint 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, the consequences from these events are not expected to result in significant off-site impacts (serious injury and/or fatality to the public or off-site population) as:
    - The BESS will be situated in a rural area.
    - The nearest non-associated residential dwelling is located approximately 680 m from the proposed BESS (R1).

Table 6.3: HAZID register

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
1.	Electrical	Battery modules BMS PCS (inverters, transformers)	Exposure to voltage	<u>Short circuit/electrical connection failure</u> - Faulty equipment - Incorrect installation - Incorrect maintenance - Human error during maintenance - Safety device/circuit compromised - Battery casing/enclosure damage <u>Earth potential rise (exposure to step and touch potentials)</u> - Electrical faults	- Electrocution - Injury and/or fatality to on-site 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 off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Decisive Voltage Classification (DVC) followed and equipment marked accordingly - Warning signs (electrical hazards, arc flash) - Engagement of reputable contractors - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - Independent certifiers/owner's engineers - Electrical switch-in & switch-out protocol - Stack-level fusing and automatic disconnection prevents electrical faults from propagating and minimize arc flash potential - BESS BMS fault detection and safety shut-off - Earthing study (mitigate touch and step potentials) - Earthing as per manufacturer and standards requirements - Perimeter fence with signage (warning of electrical hazard) - Emergency Response Plan - External firefighting assistance (FRNSW & RFS) - Use of appropriate PPE - Rescue kits (i.e. insulated hooks)	-	No
2.	Energy	Battery modules BMS PCS (inverters, transformers)	Arc flash	- Incorrect procedure (i.e. installation/ maintenance) - Faulty equipment (e.g. corrosion on conductors) - Faulty design - Human error during maintenance - Insufficient isolation/insulation to applied voltage - Mechanical damage - Vibration	- Arc blasts and resulting heat, may result in fires and pressure waves - Burns - Exposure to intense light and noise - Injury and/or fatality to on-site employees Localised effects, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Warning signs (arc flash boundary) - Engagement of reputable contractors - Installation, operations and maintenance will be undertaken by trained personnel in accordance with relevant procedures - Independent certifiers/owner's engineers - Site induction and training (i.e. high voltage areas) - Maintenance procedure (e.g. de-energize equipment) - Preventative maintenance (insulation) - Electrical switch-in & switch-out protocol - Stack-level fusing and automatic disconnection prevents electrical faults from propagating and minimize arc flash potential - 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 off-site Impact?
3.	Fire	Battery modules BMS HVAC PCS (inverters, transformers)	BESS fire	- Faulty equipment - Arc flash - Mechanical damage or failure of battery case (e.g. overload, insulation breakdown, connection failures) - Battery thermal runaway (e.g. short circuit, overheating, overcharge) - External fire (e.g. Substation fire) - Bushfire (e.g. encroachment of off-site bushfire, escalated event due to fire from other project infrastructure)	- Release of toxic and/or explosive combustion products - Escalation to the entire BESS - Injury and/or fatality to on-site employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - All relevant TransGrid's requirements for the substation will be met - Electrical switch-in & switch-out protocol at the substation - Circuit breakers provided for the substation - Substation is locked with security fence - Each battery cell includes a rigid aluminium exterior providing an added degree of protection against external impacts - Battery modules are isolated from each other by steel barriers which act as structural members of the racking system and de facto thermal barriers between modules - To minimise escalation between sub-units or other structures, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Preventative maintenance (e.g. insulation, replacement of faulty equipment) - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 3.1) - Activation of emergency shutdown - Fire Management Plan (e.g. establishing defendable fire-fighting boundary) - Emergency Response Plan - Inclusion of APZ buffer to minimise bushfire encroachment - External firefighting assistance (FRNSW & RFS)	-	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
4.	Chemical	Battery modules BMS HVAC	Release of electrolyte (liquid/ vented gas) from the battery cell	<u>Mechanical failure/damage</u> - Dropped impact (e.g. during installation/ maintenance) - Damage (e.g. crush/ penetration/puncture) <u>Abnormal heating/elevated temperature</u> - Thermal runaway - Bushfire - External fire (e.g. Main Substation)	- Release of flammable liquid electrolyte - Vaporisation of liquid electrolyte - Release of vented gas from cells - Fire and/or explosion in battery enclosure - Release of toxic combustion products - - Injury and/or fatality to on-site employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - Each battery cell includes a rigid aluminium exterior providing an added degree of protection against external impacts - Battery modules are isolated from each other by steel barriers which act as structural members of the racking system and de facto thermal barriers between modules. These modules are enclosed by an IP 21 steel enclosure - Each enclosure has the capacity to contain liquid from a large number of cells should there be a leak involving multiple cells - Spill clean-up using dry absorbent material - To minimise escalation between sub-units or other structures, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Venting and containment requirements of the BESS manufacturer to be followed - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 3.1)Fire breaks to minimise bushfire encroachment - Activation of emergency shutdown - Fire Management Plan (e.g. establishing defendable fire-fighting boundary) - Emergency Response Plan - Inclusion of APZ buffer - External firefighting assistance (FRNSW & RFS)	Vented gases are early indicator of a thermal runaway reaction	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
5.	Chemical	Battery modules BMS HVAC	BESS coolant or refrigerant leak	- Mechanical failure/damage - Incorrect maintenance	- Irritation/injury to onsite employee on exposure to leak (e.g. inhalation and skin contact) - Ingress of coolant or refrigerant to battery or other electrical components (battery enclosure) leading to short circuit, thermal runaway and fire/explosion, resulting in injury and/or fatality to onsite employees. As the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with relevant international and/or Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - Battery modules are isolated from each other by steel barriers which act as structural members of the racking system and de facto thermal barriers between modules. These modules are enclosed by an IP 21 steel enclosure. - To minimise escalation between sub-units or other structures, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 3.1) - Activation of emergency shutdown - Fire Management Plan (e.g. establishing defendable fire-fighting boundary) - Emergency Response Plan - Inclusion of APZ buffer - External firefighting assistance (FRNSW & RFS)	-	No[6]

