

PRELIMINARY HAZARD ANALYSIS FOR MARYVALE SOLAR FARM BATTERY ENERGY STORAGE SYSTEM, NSW

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Preliminary Hazard Analysis for Maryvale Solar Farm Battery Energy Storage System, NSW

Disclaimer

Maryvale Solar Farm Pty Ltd (the Applicant) commissioned Planager to prepare a PHA for the Maryvale Battery Energy Storage Project. The material in it reflects Planager's best judgement in the light of the information available to it at the time of preparation. However, as Planager cannot control the conditions under which this report may be used, Planager and its related corporations will not be responsible for damages of any nature resulting from use of or reliance upon this report. Planager's responsibility for advice given is subject to the terms of engagement with the Applicant.

The analysis of fire safety within Battery Energy Storage System, including the consequences of generation of heat, overpressure or toxic combustion gases during a fire event is limited to the available data and current hazards analyses on similar / applicable facilities. Much of the available information is still recent and subject to ongoing research, with only few industrial sized Battery Energy Storage Systems having been developed in Australia at the time of this report and with the applicable Australian and International Codes of Practice only a few years into their implementation. As such, the analysis in this report represents the current understanding of the subject matter but is subject to the limitations of available data at the time of this report.

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GLOSSARY AND ABBREVIATIONS

ADGC	Australian Dangerous Goods Code
ALARP	As Low As Reasonably Practicable
APZ	Asset Protection Zone
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AS	Australian Standard
BATSO	BESS Safety Organization
BAW	Bayswater Ancillary Works
BESS	Battery Energy Storage System
battery	Li-ion battery with associated infrastructure, located within an enclosure
CEMP	Construction Management Plan
DG	Dangerous Goods
DPIE	Department of Planning, Industry and Environment
EIS	Environmental Impact Statement
ELF	Extremely low frequency
EMF	Electric and magnetic fields
EPA	Environmental Protection Agency
ESD	Emergency Shut Down
FHA	Final Hazard Analysis
FRNSW	Fire and Rescue NSW
Ha	Hectare
HAZMAT	Hazardous materials
HIPAP	Hazardous Industry Planning Advisor Paper
HSE	Health, Safety and Environment
HV	High Voltage
kL	kilolitre
km	kilometre
kV	kilovolts
LFP	lithium iron phosphate
Li-ion	Lithium-ion (battery)
MLRA	Multilevel Risk Assessment guidelines
MV	Medium Voltage
NEH	New England Highway

NSW RFS	NSW Rural Fire Service
ICNIRP	International Commission on Non-Ionising Radiation Protection
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NSW	New South Wales
OEMP	Operations Management Plan
PG	Packaging Group
PIRMP	Pollution Incident Response Management Plan
PM	Preventative Maintenance
PPE	Personal Protective Equipment
Project Area	The combined area of the Site for the BESS and the transmission line
RFS	Rural Fire Service
SCADA	Supervisory Control And Data Acquisition
SDS	Safety Data Sheets
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
Site (the)	Location of the BESS and the Maryvale Solar Farm
SWMS	Safe Work Method Statement
PHA	Preliminary Hazard Analysis
PTW	Permit To Work
UL	Underwriters Laboratories
UN	United Nations
V	Volt
WHS	Work Health & Safety

EXECUTIVE SUMMARY

E1. Introduction

Development Consent was granted for the construction and operation of the Maryvale Solar Farm by the Minister for Planning on the 4th of December 2019 under Section 4.38 of the Environmental Planning and Assessment Act 1979 (NSW), Reference SSD 8777. The application for Development Consent was made by Maryvale Solar Farm Pty Ltd C/-Photon Energy Group which has subsequently changed to C/- WIRSOL Energy (The Applicant).

The Applicant is lodging an application to modify the Development Consent under Section 4.55 (1A) of the Environmental Planning & Assessment Act 1979, requesting permission for the addition of a Battery Energy Storage System to the approved Maryvale Solar Farm Project.

The Battery Energy Storage System would be developed with a capacity of approximately 125 megawatts (MW) with up to three (3) hours of storage and would be developed within the boundaries of the approved Maryvale Solar Farm, NSW.

The Battery Energy Storage System would be connected to the solar panels, the substation and to the existing Essential Energy 132kV transmission line that intersects the Project Area.

The Director - Energy Assessment of the NSW Department of Planning, Industry and Energy has requested that a Preliminary Hazard Analysis be developed for the Battery Energy Storage System, as follows:

The Department is generally satisfied with the issues identified in your letter to be addressed in the Modification Report. However, the Department requests that the Modification Report also includes:

- ...
- *a Preliminary Hazard Analysis (PHA) prepared in accordance with the Department's Hazardous Industry Planning Advisory Paper No. 6, 'Hazard Analysis' (HIPAP6) and Multi-level Risk Assessment (MLRA). The PHA should also have regard to any recent developments in research and standards for battery storage.*

The Applicant has appointed Planager Pty Ltd to prepare this hazard and risk assessment report, which has been developed in the format of a Preliminary Hazard Analysis in accordance with the DPIE's HIPAP6 and MLRA guideline documents.

E2. Methodology and scope

The hazard and risk assessment process encompasses qualitative methods to assess the adequacy of the controls and to demonstrate that the Battery Energy Storage System can be developed with the

associated hazards kept As Low As Reasonably Practicable (**ALARP**) and that appropriate land use safety planning can be achieved.

The assessment focusses on potential high consequence – low likelihood incidents in construction, commissioning and operation of the facility that may affect the health and safety to people and the environment outside of the boundaries of the Project Area, in accordance with the requirements in HIPAP6 and the MLRA guidelines.

The following risks are included in this assessment:

- Risk from reactions and fires associated with electrical infrastructure and flammable material, including spontaneous ignition from a runaway reaction at the BESS
- Environmental risk from spills causing land contamination
- Health and safety risk to the community
- Health and safety risks to staff and to contractors from major, high consequence process safety incidents.

E3. Findings

Using a risk matrix which has been calibrated to the Department of Planning, Industry and Environment risk criteria (in their HIPAP4 document), the hazard and risk assessment found that the risk profile for the Battery Energy Storage System is consistently between *Moderate* and *Low* risk, with no *High* or *Very High* risks identified.

The assessment found that the Battery Energy Storage System facility can be managed in accordance with the established risk criteria and in accordance with ALARP principles. Most hazards can be prevented by employing a combination of common measures, including following all applicable Australian/New Zealand Standards and Codes and with reference to international Standards, including separation distances and setbacks, physical protection and control systems measures. Mitigation measures are also available within the industry to reduce the severity of the hazards should they occur.

Table E1 provides an overview of the risks assessment results and ALARP conditions. A short summary discussion is provided below:

- The theoretical potential exists for the BESS to initiate a bushfire in the surrounding bush and grasslands. This presents the only potential impact from the Project to society outside of the boundary of the facility.

Provided the battery units are designed and tested to withstand a credible fire scenario and that sufficient separation is established within the BESS and between the BESS and the surrounding grassland (through an Asset Protection Zone), the risk of propagation of a fire at the facility can be managed ALARP.

As a precautionary approach, it is recommended that a water tank be installed at the boundary of the facility, to provide capability of fighting a fire in the surrounding grassland. Although the PHA identified that the need for external firefighting is unlikely, these conclusions are to be discussed in consultation with NSW Rural Fire Service, Fire Rescue NSW and the DPIE.

With application of the risk management measures detailed in this report there is a low risk to society outside of the boundary of the facility, and low risks to the environment.

- Environmental pollution may be possible, subject to detailed design, from a failure to contain pollutants at the Battery Energy Storage System, for example of cooling waters or thermal oils. If a spill is not contained, there is a potential for environmental pollution to ground and surface waters. Measures to prevent a leak from occurring and for secondary containment should a leak occur, e.g. as integral to the battery enclosures, would be addressed in the detailed design phase for the Project.

BESS element and hazard	Finding	Risk and ALARP evaluation
Risk of major injury or environmental damage during construction	Construction risks are well known and understood. Existing Codes and Standards are established within the industry to manage construction risk to ALARP principles. The risk arises from typical construction activities and the impact of the BESS on the risk is minimal.	MODERATE RISK: Can be managed to ALARP principles provided general relevant construction Codes and Standards are adhered to.
Fire and pollution at the Battery Energy Storage System as initiated by an internal or external event during commissioning or operation	Codes and Standards provide clear guidance as to how to prevent and protect against a fault in a battery escalating into a fire at a battery enclosure. Key controls include continuous BMS with automatic shut-down; battery fire proven not to propagate in accordance with international methodologies (e.g. UL9540, IEC 62619, IEC 63056 or similar); and establishment of minimum separation distances within the BESS and between the BESS and external boundaries. As a precautionary approach, a fire water tank should be installed at the boundary, for firefighting in the surrounding grassland. The need for external firefighting is unlikely, to be reviewed in the detailed design in consultation with RFS, FRNSW and DPIE. On-site hazardous effects are possible in case of a battery fire, and the risk associated with of generation of toxic gas and toxic combustion products should be minimised in design, safe evacuation from the facility should be considered, and should be considered in emergency response (e.g. by external authorities). Environmental pollution may be possible, subject to detailed design, from a failure to pollutants, and the need for secondary containment of a spill should be considered in detailed design. Provided all key controls are established, the risk associated with the BESS can be managed ALARP.	MODERATE RISK: Can be managed to ALARP principles provided the battery and the enclosure designed such that a credible fire will not propagate; the requirements in relevant Codes and Standards are adhered to; and the minimum separation distances within the BESS and an appropriate APZ are established and maintained
Fire and pollution at the electrical infrastructure during commissioning or operation of the Battery Energy Storage System	Provided the requirements under the Australian Standards (e.g. AS 2067 & AS 1940) and the Applicant's management practices for Low Voltage and Medium Voltage systems are adhered to, the risk associated with fire and with environmental pollution at the electrical infrastructure associated the Battery Energy Storage System can be managed ALARP.	MODERATE RISK: Conforms to ALARP provided the requirements in Codes and Standards & the Applicant's management practices are adhered to