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

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
6.	Explosive Gas	Battery modules	Generation of explosive gas (e.g. hydrogen) <u>Note</u>: also refer to above item (release of vented gas)	- Thermal runaway - Bushfire - External fire (e.g. substation fire, fire from adjacent infrastructure)	- Fire and/or explosion in battery enclosure - Release of toxic combustion products - Injury and/or fatality to on-site employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with the relevant international and Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - Battery modules are isolated from each other by steel barriers which act as structural members of the racking system and de facto thermal barriers between modules - To minimise escalation between sub-units or other structures, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - Ventilation requirements as per manufacturer's instruction - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 3.1) - Activation of emergency shutdown - Fire Management Plan (e.g. establishing defendable fire-fighting boundary) - Emergency Response Plan - Inclusion of APZ buffer - External firefighting assistance (FRNSW & RFS)		No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
7.	Reaction	Battery modules	Thermal runaway in battery	Elevated temperature - Bushfire - External fire (e.g. Main Substation) Electrical failure - Short circuit - Excessive current/voltage - Imbalance charge across cells Mechanical failure - Internal cell defect - Damage (crush/ penetration/puncture) Systems failure - BMS failure - Thermal management system/HVAC failure	- Fire and/or explosion in battery enclosure - Escalation to the entire BESS - Injury and/or fatality to on-site employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an off-site impact.	- Equipment and systems will be designed and tested to comply with the relevant international and Australian standards (e.g. AS/NZS 5139) and guidelines - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - Installation, operations and maintenance by trained personnel in accordance with relevant procedures - Each battery cell includes a rigid aluminium exterior providing an added degree of protection against external impacts - Battery modules are isolated from each other by steel barriers which act as structural members of the racking system and de facto thermal barriers between modules - 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 - Thermal management system - BESS BMS temperature monitoring, fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 3.1) - Activation of emergency shutdown - Fire Management Plan (e.g. establishing defendable fire-fighting boundary) - Emergency Response Plan - Fire breaks to minimise bushfire encroachment - External firefighting assistance (FRNSW & RFS)	Thermal runaway refers to a cycle in which excessive heat, initiated from inside/outside the battery cell, keeps generating more heat. Chemical reactions inside the cell in turn generate additional heat until there are no reactive agents left in the cell and eventually lead to destruction of the battery. Vented gases are early indicator of a thermal runaway reaction.	No
8.	EMF	BESS (overall)	Exposure to electric and magnetic fields	Operations of energy storage system and associated equipment	- High level exposure (i.e. exceeding the reference limits) may affect function of the nervous system (i.e. direct stimulation of nerve and muscle tissue and the induction of retinal phosphenes) - Injury to on-site employees EMF created from the BESS will not exceed the ICNIRP reference level for exposure to the general public. Additionally, the strengths of electric and magnetic fields attenuate rapidly away from the source. As the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an off-site impact.	- Location siting and selection (i.e. separation distance to sensitive receptors) - Optimising equipment layout and orientation - Reducing conductor spacing - Balancing phases and minimising residual current - Incidental shielding (i.e. BESS enclosure) - Equipment and systems will be designed and tested to comply with international standards and guidelines - Exposure to personnel is short duration in nature (transient) - Warning signs - Studies found that the EMF for commercial power generation facilities comply with ICNIRP occupational exposure limits	Adverse health effects from EMF have not been established based on findings of science reviews conducted by credible authorities, Ref [13]. No established evidence that Extremely Low Frequency (ELF) EMF is associated with long term health effects (ARPANSA) , Ref [14].	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
9.	External factors	BESS (overall)	Fire	Water ingress (e.g. rain, flood)	- Electrical fault/short circuit - Fire and/or explosion in battery enclosure - Injury and/or fatality to on-site employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an off-site impact.	- Location siting (i.e. outside of flood prone area) - BESS will be housed in dedicated enclosure. which will be constructed in accordance with relevant standards - The enclosure for Stack750E is rated to NEMA 4 and IP 56 suitable for outdoor use - Substation and switch room will be housed in a dedicated building and constructed in accordance with relevant standards - Drainage system - Preventative maintenance (check for leaks) - Battery modules are isolated from each other by steel barriers which act as structural members of the racking system and de facto thermal barriers between modules - To minimise escalation between sub-units or other structures, the BESS configurations will follow the specified clearances required by the manufacturer and/or applicable standards - BESS BMS fault detection and shut-off function - BESS fire and explosion protection system (battery system specific features, refer to Table 3.1) - Activation of emergency shutdown - Fire Management Plan (e.g. establishing defendable fire-fighting boundary) - Emergency Response Plan - Inclusion of APZ buffer - External firefighting assistance (FRNSW & RFS)	-	No
10.	External factors	BESS (overall)	Vandalism	Unauthorised personnel access Trespassing Deliberate damage to BESS infrastructure	- Asset damage - BESS failure/fire - Potential hazard to unauthorised person (e.g. electrocution) - Injury and/or fatality to trespasser Effects to unauthorised person are expected to be localised and not expected to have an off-site impact. The impact is to a member of public but occurs on-site. For a fire event, the effects are not expected to have an off-site impact as the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling,	- The BESS will be located in a rural location - The BESS area will be fenced - Warning signs (i.e. trespassers and on-site hazards) - Security cameras will be provided at the Substation and in vicinity of the BESS. - On-site security protocol - Presence of staff during operational hours	-	No

ID	Hazard	BESS component/ infrastructure	Event	Cause	Consequence	Controls	Other Comments	Significant off-site Impact?
11.	External factors	BESS (overall)	Lightning strike	Lightning storm	- Fire - Injury and/or fatality to on-site employees As the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an off-site impact.	- Lightning protection mast - Earthing as per manufacturer and standards requirements - Activation of emergency shutdown - Battery modules are isolated from each other by steel barriers which act as structural members of the racking system and de facto thermal barriers between modules - 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 - Fire Management Plan (e.g. establishing defendable fire-fighting boundary) - Emergency Response Plan - Inclusion of APZ buffer - External firefighting assistance (FRNSW & RFS)	-	No
12.	Escalation to onsite substation	BESS (overall)	Escalation from the BESS to adjacent on-site substation	BESS fire	Escalation to adjacent substation resulting in potential off-site impacts As the BESS and substation will be situated in a rural area and there is a large separation distance to the nearest residential dwelling, the effects are not expected to have an off-site impact.	- Battery modules are isolated from each other by steel barriers which act as structural members of the racking system and de facto thermal barriers between modules - 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 - The closest separation distance between the BESS and the TransGrid substation (civil works area boundary associated with upgrade work to be undertaken as part of the project) is approximately 150 m - BESS fire and explosion protection system (battery system specific features, refer to Table 3.1) - Activation of emergency shutdown - Fire Management Plan (e.g. establishing defendable fire-fighting boundary) - Emergency Response Plan - Fire breaks to minimise bushfire encroachment (inclusion of APZ buffer) - External firefighting assistance (FRNSW & RFS)	Separation distance between the BESS and the BESS substation is not known at this stage of the project. The BESS substation will be located within the allocated area for the “Substation, control room and switch room”. However, the location of the substation within this area has not been finalised at this stage of the project.	No

7. ELECTRIC AND MAGNETIC FIELDS

7.1. 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 [15].

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

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

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

Use of electricity means that people are exposed to EMF as part of daily life. The background electric and magnetic fields in a typical home is around 20 V/m and 0.1 µT, respectively. These may vary depending on the number and type of appliances, configuration and positioning and distances to the other sources (e.g. powerlines). Typical EMF strengths for common household electrical appliances (at distance of 30 cm) are shown in Table 7.1, Ref [16].

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[7] as Extremely Low Frequency[8] (ELF) EMF, Ref [15].

Table 7.1: 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

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

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

7.2. Effects of exposure to EMF

7.2.1. 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 [17].

7.2.2. Chronic effect

Numerous studies have been conducted to understand the effects of long-term exposure to EMF. Some studies have linked prolonged exposure to 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 [17].

7.2.3. Advice from public authority

The 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.

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.”,* Ref [14].
- *“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.”,* Ref [18].

7.3. Study approach

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

A task group assembled by the World Health Organisation to assess any potential health risks from exposure to ELF EMF in the frequency range of 0 to 100,000 Hz found that there are no substantive health issues related to ELF electric fields at levels generally encountered by the general public, Ref [19]. Therefore, the information presented in the following sections address predominantly the effects of exposure to ELF magnetic fields.

7.4. 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 7.2, Ref [17]. The guideline adopted more stringent exposure restrictions compared to occupational exposures recognising that in many cases the general public are unaware of their exposure to EMF.

Table 7.2: 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

7.5. BESS and grid connection infrastructure EMF

7.5.1. BESS

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

7.5.2. PCS

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 [20].

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 m 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.

7.5.3. Substation and grid connection

The 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 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 [21].

7.5.4. Transmission lines

The magnetic field from transmission lines will vary with configuration, phasing and load. The typical magnetic fields near overhead transmission lines measured at one metre above ground level range between 1-20 µT (directly underneath) and 0.2-5 µT (at the edge of easement), Ref [21].

7.6. 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.

7.7. 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 10.2.

8. BESS SEPARATION DISTANCES

8.1. Overview

As per the project SEARs, the PHA also includes a requirement to '*consider all recent standards and codes'* and *'demonstrate that the separation distances between the BESS to onsite or off-site receptors and the separation distances between BESS sub-units prevent fire propagation'*.

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

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

This section covers the following:

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

8.2. Separation distances between BESS sub-units

8.2.1. NFPA 855

The National Fire Protection Agency (NFPA) 855 *Standard for the Installation of Stationary Energy Storage Systems* is widely viewed as the most comprehensive set of best practice guide in the industry. A review of NFPA 855 was undertaken to determine the required separation distances between the BESS units, Ref [22].