Table E1: Overview of risks assessment results and ALARP conditions (concept design stage)

E4. Conclusion and recommendations

In conclusion, the risk profile for the Battery Energy Storage System is consistently within the *Low* or *Moderate* risk ranking following the qualitative risk criteria established by the Department of planning, Industry and Environment and ALARP principles can be established provided the following recommendations are included in the detailed design:

1. The separation distance between infrastructure within the Battery Energy Storage System is to be determined in accordance with Codes and Standards and manufacturer's recommendations so that the preferred strategy of allowing a fire in one battery enclosure or inverter to burn without the risk of propagating to other infrastructure can be maintained without the need for external firefighting
2. The separation distance within the Battery Energy Storage System is to be determined in accordance with Codes and Standards and manufacturer's recommendations to allow safe escape from the facility in case of a fire
3. All relevant requirements in the Australian Standard AS5139 (2019) are to be adhered to at the Battery Energy Storage System. Adherence to requirements in international Standards should also be considered, for example, to the US NFPA 855 (2020) Code or other similar IEC Standards.
4. Procurement of a battery system that is certified to UL 9540 and/or IEC 62619 and/or other relevant Code, proving that a credible fire within a battery or battery enclosure will not propagate to other battery units
5. Install a fire water tank at site boundary, to allow for firefighting in case of grass fires or other small fires in the area. Detailed firefighting response and any need for fire water containment should be assessed and reported (e.g. in the format of a Fire Safety Study) post development approval, for review by the DPIE, NSWFR and the RFS
6. Measures to prevent a leak occurring at the BESS, and for containment of a spill of pollutant from the BESS, should be addressed in the detailed design phase for the Battery Energy Storage System
7. The specific risk associated with the potential for dust storms and ingress of dust causing damage to infrastructure needs to be integrated into the design and the B contractors and Applicant staff need to be aware of this threat during Project design, construction and operation
8. The register of commitment (Appendix 1 of the PHA) is integrated into the development of the Battery Energy Storage System. This includes integration of 29 individual commitments, including for the design, installation and maintenance of the BESS automatic shutdown system on exceedance of safe limits; installation of deflagration venting and fire protection inside the battery enclosures; design of the BESS such that the risk of pollution from a release is reduced

to ALARP; installation of protective barriers e.g. at the transformers and fire resistance of the battery enclosures; and application of a rigorous and formal management of change process for the BESS, including detailed hazard identification and risk assessment processes.

REPORT

1 INTRODUCTION

1.1 BACKGROUND

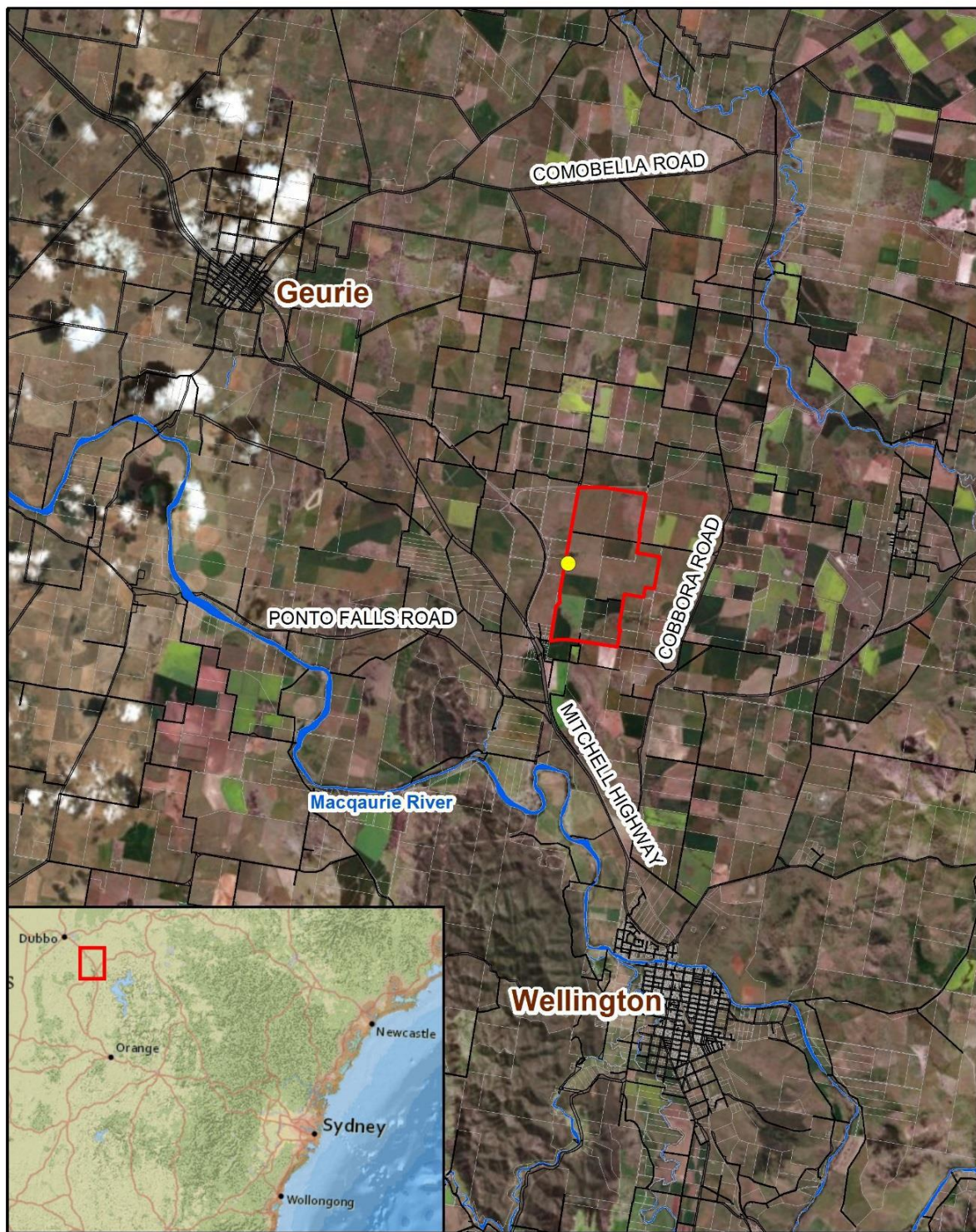
Approval was granted to Maryvale Solar Farm Pty Ltd C/-Photon Energy Group which has subsequently changed to C/- WIRSOL Energy (**the Applicant**) by the Minister for Planning on the 4th of December 2019 under Section 4.38 of the Environmental Planning and Assessment Act 1979 (NSW), Reference SSD 8777, for the construction and operation of the Maryvale Solar Farm (**Maryvale Solar Farm**). The solar farm would be developed as a 125 megawatt (MW) (AC) (160MW DC) solar photovoltaic (PV) facility including ancillary works and associated infrastructure at 121 Maryvale Road, Maryvale and 801 Cobbora Road, Maryvale NSW 2820 (the **Project**).

The applicant is lodging an application to modify the Development Consent under Section 4.55 (1A) of the Environmental Planning & Assessment Act 1979, requesting permission for the addition of a Battery Energy Storage System (**BESS**) to the approved Project.

The BESS would be developed with a capacity of approximately 125 megawatts (MW) with up to three (3) hours of storage and would be developed within the boundaries of the approved Maryvale Solar Farm, NSW (hereafter referred to as **the Approved Project**).

The BESS would be connected to the solar panels, the substation (which formed part of the Project) and to the existing Essential Energy 132kV transmission line that intersects the Project Area.

The locality map for the Project Area is presented in Figure 1.



N
Coordinate System: GDA 1994 MGA Zone 55
1:125,942 When Printed at A4
0 1 2 3 4 Kilometres

Map ref: SY17238 Figure1-1
Revision: A
Author: mdugan
Date: 22/08/2018
Data sources: Dubbo LGA

Legend

- Substation
- Subject Land
- Road Corridor
- Lot
- WaterFeature

pitt&sherry

Photon Energy

Maryvale Solar Farm

Source: Extract from EIS

Figure 1: Locality map

The NSW Department of Planning, Industry and Energy (**DPIE**), through the *Director - Energy Assessment* has requested that a Preliminary Hazard Analysis (**PHA**) be developed for the BESS as follows:

The Department is generally satisfied with the issues identified in your letter to be addressed in the Modification Report. However, the Department requests that the Modification Report also includes:

- ...
- *a Preliminary Hazard Analysis (PHA) prepared in accordance with the Department's Hazardous Industry Planning Advisory Paper No. 6, 'Hazard Analysis' (HIPAP6) and Multi-level Risk Assessment (MLRA). The PHA should also have regard to any recent developments in research and standards for battery storage.*

The Applicant has appointed Planager Pty Ltd (**Planager**) to prepare this hazard and risk assessment report, which has been developed in the format of a PHA in accordance with the DPIE's HIPAP6 (Ref 1) and MLRA guidelines (2).

The hazard and risk assessment process encompasses qualitative methods to assess the adequacy of the controls and to determine if the BESS can be developed with the associated hazards kept As Low As Reasonably Practicable (**ALARP**) and ensuring appropriate land use safety planning.

This PHA should be read in conjunction with the bushfire risk assessment prepared for the BESS formats by Eco Logical Australia Pty Ltd (Ref 3).