NFPA 855 specifies the default maximum allowable energy storage unit at 50 kWh (and 600 kWh for the overall BESS installation) and minimum separation of 914 mm between units and walls (for indoor installations). However, NFPA 855 also specifies that the BESS may be installed in units with larger energy capacities or smaller separation if they meet the fire and explosion testing in accordance with UL 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*, or equivalent test standard. As such, the results of the UL 9540A test (performed with clearances as specified by the BESS manufacturer) form a key parameter to determine clearances.

The UL 9540A testing is a destructive test method used for evaluating the thermal runaway impacts in a BESS and gathering data to assist in assessing or developing mitigation measures for the failure event, propagation of the failure, or consequences of an event, such as an explosion or fire. It is currently considered to be the most appropriate published methodology to provide comprehensive, consistent, and reliable data for battery failure testing.

The Powin Stack750E product datasheet indicates that it is compliant with UL 9540A, Ref [4]. Based on information obtained, Sherpa noted that:

- Powin's website, Ref [3]

  "Throughout the development of the Centipede's development, Powin worked with an independent testing firm, Energy Safety Response Group (ESRG), to validate the efficacy of safety systems above and beyond the required UL testing for energy storage systems. In November 2021, ESRG completed a large-scale test of Stack750E that simulated a complete failure of all active safety measures during an intentionally induced fire. The results were conclusive, showing that fire does not propagate from one Stack750E to another and that explosion risk in adjacent Stacks exposed to the fire is effectively mitigated."

- Powin's lithium-ion battery emergency response guide, Ref [1]

  "Testing to UL test methods has demonstrated that a single cell thermal runaway does not propagate to neighboring cells. In addition, modules are also isolated from each other by steel barriers which act as structural members and de facto thermal barriers. All internal and UL testing to date demonstrates these thermal barriers effectively stop thermal runaway from propagating from module to module."

8.2.2. Manufacturer specified clearances

The concept BESS layout and clearances between the units are shown in Figure 8.1 and

Figure 8.2, respectively. At the time of this study, the installation manual for the Centipede platform or Stack750E was not available to Sherpa. Therefore, Sherpa was unable to verify the manufacturer specified clearances (e.g. side-to-side, back-to-back installation, etc). Sherpa assumed that the clearances included in

Figure 8.2 reflect the manufacturer's specified clearances.

Figure 8.1: Concept BESS layout

(Reproduced from the preliminary layout drawing AKE-LAY-001 Rev 1.1 with Akaysha markup)

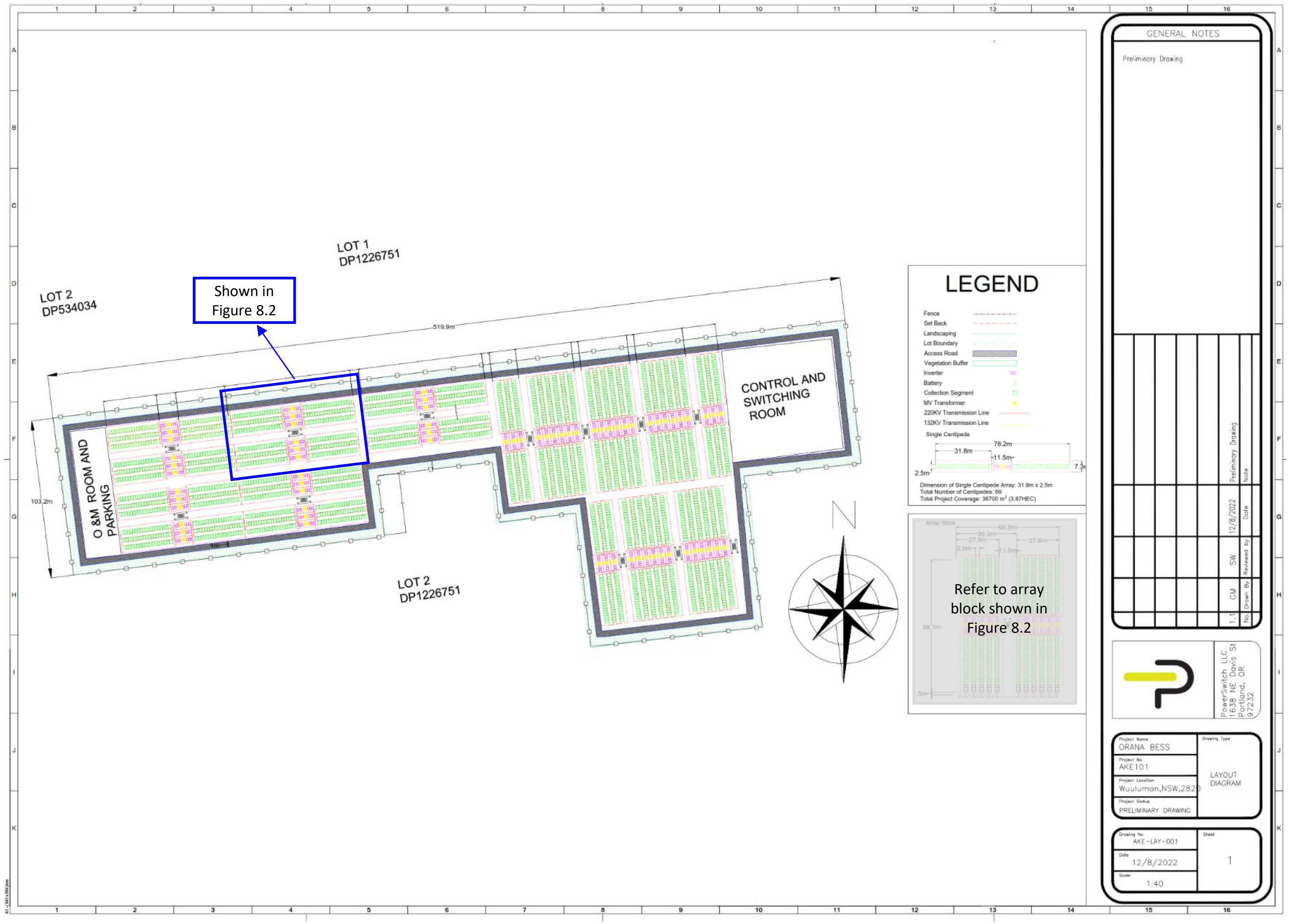
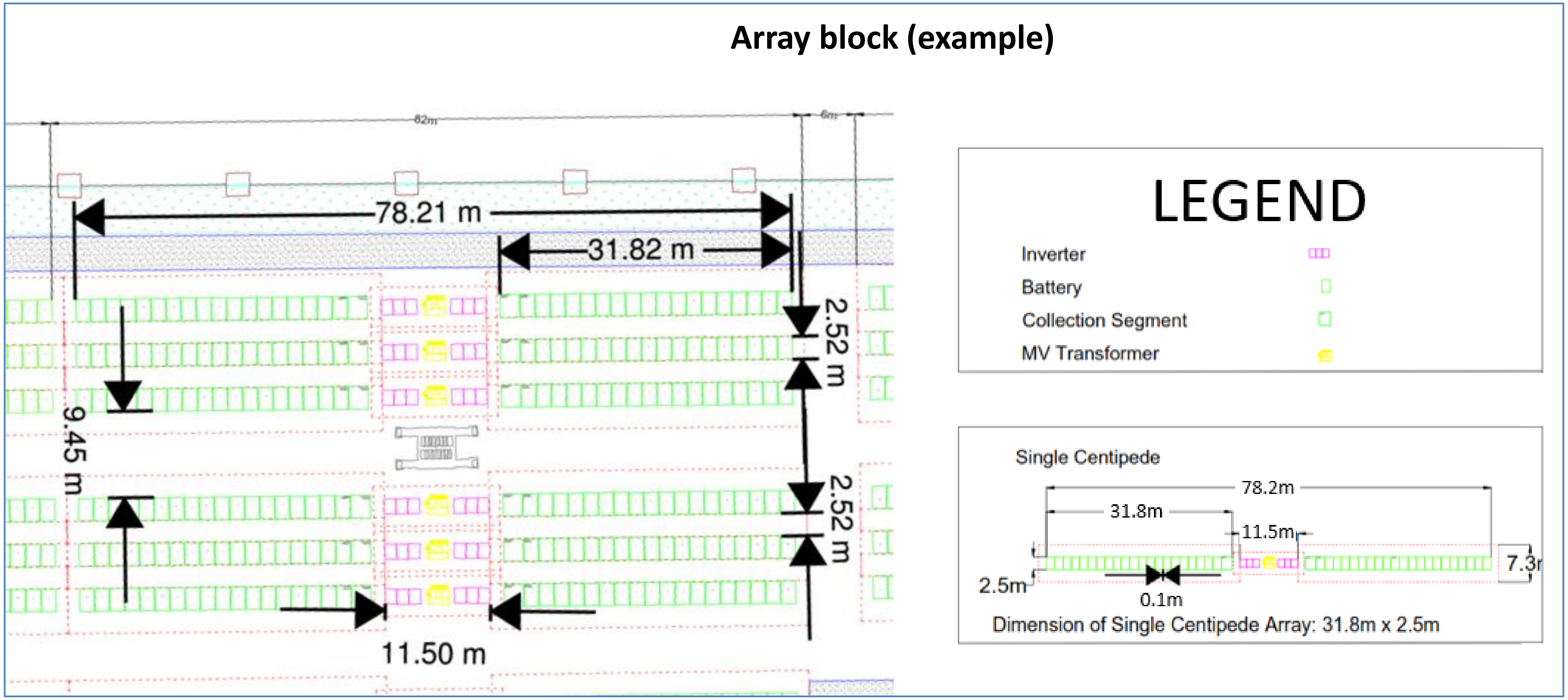


Figure 8.2: Concept BESS layout – Clearances between units



Note: Measurement based on preliminary layout drawing AKE-LAY-001 Rev 1.1 with Akaysha markup

8.3. Land area designated for the BESS

The designated land area is sufficient to accommodate the proposed BESS units as shown in Figure 8.1. At the time of this study, the installation manual for the Centipede platform or Stack750E was not available to Sherpa. Therefore, Sherpa was unable to verify the manufacturer specified clearances. Sherpa assumed that the included clearances reflect the manufacturer's specified clearances.

8.4. Onsite receptors

The closest onsite receptors to the BESS will be other project infrastructure located within the development footprint, including:

- O&M building
- BESS substation and switch room
- BESS control room
- TransGrid substation.

Within the development footprint, dedicated areas have been allocated for the (1) O&M building and (2) BESS substation, switch room and control room (refer to Figure 8.1). At the time of this study, detailed layouts for these areas were not available. These will be developed during detailed design which will be conducted post project approval.