1.2 SCOPE AND PURPOSE

1.2.1 BESS scope and purpose

The BESS covers the following elements, as relevant to the PHA:

- Construction, commissioning and operation (including maintenance) of the BESS with a capacity of approximately 125 Megawatts (**MW**) which is to be used to store energy produced in the Maryvale Solar Farm, and discharge the energy to the existing Essential Energy 132kV transmission line
- Connection of the BESS to the substation which forms part of the Maryvale Solar Farm Project, via a 33kV or 66kV kilovolt (**kV**) electrical cable connection. The connection to the solar farm and the existing 132 kV transmission line is via the substation, approved as part of the Maryvale Solar Farm Project.

1.2.2 PHA scope and purpose

The overall purpose of this PHA is to address the hazards and risks associated with the BESS, notably as associated with the following:

- Risk from reactions and fires associated with electrical infrastructure and flammable material, including spontaneous ignition from a runaway reaction at the BESS
- Environmental risk from spills causing land contamination
- Health and safety risk to the community
- Health and safety risks to staff and to contractors from major, high consequence process safety incidents..

The hazard analysis process encompasses qualitative methods to assess the adequacy of the controls. The aim is to demonstrate that the BESS can be developed with the associated risks kept As Low As Reasonably Practicable (**ALARP**) and to ensure appropriate land use safety planning can be achieved.

The PHA is prepared in accordance with DPIE methodology in their HIPAP6 *Hazard analysis* (Ref 1) and *Multi-level risk assessment* (MLRA, Ref 2).

As per the hazard analysis methodology (Refs 1, 2), the assessment focusses on potential high consequence / low likelihood incidents during construction, commissioning and operation of the BESS that may affect the health and safety of people and the environment outside of the boundaries of the Project Area.

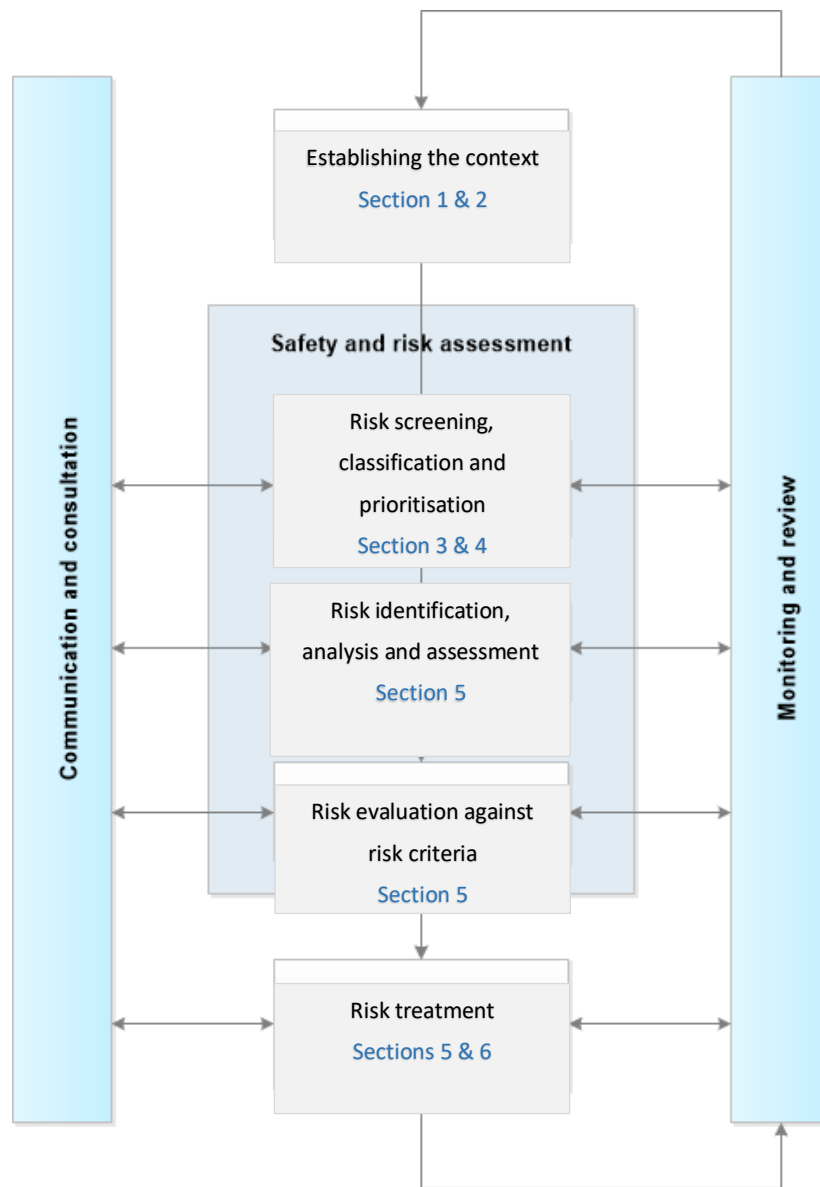
1.3 EXCLUSIONS AND LIMITATIONS

The study exclusions are summarised as follows:

- The Bushfire Threat Assessment was conducted as a separate study (Ref 3) and the outcomes were used to inform this PHA
- This PHA does not include a detailed identification and assessment of construction and commissioning risks (if needed, this would be better suited to a Construction Safety Study conducted at final design of the Project)
- The PHA was based on concept design and the results depend on the implementation of the commitments made during the study (as listed in Appendix 1) and the recommendations made in the PHA
- Consultation with the DPIE planning team was conducted as part of the development of the present PHA in the form of preliminary feedback on the PHA draft report. Consultation with the NSWFR and the RFS would be conducted in conjunction with the establishment of detailed design, including during the development of the Fire Safety Study.

1.4 METHOD AND REPORT STRUCTURE

An overview of the methodology employed in the hazard and risk assessments, together with the applicable Sections in the report, is depicted in Figure 2.



Adapted from ISO31000

Figure 2: Risk management framework

The process utilised for this assessment follows standard processes established internationally and in Australia for hazard and risk assessments, and outlined in DPIE's guidelines for hazard analysis (Ref 1)

and the *Multilevel risk assessment* (Ref 2). It includes the tasks outlined in the following Sections of the PHA:

- Sections 1 and 2 establish the context for the PHA, including the background, scope, aim and methodology of the PHA and a description of the BESS
- Sections 3 and 3.2 include a risk screening, classification and prioritisation of potential hazards and risk factors associated with the BESS. The aim is to determine the focus and format of the subsequent Sections of the PHA. Details of the methodologies for the risk screening process is provided in Section 3.1 and, for the risk classification and prioritisation, in Section 4.1
- Section 5 provides the detailed hazard identification and risk analysis and assessment of the BESS in the context of this PHA. It defines the hazardous incidents potentially associated with the BESS, analyses the consequences should an incident occur, evaluates the proposed risk treatment and evaluates the risk against the established risk criteria. The aim is to demonstrate that the risks can be kept ALARP and in accordance with appropriate land use safety planning. Details of the criteria used in the risk assessment are provided in Section 1.5, and of the methodologies for the hazard identification and risk assessment, provided in Section 5.1
- Section 6 summarises the findings from the analysis and provides the recommendations regarding what items need to be defined in the detailed design phase for the BESS to allow an understanding of the Project and assurance that it will not create any conflicts from a land use safety point of view.

The commitments register in Appendix 1 provides the basis for the assessment performed in the PHA.

1.5 RISK CRITERIA

Risk evaluation considers whether the level of risk meet generally acceptable risk criteria and has been reduced ALARP. The risk evaluation has three possible outcomes:

- Well below the acceptable criteria: further risk reduction may be impracticable
- Sufficiently close to or above the acceptable criteria: further risk reduction controls to be investigated in detail using ALARP principles
- Well above the acceptable criteria: further controls need to be found or continued operation questioned.

Qualitative guidelines are given to ensure that risk is eliminated or prevented and where that is not possible, controlled. The risk criteria used for this PHA are provided in Appendix 2 in the form of a risk matrix. The criteria have been calibrated against the DPIE risk criteria in their *HIPAP 4 Risk criteria for land use planning* (Ref 4). Where a hazard has the potential for off-site effects, the consequence levels

in the risk matrix apply to both on-site workers and people off-site who are within the range of the effect.

In addition to meeting the qualitative criteria, risk minimisation and use of best practice must be demonstrated. These terms imply (adapted from HIPAP 4, Ref 4):

- *Risk minimisation* - risks should be reduced to ALARP, regardless of calculated risk levels and criteria.
- *Best practice* - industry best practicable should be used in the engineering design, and industry best practice management systems should be used for the operation of new 'plant'.

In the context of the present Project, this applies to the BESS and the electrical connections to the substation within the Project Area.

1.6 SAFETY MANAGEMENT SYSTEMS

Risk assessments can only be a valid tool for assisting in the overall assessment of a development if the facility being examined is or will be subject to appropriate management control of hazards. Without such control, the assumptions inherent in the assessment techniques become invalid in two general areas. First, the identification of hazards is based on experience in similar installations and engineering judgement. Without proper management control of safety issues, the range and impact of potential hazards become unpredictable. Second, the likelihood at which incidents of any type may occur cannot be adequately estimated using historical data.

Safety management systems allow the risk from potentially hazardous installations to be minimised by a combination of hardware and software factors. It is essential to ensure that the reliability of the hardware systems and software procedures used to ensure the safe operation of the facility are of the highest Standards. These systems will apply to construction, operation and decommissioning of the BESS.