The separation distances between the proposed BESS and the identified onsite receptors are shown in Table 8.1. As the O&M building will be manned by onsite personnel, Sherpa recommends that the O&M building be located at least 30.5 m away (100 feet) from the closest BESS enclosure. This clearance corresponds with the minimum safety perimeter in the event of an emergency specified in the Battery Emergency Response Guide, Ref [1].

Table 8.1: Separation distances to onsite receptors

Onsite receptors	Separation distance (m) from	
	BESS area boundary	Closest BESS
O&M area boundary[(a)]	0	2.5
Substation, switch room, control room area boundary[(a)]	0	2.5
TransGrid substation[(b)]	102	105

Note

a) Separation distance measured from the respective area boundary. The O&M and substation areas will be located adjacent to the BESS area. At the time of this study, the O&M and substation area detailed layouts were not available.

b) Separation distance measured from the civil works area boundary associated with upgrade work to be undertaken as part of the project.

8.5. Off-site receptors

For the PHA, the non-associated residential dwellings or occupied areas are considered as sensitive receptors for determination of off-site impact. The nearest township to the proposed BESS is Wellington, located approximately 2 km south-west.

For fire events the separation distance from the proposed BESS to the non-associated residential dwellings were used to determine off-site impact.

A review of the separation distances to off-site receptors is shown in Figure 8.3. The separation distance to the nearest sensitive receptor is 680 m from the proposed BESS.

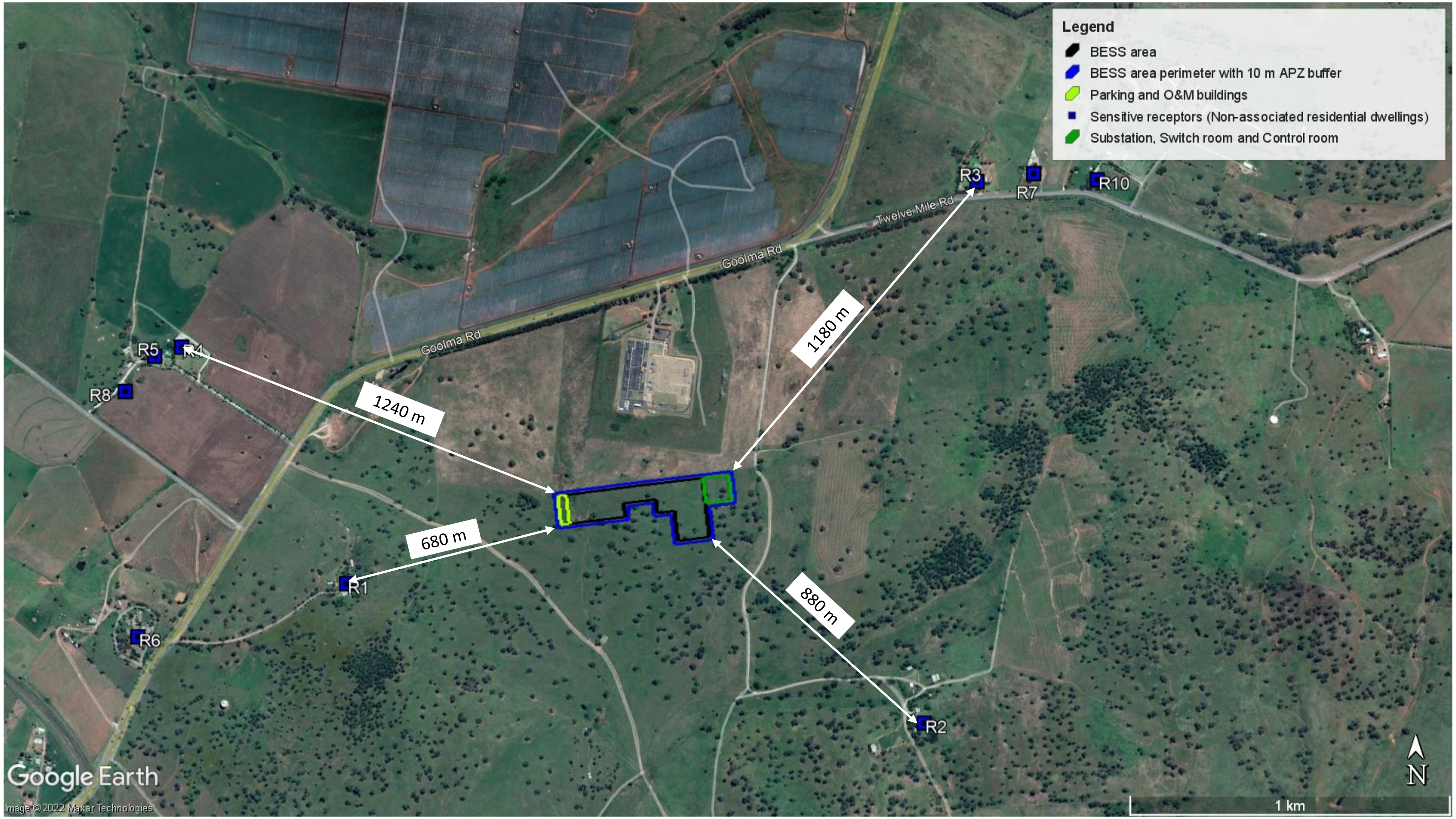
8.6. Review findings

The review of BESS separation distances found that:

- The proposed BESS has been tested to UL 9540A and the results indicate that:
  - Module-to-module propagation was not observed, and
  - Unit level results show a fire does not propagate from one Stack750E to another.