The Applicant has a commitment to workplace health and safety and have numerous policies and procedures to achieve a safe workplace. Those pertaining to the BESS include, but are not limited to:

- The operation of the proposed BESS and electrical connection would be continually monitored and controlled from a central control room via a Supervisory Control and Data Acquisition (**SCADA**) system
- An incident reporting and response system would be established as part of the operation of the Maryvale Solar Farm, providing 24-hour coverage
- The elements included in the BESS would comply with all Australian and international (e.g. NFPA 855 or IEC equivalent) Codes and statutory requirements, requirements with respect to BESS design and work conditions

- All personnel required to work with Dangerous Goods (**DG**) and hazardous material and with electricity would be trained in their safe use and handling, and provided with all the relevant safety equipment and documentation e.g. Safety Data Sheets (**SDS**) and Personal Protective Equipment (**PPE**)
- Emergency procedures, including pollution incident response, would be developed, and personnel would be trained in emergency response.
- A person (e.g. with the title *Plant Manager*¹) would be appointed, with overall responsibility of the BESS and the solar farm, and who would be supported by suitably qualified personnel trained in the operation, maintenance and support of the facility
- A Permit to Work (**PTW**) system, including energy isolation and Hot Work Permit for any work that could provide an ignition source (also during construction), and a system to control modifications, would be in use during construction and operation of the facilities forming part of the development, to control work and to protect plant and structures from substandard and potentially hazardous work and modifications
- Protective systems would be routinely inspected and tested to ensure they are, and remain, in a good state of repair and function reliably when required to do so. This would include scheduled testing of shutdown systems, trips and alarms, and relief devices associated with the BESS. Any protective system which is taken out of service, defeated or bypassed would be managed under a modification control system and heightened management monitoring
- All personnel working within the Project Area would be provided with the appropriate PPE suitable for use with the specific type of activity i.e. handling of hazardous substances or electricity
- A first aid station would be installed at the BESS boundary, comprising appropriate first aid kit(s) and first aid instructions, including SDS's, for all hazardous substances kept or handled within the BESS.

¹ The appointment of such a manager would require alignment between the Project Owner, EPC, Operator and the Contractors safe systems of work

2 DESCRIPTION OF BESS

2.1 LOCATION

The locality map is shown in Figure 1 in in Section 1.1.

The BESS would be constructed and operated within the boundaries of the approved Maryvale Solar Farm at 121 Maryvale Road, Maryvale and 801 Cobbora Road, Maryvale NSW 2820.

The site is located approximately 15 km north-east of the Wellington town centre within the Dubbo Regional Council Local Government Area (LGA), as per the locality map in Section 1.1.

The Project Area, comprising the solar farm and the BESS, would be located at “Waroona” 121 Maryvale Road, Maryvale and *Scarborough House*, 801 Cobbora Road, Maryvale, NSW and contained within Lot 1 in Deposited Plan 1031281; Lot 2 in Deposited Plan 573426; Lot 122 in Deposited Plan 754318; Lot 130 in Deposited Plan 754318 : Lot 182 in Deposited Plan 754318; Lot 2 in Deposited Plan 252522; Lot 1 in Deposited Plan 252522; Lot 1 in Deposited Plan 1006557; Lot 11 in Deposited Plan 1260757; Lot 12 in Deposited Plan.

There is an existing Essential Energy 132kV easement which runs through Lot 2 DP 573426 in a north – west to south-east direction and this easement contains an existing 132 kV powerline on wooden pole structures which connects with the Wellington substation some 12 km to the south. The Wellington substation is located approximately 3.5km to the north of Wellington.

The nearest neighbour is located along Combo Road, approximately 1km north-west of the Site (469 Combo Road). There are four other residences within 1.5km of the Site: one to the west of the Site (1148 Mitchell Highway), and three located to the south and south-east of the Site along Maryvale Road (112, 121 and 265 Maryvale Road). Another 10 residences are within 2km of the Site, most being located west of the Mitchell Highway. Twenty-seven further rural residential lots are sited west of the Mitchell Highway, within 5km of the Site, along Twiggs Road, Phillipsons Lane, Ponto Falls Road, Tarwong Lane and Whiteleys Lane.

Ancillary works conducted as part of the solar farm development would also occur in the road reserve along Maryvale and Seatonville Road to facilitate safe access to the Site and within the existing 132 kV powerline between the Site and Wellington Substation. These works will be useful for the development of the BESS.

Further details of the existing environment are provided in the Environmental Impact Statement which was developed for the solar farm (Ref 5).

2.2 EXISTING ENVIRONMENT

Figure 3 outlines the Project Area.

The Project Area occupies approximately 375 hectares, with the remaining land retained as agricultural land. The BESS would be contained entirely within the existing approved footprint of the solar farm.

The Project Area is currently used for agriculture and is mostly cleared with scattered mature shade trees remaining and one larger clump of mature trees on the western boundary which continues in to the adjoining property.

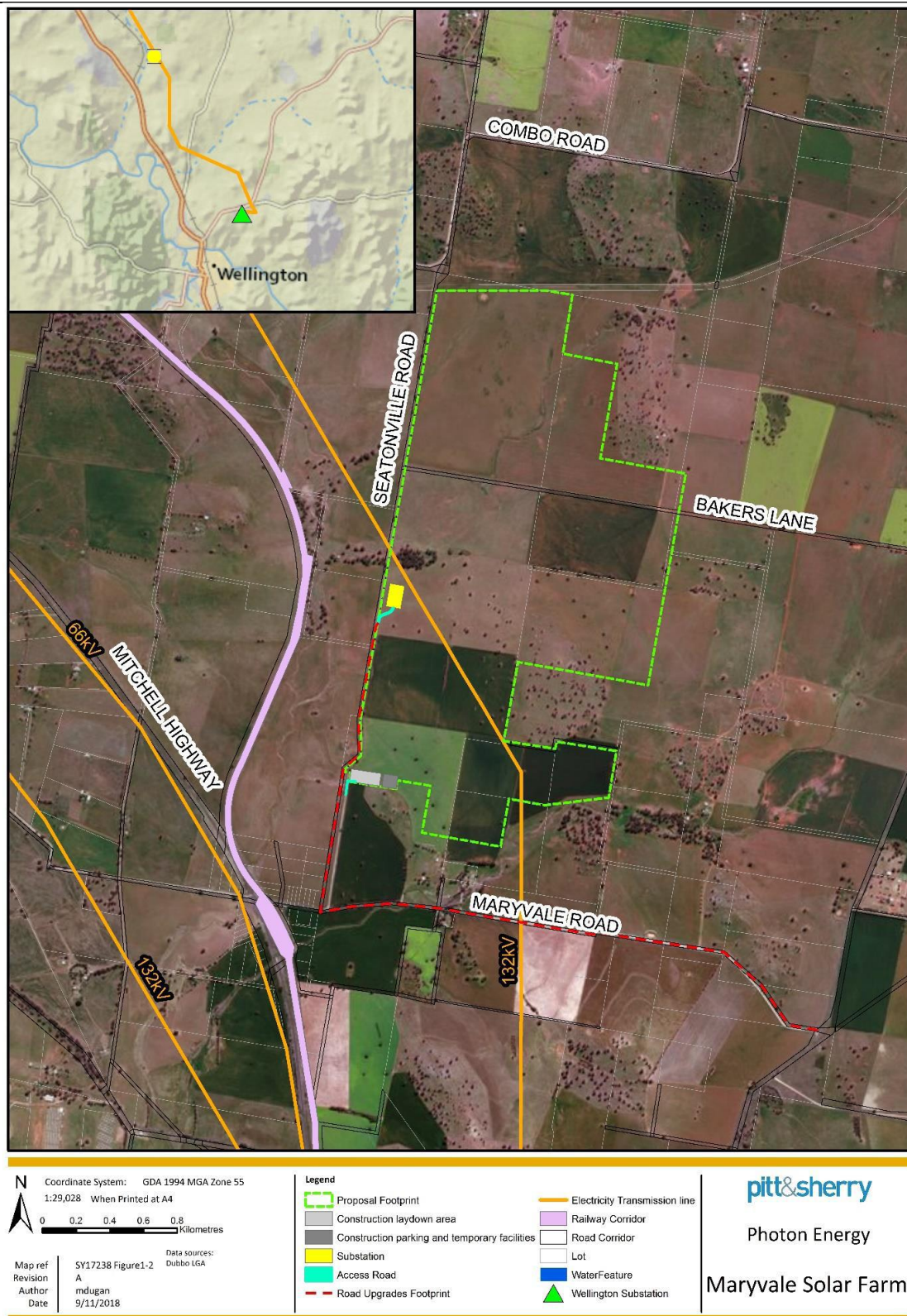
The surrounding vegetation is not mapped as bushfire prone land. The Bushfire risk assessment (Ecological Australia, Ref 3) reported that the area is regarded as low risk for bushfires and that fires are usually small and controlled by direct attack (Ref 3). Potential ignition sources from construction, operation and decommissioning of the BESS are generally consistent with the existing environment apart from any electrical faults, which are standard issues that will be picked up during the DC testing phases of the install before commissioning; and runaway reactions which are managed via SCADA control and the integrity of the battery system (Ref 3). BESSs also present unusual risks to fire fighters such as electrocution and inhalation of toxic fumes which may be generated in a fire.

The topography of the project area is generally flat with some gently undulating lower slopes intersected by shallow drainage depressions. The flowlines which drain the area run predominantly from the north to the south. In the northern section of the Project Area, two unnamed flowlines drain to the west where they intersect Maryvale Creek on the adjoining land. Bodangora Creek originates to the east of the Project Area and flows through the south-eastern corner of the site. Bodangora and Maryvale Creeks both flow away from the Project Area to the south west where they form tributaries of the Macquarie River.

The EIS (Ref 5) indicates that the Site is not currently mapped as being a risk area for acid sulphate soils.

The Geoscience earthquake risk map (Ref 6) indicate a low to moderate earthquake risk at the Project Area in Maryvale, NSW, similar to the risk in the Dubbo and Sydney areas. Further, there are no known mines under the site and no known historical excavation or dumping on the site - as noted in the original EIS for the Maryvale Solar Farm, the Bodangora Soil Landscape on the site is slightly to moderately erodible where vegetation or earthworks are not maintained. There are no other known subsidence risks for the site and as such the risk is expected to be low.

The Bureau of Meteorology lightning-ground flash density indicate 3 to 4 flashes per km² per year (20 to 25 thunder day per km² per year), which is similar to in the Dubbo and Sydney areas and can be managed using Australian Standards requirements AS/NZS 1768 *Lightning protection*.