  The result of the UL 9540A test (performed with clearances as specified by the BESS manufacturer) form a key parameter to determine clearances.
- As the BESS installation manual was not available at the time of this study, Sherpa was unable to verify the manufacturer specified clearances. Sherpa assumed that the clearances included in the BESS concept layout reflect the manufacturer's specified clearances.
- The designated land area can accommodate the proposed BESS units to meet the proposed capacity.
- There is a considerable separation distance between the proposed BESS and the TransGrid substation (i.e. >100 m). The separation distance to the O&M and BESS substation will be better informed during detailed design. Sherpa recommends that the O&M building be located at least 30.5 m away (100 feet) from the closest BESS enclosure in line with the minimum safety perimeter in the event of an emergency specified in the Battery Emergency Response Guide, Ref [1].
- The closest non-associated residential dwelling is approximately 680 m away from the proposed BESS. No off-site impact is expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest sensitive receptor.

Figure 8.3: Separation distance to off-site receptors



9. LEVEL OF ANALYSIS DETERMINATION

9.1. Level of analysis

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

- The proposed BESS will be situated in a rural area.
- The nearest sensitive receptor (non-associated residential dwelling) is located approximately 680 m from the proposed BESS (R1; refer to Figure 8.3).

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

- The proposed BESS will be situated in a rural area with the scattered residential dwellings. The nearest sensitive receptor (non-associated residential dwelling) is approximately 680 m from the proposed BESS (R1).
- The nearest township is Wellington, located approximately 2 km south-west of the proposed BESS.

Based on the above findings and the *Multi-Level Risk Assessment* guideline, Ref [9], and guidance to determine the required level of analysis for the PHA (Table 5.1), a fully qualitative approach (i.e. Level 1 analysis) was determined appropriate for this study. The risk analysis is presented in Section 10.

9.2. Qualitative risk criteria

The HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [10], recommends a set of qualitative criteria/principles be adopted concerning the land use safety acceptability of a development.

The risk assessment against HIPAP No. 4 criteria is provided in Section 11.

10. RISK ANALYSIS

10.1. Overview

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

For each identified event, the risk to off-site population was qualitatively determined from the resulting severity and likelihood rating pair using the risk matrix shown in Table 10.1. In the absence of a suitable company risk matrix, the risk matrix provided in AS/NZS 5139 was used for the study. In line with AS/NZS 5139, events with risks greater than 'Low' should be discussed with the system owner and operator and anyone involved in the installation of the system.

For this study, the acceptance criteria used to assess the risk for off-site 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 10.1: 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

10.2. 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 10.2 which was reproduced from AS/NZS 5139.

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 a 'Insignificant' rating to indicate minimal impact to off-site population.

Table 10.2: 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

10.3. Likelihood rating

The likelihood of an event was estimated using the category scale shown in Table 10.3 which was reproduced from AS/NZS 5139.

Table 10.3: Likelihood rating

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

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

10.4. Risk results and analysis findings

The qualitative risk results for the identified events are shown in Table 10.4.

The risk analysis findings are as follows:

- **Consequence**: The worst-case consequence for the identified events is a BESS fire and/or explosion event which may result from causes such as battery thermal runaway, encroachment from off-site bushfire or a substation fire. The study found that for all events the impacts are not expected to have significant off-site impacts. This was assessed based on the location of the proposed BESS (i.e. rural area) and separation distance between the BESS and sensitive receptors (i.e. non-associated residential dwellings).
- **Likelihood**: The highest likelihood rating for the identified events is 'Unlikely' (i.e. not expected to occur, but there is a slight possibility it may occur at some time).
- **Risk analysis**: A total of 12 hazardous events were identified. The breakdown of these events according to their risk ratings are as follows:
  - <u>'Medium' risk event: 1</u>

    This event relates to unauthorised person access to the 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 will be implemented accordingly. In addition to the rural location of the site, it is anticipated that security fencing, cameras and warning signs will be provided. Mitigation measures would also include onsite security protocol and presence of staff 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'.
  - <u>'Very Low' risk events: 11</u>

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

Table 10.4: Risk results

Hazard	Event	Consequence	Off-site consequence	Significant off-site impact?	Risk analysis (off-site and public impact)		
					Severity	Likelihood	Risk
Electrical	Exposure to voltage	- Electrocution - Injury and/or fatality to on-site employees - Injury and/or fatality to member of public due to touch and step potential	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling.	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 on-site employees	Localised effects, the effects are not expected to have an off-site impact.	No	Insignificant	Unlikely	Very Low
Fire	BESS fire	- Release of toxic and/or explosive combustion products - Escalation to the entire BESS - Injury and/or fatality to on-site employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling.	No	Insignificant	Unlikely	Very Low
Chemical	Release of electrolyte from the battery cell (liquid/vented gas)	- Release of flammable liquid electrolyte - Vaporization 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 on-site employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling.	No	Insignificant	Unlikely	Very Low
	BESS coolant or refrigerant leak	- Irritation/injury to onsite employee on exposure to leak (e.g. inhalation and skin contact) - Ingress of coolant or refrigerant to battery or other electrical components (battery enclosure) leading to short circuit and fire, resulting in injury and/or fatality to onsite employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling.	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 on-site employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling.	No	Insignificant	Unlikely	Very Low