Source: Extract from EIS

Figure 3: Project Area

2.3 SITE LAYOUT

Two alternative battery storage formats are being considered for the BESS, as follows:

- *Format 1 – Centralised BESS Option:* a large central battery which would sit electrically between the solar farm and substation be positioned adjacent to the substation within the Project Area. This BESS formation would occupy approximately 10 acres of land and comprise multiple (approximately 180) shipping container style enclosures grouped together to house the batteries and the ancillary connection and management equipment enabling the batteries to interface with the solar farm substation and the grid.
- *Format 2 – Distributed BESS Option:* this option comprises the same number (approx. 180) of shipping container style enclosures housing the batteries, but the battery enclosures would be distributed across the Project Area and co-located with each of the solar farm inverter stations that are located throughout the Project Area, adjacent to the PV arrays.

The alternative BESS layouts are provided in Figure 4 (for *Format 1 Centralised BESS option*) and Figure 5 (for *Format 2 Distributed BESS option*).

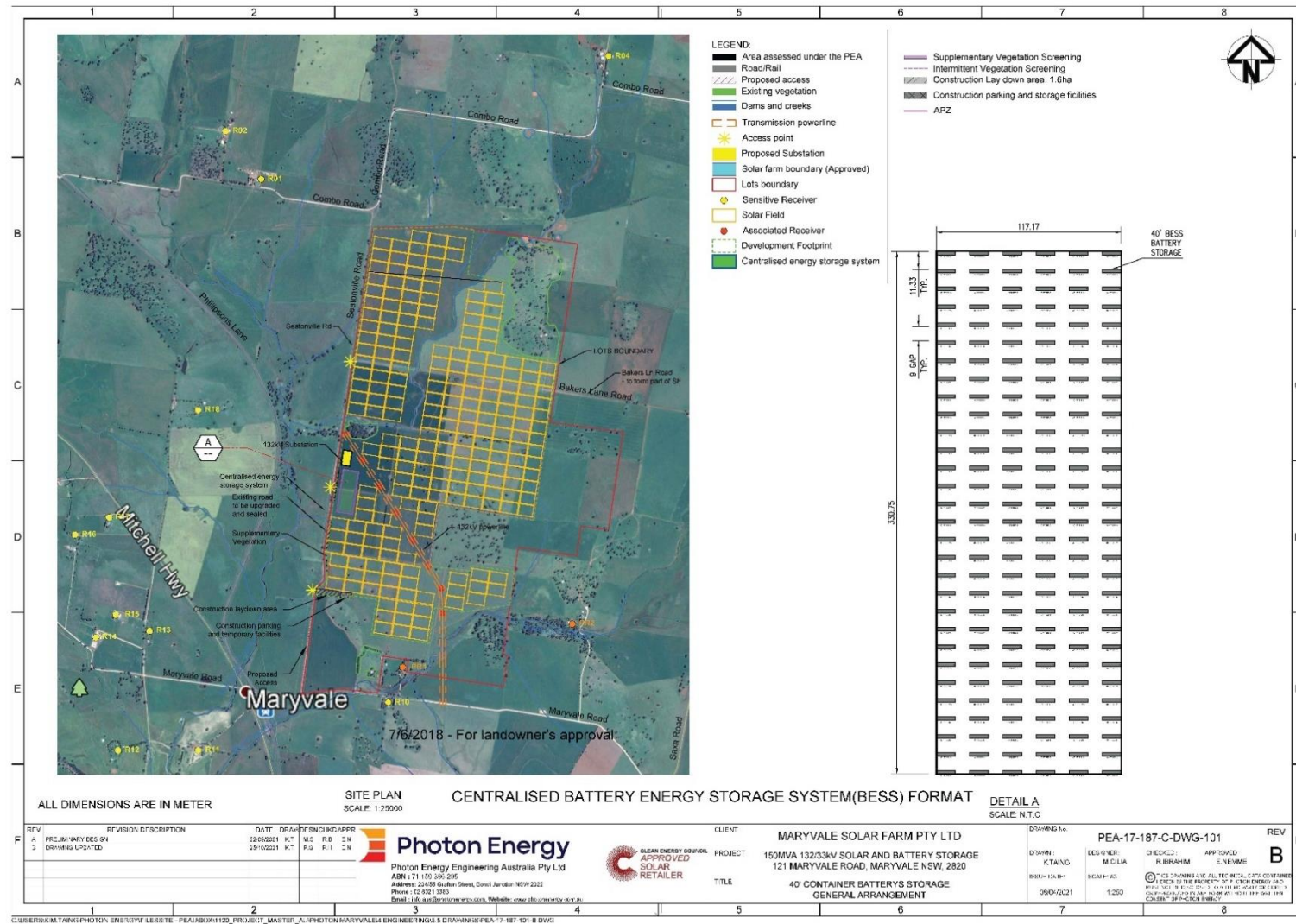


Figure 4: Project Area layout - Format 1 Centralised BESS Option

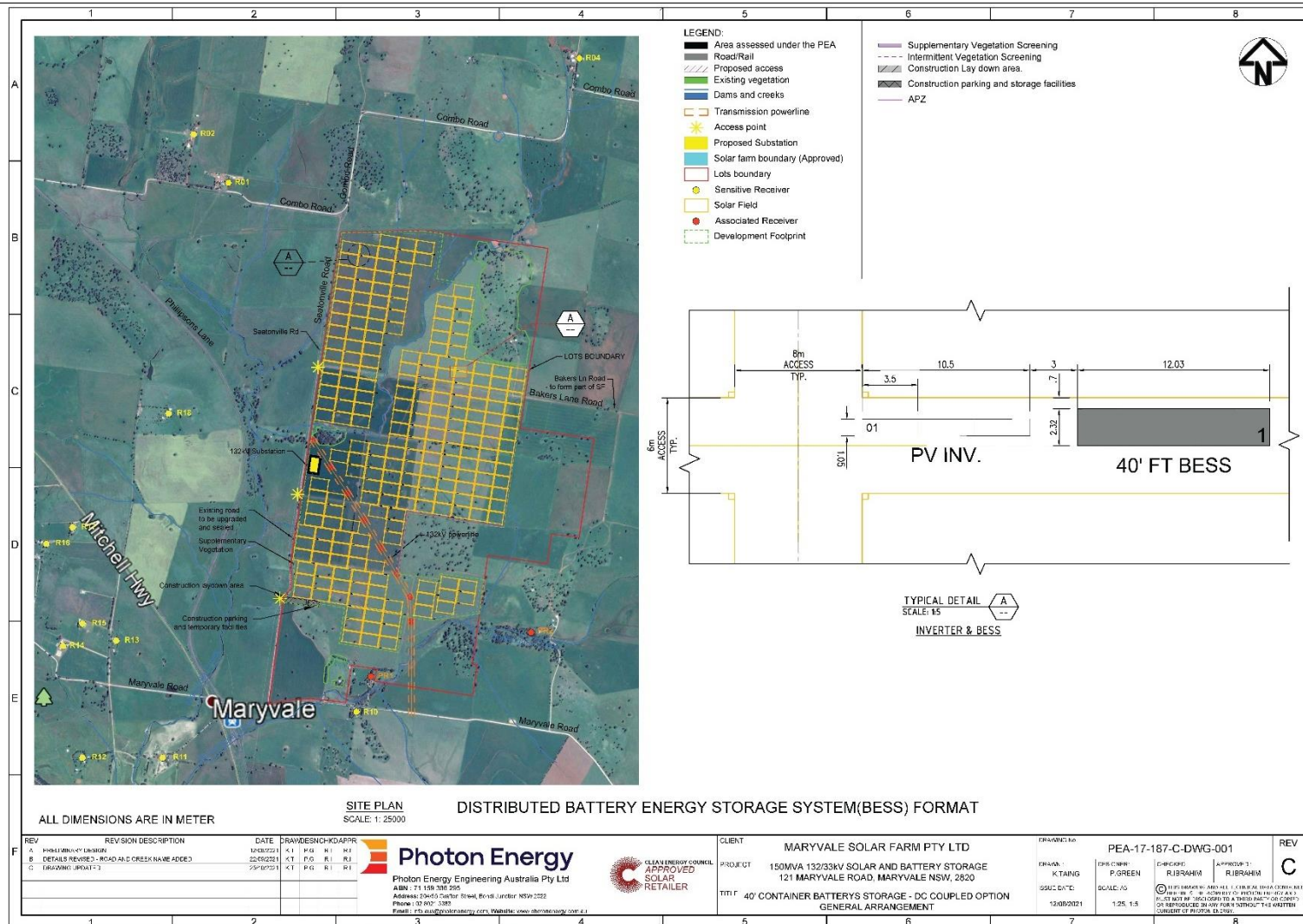


Figure 5: Project Area layout - Format 2 Distributed BESS Option

These BESS works would involve the following infrastructure:

- Lithium-ion (**Li-ion**) batteries inside battery enclosures (non-walk-in), installed outdoors. The batteries would be of lithium iron phosphate (LFP) design. The centralised formation option would include the inverters inside the buildings. In the distributed option, the batteries would be connected to the inverters associated with the solar farm
- Cabling and collector units between the battery enclosures and the substation (centralised formation option) or between the battery enclosures and the solar farm inverters (distributed formation option). The connection between the substation and the existing 132 kV transmission line is already covered in the Maryvale Solar Farm Approval.
- Temporary site office during construction as part of the broader temporary site office accommodation that will be deployed to support construction of the solar farm and BESS
- Asset Protection Zone (**APZ**), security fencing and lighting, access, internal roads and car parking
- Drainage and stormwater management
- Other ancillary infrastructure including communication to the remote SCADA and CCTV.

The batteries would be connected to a Battery Management System (**BMS**), which provides a range of safety measures including:

- Preventing overcharging and current surges
- Maintaining voltage levels and ensuring the automatic cut-out in the event of electrical shorts
- Overheating or other unplanned events.

A Heating, Ventilating, and Air Conditioning (**HVAC**) system would maintain the batteries in the enclosures within safe operational temperature limits.

2.4 TYPICAL OPERATING SCENARIO

The battery would function as either a load or a generator and is expected to be dispatched by an Electricity Market Dispatch Engine (**NEMDE**).

The BESS is expected to operate on a 24 hour per day, seven days per week basis.

The BESS is expected to undergo approximately 1 charge and discharge cycle per day, averaging 350 full cycles per year.

Based on a 125 MW facility, the BESS would have a charge and discharge cycle of up to 375 MWh.

2.5 OCCUPANCY AND OPERATIONAL WORKFORCE

The BESS would be an unmanned facility managed remotely from the off-site control centres to ensure systems are working correctly, investigate alarms and monitor system performance. The BESS would be monitored on a 24 hours per day, seven days per week basis from a remote located control room using SCADA.

Routine inspections and maintenance of the BESS would be undertaken on a regular basis in accordance with the manufacturer's recommendations, with repairs, undertaken on an as needs basis.

Maintenance equipment associated with the BESS will be stored within the shipping containers.

A small area will be maintained for parking of vehicles.

2.6 SECURITY, ACCESS AND EGRESS

There would be no need to modify the site access as part of the addition of the BESS to the Maryvale Solar Farm Project, with the following details defined in the Maryvale Solar Farm EIS (Ref 5):

- Access to the Project Area, including to the BESS, would through the Maryvale Solar Farm, via the new access roads off Seatonville Road
- The access road would be sealed for the first 30 metres to allow for safe construction, operational and decommissioning traffic movements and to reduce potential for dust and erosion. The remaining section of access road would be constructed of suitable compacted gravel and a shaker device will be installed to ensure dust and other material is removed from vehicles and not tracked onto Seatonville Road.

There would be no need to modify the perimeter security fencing due to the addition of the BESS, with the following details defined in the Maryvale Solar Farm EIS (Ref 5):

- The perimeter of the Project Area would be fenced with security fencing at least 1.8m high with 24/7 surveillance cameras.
- The fence would be designed to ensure adequate access and exit points are provided during the construction, commissioning ongoing operational phases of the solar farm and BESS.

2.7 SIGNIFICANT DESIGN STANDARDS, GUIDELINE DOCUMENTS AND REGULATORY COMPLIANCE

The significant statutory framework that apply to ensuring the safety of a BESS, and that forms the basis of this PHA, is listed below² (only those that are directly related to the PHA are included):

Acts and Regulations:

- *NSW Work Health and Safety Act 2011 and Regulation 2017*
- *NSW Electricity Supply Act 1995, Electrical Supply (General) Regulation 2014 and Electricity Supply (Safety and Network Management) Regulation 2014*
- *NSW Environmental Planning and Assessment Act 1979 and Regulations 2000*

Governmental Policy and guideline documents:

- *Hazard Analysis guidelines, 2011 (Ref 1)*
- *Multilevel Risk Assessment guidelines, 2011 (Ref 2)*
- *Planning for Bushfire Protection, 2019 (Ref Error! Bookmark not defined.)*
- *State Environmental Planning Policy No 33, 1992 (SEPP33, Ref 7)*
- *Guidelines for Applying SEPP33, 2011 (Ref 8)*

Codes and Standards

While large-scale BESSs, such as the one proposed for the Maryvale Solar Farm, are relatively new in Australia, there are numerous Australian Codes and Standards and protocols that apply, with a listing of significant Australian Codes and Standards provided in Table 1 below.

In addition, a number of international Codes and Standards apply, including those from the (US) National Fire Protection Association (**NFPA**), (US) Underwriters Laboratories (**UL**), Institute of Electrical and Electronics Engineers (**IEEE**), National Electrical Manufacturers Association (**NEMA**), International Electrotechnical Commission (**IEC**), United Nations (**UN**), and BESS Safety Organization (**BATSO**). The

² The full list of Acts, Codes, Standards and guidelines would be identified by the Photon Energy Engineering Contractor selected for each element of this Project, with the Engineering Contractor ultimately responsible for nominating the applicable Codes and Standards.

reference to such international codes and standards have been listed here, for reference only, and will be defined in the detailed design of the BESS.

Safety aspect	Significant Codes and Standard
Australian Standards	AS 1670: <i>Fire detection, warning, control and intercom systems</i>
	AS/NZS 1851 <i>Maintenance of fire protection equipment</i>
	AS/NZS 1850 <i>Portable fire extinguishers</i>
	AS/NZS 1851 <i>Maintenance of fire protection equipment</i>
	AS/NZS 1850 <i>Portable fire extinguishers</i>
	AS 1939 <i>Degrees of protection provided by enclosures (IP Code)</i>
	AS 1940 <i>The storage and handling of flammable and combustible liquids</i>
	AS/NZS 2430.3 <i>Classification of hazardous areas (all parts)</i>
	AS 3439-2002 <i>Low voltage switchgear and control gear assemblies</i>
	AS 3959-2009 <i>Construction of buildings in bushfire prone areas</i>
	AS 2067 <i>Substations and high voltage installations exceeding 1 kV a.c.</i>
	AS 2374.1-1997 <i>Power transformers Part 1: General</i>
	AS 3959-2009 <i>Construction of buildings in bushfire prone areas</i>
	ASC/ESC 5000: <i>The Australian Battery Guide by the Energy Storage Council</i>
	AS/NZS 5139:2019, <i>Electrical installations — Safety of battery systems for use with power conversion equipment</i> (Ref 9)
	AS/ IEC 60076 <i>Transformer</i>
	AS/ IEC 60364 <i>Low Voltage Installation - Fundamental principles, assessment of general characteristics, definitions</i>
	AS/ IEC 61439-1 & 2 <i>LV switchgear</i>
	AS 61508 <i>Functional safety of electrical/electronic/programmable electronic safety-related system</i>
	AS/ IEC 62271-200 <i>MV switchgear</i>
Australian Codes of practice and guidelines	AS / IEC 62619 <i>Safety requirements for secondary lithium cells and batteries, for use in industrial applications</i> (Ref 10)
	IEC 63056, <i>Safety requirements for secondary lithium cells and batteries for use in electrical energy storage systems</i> (recently published)
	National Network Safety Code ENA DOC 001 – 2008
	National Guideline for <i>Safe Approach Distances to Electrical Apparatus</i> ENA NENS 04 - 2006
	National Guideline for <i>Safe Access to Electrical and Mechanical Apparatus</i> ENA NENS 03 - 2006
	Work Cover Code of Practice <i>Work Near Overhead Power Lines</i> 2006
	Safe Work Australia Code of Practice <i>Managing Electrical Risks in the Workplace</i>
International Codes, for reference	Work Cover Guide <i>Work Near Underground Assets</i> 2007
	The Blue Book 2017: <i>Code of Practice on Electrical Safety for the work on or near high voltage electrical apparatus</i>
	NFPA 855 <i>Standard for the Installation of Stationary Energy Storage Systems</i> (Ref 11)
	NFPA 68 <i>Standard on Explosion Protection by Deflagration Venting</i>
	IEC 62619 <i>Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications</i>

Safety aspect	Significant Codes and Standard
	IEC 62933 <i>Electrical energy storage (EES) systems</i> (including IEC 62933-5-1 <i>Safety Considerations for Grid-integrated EES Systems – General</i>)
	IEC 62116 <i>Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures</i>
	IEC 62897, <i>Stationary Energy Storage Systems with Lithium Batteries – Safety Requirements</i>
	EN 13501-2 <i>Fire classification of construction products and building elements. Classification using data from fire resistance tests, excluding ventilation services</i>
Testing and evaluating BESS to ensure the design prevent propagation in a fire	<u>UL method:</u> - UL 9540 <i>Standard for Energy Storage Systems and Equipment</i>, for the basis for documenting and validating the safety of an ESS as an entire system or product - UL 9540A <i>Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems</i>, for a test method for evaluating thermal runaway propagation in battery ESS <u>IEC method:</u> - IEC 62619 <i>Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications</i> - IEC 63056 <i>Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries for use in electrical energy storage systems</i> (recently published)
Notes: • The Australian Standard AS 5139 (2019) provides the basis for the safety and installation of the BESS in Australia where the individual unit is equal to or less than 200 kWh. The requirements under AS 5239 (2019) should be adhered to, where applicable, including Section 6 which refers to IEC 62619 (Ref 10). • The US National Fire Protection Association Code NFPA 855 (2020) provides the minimum requirements for mitigating the hazards associated with Li-ion BESS of at least 20 kWh. The requirements under NFPA 855-2019 and AS 5239-2019 align in many important areas.	

Table 1: Significant Standards and Codes of practice for the BESS

2.8 MAIN DESIGN PARAMETERS

The BESS design parameters are presented in Table 2.