Hazard	Event	Consequence	Off-site consequence	Significant off-site impact?	Risk analysis (off-site and public impact)		
					Severity	Likelihood	Risk
Reaction	Thermal runaway in battery	- Fire and/or explosion in battery enclosure - Escalation to the entire BESS - Injury and/or fatality to on-site employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling.	No	Insignificant	Unlikely	Very 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) - Injury to on-site employees	EMF created from the project will not exceed the ICNIRP reference level for exposure to the general public. No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling.	No	Insignificant	Rare	Very Low
External factors	Water ingress (e.g. rain, flood)	- Electrical fault/short circuit - Fire and/or explosion in battery enclosure - Injury and/or fatality to on-site employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling.	No	Insignificant	Unlikely	Very Low
	Vandalism due to unauthorised personnel access and deliberate damage to the BESS	- Asset damage - BESS failure/fire - Potential hazard to unauthorised person (e.g. electrocution) - 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 onsite. For a fire event, the effects are not expected to have an off-site impact as the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling.	No	Major	Unlikely	Medium
	Lightning strike	- Fire - Injury and/or fatality to on-site employees	No off-site impact expected as the BESS will be situated in a rural area and there is a large separation distance to the nearest residential dwelling.	No	Insignificant	Unlikely	Very Low
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 rural area and there is a large separation distance to the nearest residential dwelling.	No	Insignificant	Unlikely	Very Low

11. RISK ASSESSMENT

11.1. Assessment against company risk acceptance criteria

Using the study risk matrix referenced from AS/NZS 5139, the identified hazardous events were qualitatively risk profiled. Of the 12 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 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. In addition to the rural location of the site, the proposed BESS will be located in a secure area with fencing 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 off-site impacts. Based on the study risk acceptance criteria, the risk profile for the proposed BESS is considered to be tolerable.

11.2. Assessment against HIPAP No. 4 criteria

Assessment against the HIPAP No. 4 qualitative land use planning risk criteria is provided in Table 11.1.

Table 11.1: Assessment against HIPAP No. 4 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 risks associated with the proposed operations of the BESS. The BESS location is suited for the proposed operation, situated within the Central-West Orana REZ, in a rural area with considerable separation distance to sensitive receptors to avoid off-site risks. It is not possible to eliminate batteries from a BESS development. Selection of the battery technology is a balance of cost and availability with the most commonly used versions being lithium ion.	Yes
The risk from a major hazard should be reduced wherever practicable, irrespective of the numerical value of the cumulative risk level from the whole installation. In all cases, if the consequences (effects) of an identified hazardous incident are significant to people and the environment, then all feasible measures (including alternative locations) should be adopted so that the likelihood of such an incident occurring is made very low. This necessitates the identification of all contributors to the resultant risk and the consequences of each potentially hazardous incident. The assessment process should address the adequacy and relevancy of safeguards (both technical and locational) as they relate to each risk contributor.	Based on the separation distance to sensitive receptors, consequence impacts from the identified hazardous events are not expected to have significant off-site impacts.	Yes
The consequences (effects) of the more likely hazardous events (i.e. those of high probability of occurrence) should, wherever possible, be contained within the boundaries of the installation.	Events with high probability of occurrence are expected to be contained within the boundaries of the installation. Based on the separation distance to sensitive receptors, consequence impacts from the identified hazardous events (e.g. fire and explosion) are not expected to have significant off-site impacts.	Yes
Where there is an existing high risk from a hazardous installation, additional hazardous developments should not be allowed if they add significantly to that existing risk.	There are no hazardous developments (in the context of the Resilience and Hazards SEPP) in the vicinity of the project site.	Yes

11.3. Conclusion and recommendations

A PHA was completed to identify the hazards and assess the risks associated with the proposed operations of the BESS at the planning stage to determine risk acceptability from land use safety planning perspective.

The PHA was completed following the methodology specified in HIPAP No. 6 *Hazard Analysis* and the *Multi-Level Risk Assessment* guidelines for assessment against HIPAP No. 4 criteria. A Level 1 PHA (qualitative) was completed.

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 off-site impacts.
- The proposed BESS meets the HIPAP No. 4 qualitative risk criteria.

The following recommendations were identified:

1. Akaysha Energy to locate the O&M building at least 30.5 m away (100 feet) from the closest BESS enclosure. This clearance corresponds with the minimum safety perimeter in the event of an emergency specified in Powin's Battery Emergency Response Guide, Ref [1].
2. Akaysha Energy to review the investigation reports on the Victorian Big Battery Fire (occurred on 31 July 2021) and implement relevant findings for the project. The publicly available investigation reports include:
   - Energy Safe Victoria: Statement of Technical Findings on fire at the Victorian Big Battery.
   - Fisher Engineering and Energy Safety Response Group: Report of Technical Findings on Victorian Big Battery Fire.
3. Akaysha Energy to consult with Fire and Rescue NSW (FRNSW) to ensure that the relevant aspects of fire protection measures have been included in the design. These may include: (i) type of firefighting or control medium (ii) demand, storage and containment measures for the medium. The above aspects will form an input to the Fire Safety Study which may be required as part of the development consent conditions, for review and approval by FRNSW.

12. REFERENCES

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