BESS element	Design parameter
BESS discharge capacity	Up to 125 MW
BESS storage capacity	Peak capacity of 125 MW and storage capacity of up to 375 MWh, used to store energy from the Maryvale Solar Farm
BESS components	▪ the BESS would consist of containerised or stacked Lithium-ion (Li-ion) type batteries³ installed within battery modules and arranged within approximately

³ The cells will be of lithium iron phosphate – LFP – design

BESS element	Design parameter
	180 enclosures (or units) with integrated BMS, ventilation and air conditioning units - Inverters and medium voltage (MV) transformers would be integrated with each group of battery units in the case of <i>Format 1 - Centralised BESS Option</i>, or, for <i>Format 2 – Distributed BESS Option</i>, the battery units would be connected to the inverters that are to be installed as part of the Maryvale Solar Farm project. 33kV or 66 kV cable would connect the solar farm to the BESS and the BESS to the substation in the solar farm. The substation, which forms part of the already approved solar farm, would connect up to the 132 kV transmission line landing gantry (not part of the BESS scope of work) - Ancillary infrastructure including a workshop area, lightning protection, security fencing, CCTV, internal roads Numbers provided are indicative only.
BESS dimensions	- Both BESS format options will fit entirely within the footprint of the Maryvale Solar Farm, which will cover 375 hectares. <i>Format 1 – Centralised BESS Option</i> would cover approximately 4 hectares (10 acres) within the solar farm footprint. <i>Format 2 – Distributed BESS Option</i> would be distributed within the solar farm. - The BESS would include approximately 180 battery units of approximately the same dimensions of a forty-foot container, i.e., length 12.2m, width 2.4m and height 2.6m. The height of the battery units would be maximum 3 metres above ground level, which is 1 metre lower than the maximum height of the approved solar field. The approximate dimensions of a battery unit are presented in Figure 6.
BESS control and safety features	- Fully-integrated operating system for comprehensive control, asset management, and system visibility - BMS for safety functions including emergency shutdown, fire detection and gas detection - Physical safety functions including deflagration panels, lockable disconnect switch, open door sensor, gas spring damper, and sliding door lock.
Design environment	- Maximum and minimum design temperatures to be defined during the detailed design stage - IP rating such that the battery enclosure would be protected against dust ingress that could be harmful for the normal operation of the battery, against solid objects and water spray or jets (level of protection is to be defined in detailed design)

Table 2: Design parameters

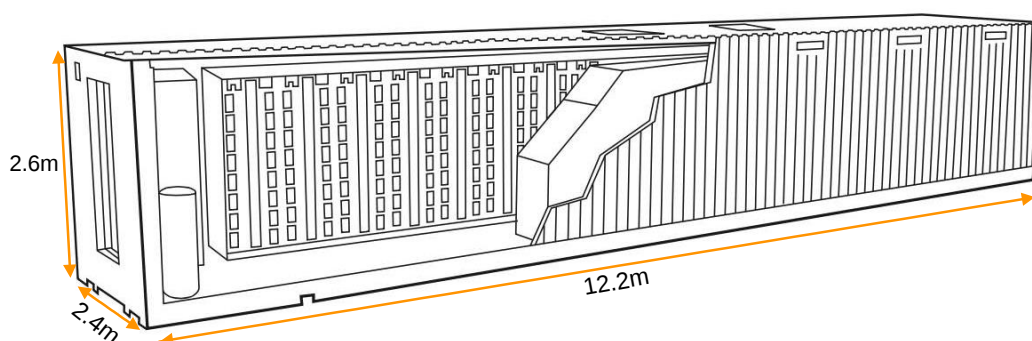


Figure 6: Approximate dimensions of an individual battery enclosure (unit)

3 RISK SCREENING

3.1 OVERVIEW OF THE RISK SCREENING PROCESS

The objective of risk screening as per the MLRA guideline document (Ref 2) is to determine whether a proposed development or facility is considered as *potentially hazardous* as per the following definition by the DPIE:

‘Potentially hazardous industry’ means a development for the purposes of an 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 rigorous PHA as per the requirements set in HIPAP No. 6 (Ref 1) to determine the risk to people, property and the environment.

Additionally, and irrespective of the outcome of the risk screening process, the DPIE can request that a PHA be developed for a proposal, based on other criteria.

If the residual risk exceeds the acceptability criteria, the development is regarded as *hazardous industry* and may not be permissible within NSW.

The risk screening process in the MLRA (Ref 2) considers the type and quantity of *hazardous materials storage* and the distance of the storage area to the nearest site boundary; the expected number of transport movements associated with hazardous material; and *other types of hazards*, refer below:

Hazardous materials are defined within the guidelines as substances that fall within the classification of the Australian Dangerous Goods Code (**ADGC**, Ref 12), i.e. have a DG classification. Detail of the DG classification is typically obtained from the materials’ safety data sheet (**SDS**). The screening threshold in the MLRA methodology presents the quantities below which it can be assumed that significant risk to adjacent land use is very unlikely.

As such, those aspects of a proposed development that are unlikely to present significant risk to adjacent land use can be filtered out from the rest of the PHA, and the PHA can focus on those risks that may have significant risks to adjacent land use.

- *Other types of hazards* are evaluated following the definitions in the MLRA, and include: material incompatibility, reactivity and instability; hazardous wastes; hazardous activities

or process conditions; known past incidents (and near misses) in similar industries; and environmental sensitivity in the local area.

The results of the MLRA screening for the proposed BESS can be found in the following tables:

- Table 3: Hazardous materials storage
- Table 4: Transport of hazardous material
- Table 5: Other types of hazards.

Hazardous material	DG Class	Category	Existing quantities	New (proposed) quantities	SEPP33 threshold	Proposal exceeds SEPP33 threshold?
Lithium ion (Li-ion) batteries	DG Class 9	Miscellaneous dangerous goods	0	Exact weights of these materials are not known at the concept design stage of the BESS project. However, the weight is not expected to impact on the findings and outcomes of or risk screening	DG Class 9 material is excluded from screening process	NO
Coolant may be used in HVAC	Not expected to be a DG	Not expected to be combustible or toxic	0		Non-DG material is excluded from screening process	NO
Refrigerant compressed gas may be used in the battery rack	Expected to be DG Class 2.2	Non-Flammable, Non-Toxic Gases	0		DG Class 2.2 material is excluded from screening process	NO
Oil and other petroleum products	Not a DG	Combustible liquid C1 (AS1940)	0		Combustible liquid is excluded from screening process	NO

Legend: Not hazardous as per MLRA (Ref 2) Potentially hazardous as per MLRA (Ref 2)

Table 3: SEPP33 risk screening summary – Storage of hazardous materials

Hazardous material	DG Class and Packaging Group	Category	Vehicle movements		SEPP33 threshold (vehicles carrying Dangerous Goods)	Proposal exceeds SEPP33 threshold?
			Cumulative annual	Peak weekly		
Li-ion batteries	DG Class 9	Miscellaneous dangerous goods	<i>Ongoing operations:</i> Zero <i>During construction:</i> Much less than the threshold of 1,000 vehicles	<i>Ongoing operations:</i> Zero <i>During construction:</i> Much less than the threshold of 60 vehicles	>1,000 (annual) >60 (peak weekly)	NO
Coolant may be used in HVAC	Not expected to be a DG	Not expected to be combustible or toxic				
Refrigerant compressed gas may be used in the battery rack	Expected to be DG Class 2.2	Non-Flammable, Non-Toxic Gases				
Oil and other petroleum products	Not DGS	Combustible liquid C1 (AS 1940)				NO

Legend: Not hazardous, as per SEPP33 Potentially hazardous, as per SEPP33.

Table 4: SEPP33 risk screening summary – Transport of hazardous materials

Other Types of Hazards	Applicable (Yes or No)	Details - where applicable	Proposal exceeds SEPP33 threshold?
Any incompatible materials (hazardous and non-hazardous materials)	No	No incompatible materials identified for this BESS	NO
Any wastes that could be hazardous	Yes	No significant hazardous wastes identified	NO
Types of activities the dangerous goods and otherwise hazardous materials are associated with (storage, processing, reaction) – if different to Table 1 above	No	No significant hazardous activities associated with DGs identified for this BESS	NO
Incompatible, reactive or unstable materials and process conditions that could lead to uncontrolled reaction or decomposition	Potentially yes	Runaway reaction associated with Li-ion batteries has occurred in other similar industry in the past	YES: potential exists for runaway reaction in a battery cell which may lead to a battery fire
Storage or processing operations involving high (or extremely low) temperatures and/or pressures	No	No extreme conditions with high (or extremely low) temperatures and/or pressures identified as associated with this BESS	NO
Details of known past incidents (and near misses) involving hazardous materials and processes in similar industries	Potentially yes	Runaway reaction associated with Li-ion batteries has occurred in other similar industry in the past	YES: past incidents have occurred in BESS leading to a major incident involving battery cells and battery enclosures
The Project may threaten the particular qualities of the environment (for example, the likely presence of rare or threatened species, water courses)	No	Information available for the Project is such that no significant rare or threatened species, water courses are likely to be affected, and management measures will be incorporated into an overarching CEMP/OEMP or other management plans as required and as specified in the EIS (Ref 5)	NO
The nature of the hazards that the environment will be exposed to, and the likely response of the environment to such a hazard, and the reversibility of any hazardous impact	Potentially yes	Information available for the Project is such that environmental pollution cannot be ruled out at the concept design stage	YES: subject to selection of battery manufacturer and detailed design

Legend: Not hazardous, as per SEPP33 Potentially hazardous, as per SEPP33.

Table 5: SEPP33 risk screening summary - Other types of hazards

3.2 RESULTS OF THE RISK SCREENING

The results of the risk screening, providing a focus for the PHA, are summarised below:

- The expected storage of hazardous materials associated with the BESS would not exceed the relevant risk screening threshold
- The expected transport of hazardous materials associated with the BESS would not exceed the relevant risk screening threshold
- Other types of hazards that require further assessment in the PHA are as follows:
 - Uncontrolled runaway reaction or decomposition within the Li-ion batteries potentially leading to propagation to other infrastructure
 - Environmental impact or health and safety impact from exposure if there is a spill of pollutant from the BESS, e.g. cooling medium or oil. This risk may be ruled out once the battery manufacturer and further project details become known.

4 RISK CLASSIFICATION AND PRIORITISATION

4.1 OVERVIEW OF THE RISK CLASSIFICATION AND PRIORITISATION METHODOLOGY

This process, as demonstrated in Figure 7, begins by prioritising risks with any significant potential to harm people, property or environment for further analysis.

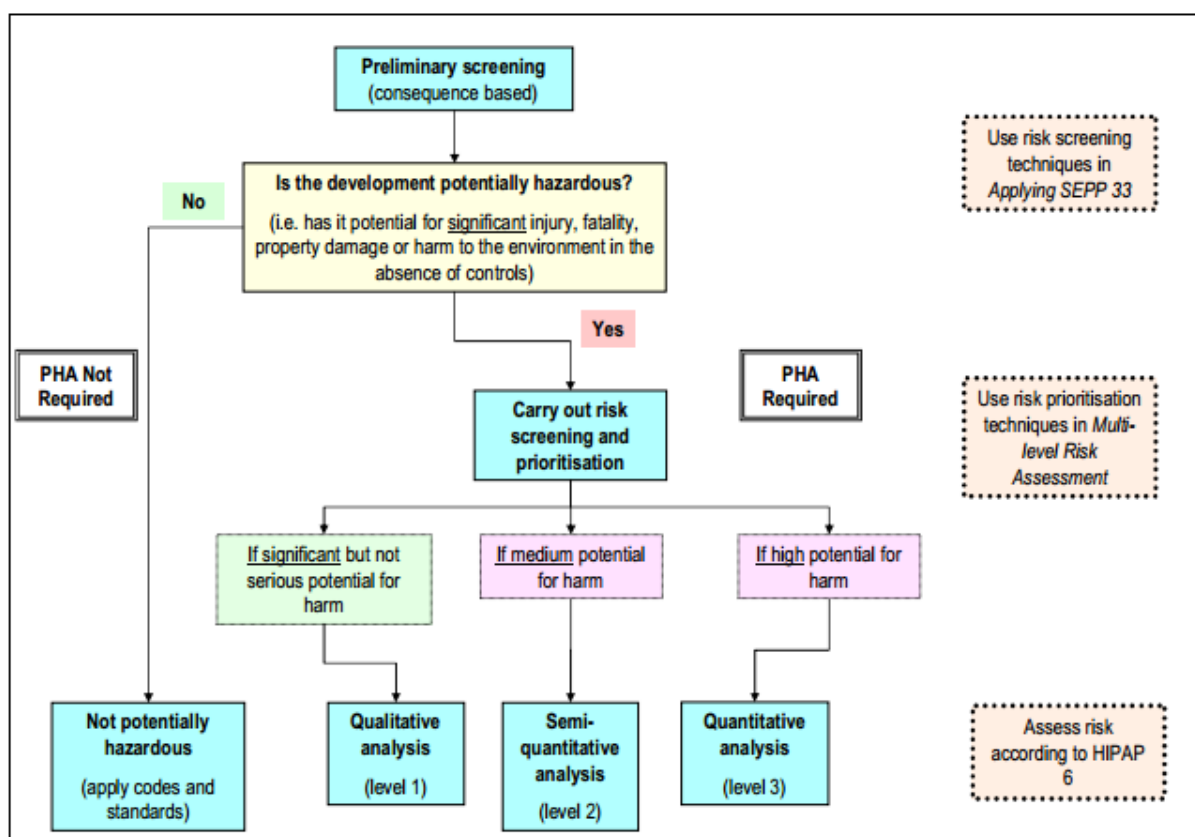


Figure 7: Multi-level Risk Assessment process (Figure 3 of DPIE Multi-Level Risk Assessment guidelines)

The MLRA method is based on the *Manual for the classification and prioritisation of risks due to major accidents in the process and related industries* (IAEA, Rev. Ed. 1996). This method is risk-based and relies on broad estimations of the consequences and likelihoods of accidents. The outputs may be expressed in terms of individual and societal fatality risk, which can be compared against criteria for determining the appropriate level of further assessment.

Using these criteria, the indicative level of risk, as determined in the risk classification and prioritisation stage, may lead to three possible outcomes:

- A level 1 assessment: Can be justified if the analysis of the facility demonstrates societal risk in the negligible zone and there are no potential accidents with significant consequences to adjacent land use
- A level 2 assessment: Can be justified if the societal risk estimates fall within the middle ALARP zone and the frequency of risk contributors having consequences to adjacent land use is relatively low
- A level 3 assessment: Required where the societal risk from the facility is plotted in the intolerable zone or where there are significant risk contributors to adjacent land use, and a level 2 assessment is unable to demonstrate that the risk criteria will be met.

4.2 RESULTS

The assessment found that the worst-case consequence for the identified events is a fire event associated with the BESS. Such a fire may be initiated through a thermal runaway or an electrical fault inside the battery, or potentially from an external event such as a nearby fire or impact/crushing of the battery.

A battery fire would generate heat, toxic gas and combustion products. A major fire associated with a BESS has the theoretical potential to propagate to areas outside of the Project Area and initiate a brush/bushfire.

Provided the battery is designed such that a battery fire will not propagate to other battery enclosures and that sufficient separation distances are established between the Project infrastructure and the surrounding land, including through the establishment and maintenance of the APZ (refer to the Bushfire Assessment in Ref 3), the risk of a major BESS fire involving more than one enclosure is low and can be managed ALARP.

Another potential high consequence event that cannot be screened out at the concept stage of the BESS design relates to a failure to capture a loss of containment of oil or, potentially, cooling water or refrigerant from the batteries, subject to detailed design. The detailed design stage needs to ensure that the risk of a spill and runoff into local surface waters and groundwater systems or ground pollution, or hazardous exposure to personnel and emergency services is eliminated where possible or reduced to low risk if elimination is not possible.

Provided the battery enclosures are designed such that a fire or deflagration event in one enclosure would not propagate to other enclosures, and that an appropriate APZ is established and maintained, none of the consequences of potential hazardous incidents associated with the BESS have a potential to any significant societal risk of harm to people outside of the Project Area boundary.

Societal risk from the BESS would be within the negligible zone and a Level 1 risk assessment can be justified.

5 RISK ANALYSIS AND ASSESSMENT

5.1 HAZARD IDENTIFICATION

The hazard identification consists of the following steps:

- 1) List of hazardous properties of materials - Section 5.1.1
- 2) Identification of potentially hazardous incidents and their control - Section 5.1.2.

5.1.1 Material hazardous properties

The potentially hazardous properties of materials expected to be stored and handled during the construction, commissioning and operations phases of the BESS are detailed in Table 6.

The inventories expected during the commissioning and operations phases are provided in the MLRA in Table 3 above. Only small amounts of hazardous materials are expected to be used during the construction phase, as typical for any construction, and are not detailed in this PHA.

Material	Description and potential hazards
<i>Design and construction phase</i>	
Flammable & combustible material	Limited amounts of flammable or combustible material (e.g. diesel, petrol, superglue, solvents, thinners and paints) and of corrosive and toxic liquids (e.g. small containers of hydrochloric acid and other corrosives for surface preparation, pesticide for ground clearing etc.) are expected to be stored and handled during the construction phase of the BESS. Specifications for the safe handling and storage of these chemicals include bunding and ventilation arrangements, control of ignition sources, and requirements for personal protective equipment.
Corrosive liquids and aerosols	Adherence to Australian Standards (e.g. AS1940 <i>The storage and handling of flammable and combustible liquids</i> and AS3780 <i>The storage and handling of corrosive substances</i>) apply for the management of risks of these chemicals. Contractor management systems would be set up and SWMS, JHAs and Permits would be used. Provided that the internal (the Applicant) and external (Australian Dangerous Goods Codes and Standards) requirements are followed, the risks associated with these chemicals is low.
<i>Commissioning and operations phases</i>	
Li-ion batteries and BESS	Fire at a Li-ion battery may be caused through uncontrolled reaction (e.g. thermal runaway), overcharge, short-circuit, damage or decomposition within the cell. Thermal runaway is triggered when the cell reaches a certain temperature (probably around 160°C). The heat source can be external or internal (i.e. due to cell failure). A fire event would generate heat, possible deflagration overpressure if flammable vapours were ignited, and toxic gas and combustion products. Depending on the design and manufacture of the Li-ion battery, projectiles or cell explosions in case of failure to vent off-gases may occur (Refs 11, 13). Toxic vapours formed during a fire event may contain decomposition products which can vaporise and be vented from cells, and the vented electrolyte may be flammable, and may ignite (Ref 13). BESS cell vent gas composition would depend upon a number of factors, including cell composition, cell state of charge, and the

Material	Description and potential hazards
	cause of cell venting. Vent gases may (in general) include volatile organic compounds (VOCs), hydrogen gas, carbon dioxide, carbon monoxide and soot, as well as, depending on the battery manufacturer, particulates containing oxides of nickel, aluminium, lithium, copper, and cobalt, and phosphorus pentafluoride (PF5), phosphoryl fluoride (POF3), and hydrogen fluoride (HF) vapours (Ref 13). Vented gases may irritate the eyes, skin, and throat. Cell vent gases are typically hot and upon exit from a cell, can exceed 600°C (Ref 13). If the burning battery cells are located close to combustible material within the enclosure, or close to other battery cells that can go into runaway reaction, or if the enclosure is located close to other infrastructure, there is a potential for escalation within the enclosure, to adjacent enclosures and infrastructure and, potentially, to the entire BESS. The result would be increasing generation of heat and toxic gases and combustion products. If the BESS is located close to the surrounding environment, including to neighbouring bushland, the fire may propagate to this, potentially initiating fire in the surrounding area. The heat and toxic gases and combustion products generated by the fire involving only one battery or battery enclosure are unlikely to cause any significant hazardous effects off-site (Refs 14, 15, 16). However, if the fire continues to spread to other enclosures then further hazardous effects may occur, potentially affecting land use outside of the Project Area. Therefore, the battery and battery enclosure design and the BESS layout must be such that the potential for propagation to adjacent enclosures and other infrastructures is eliminated or at least minimised. Separation distances to minimise the risk of propagation to adjacent infrastructure and to surrounding bushland would be established at detailed design, using, as one of the inputs, fire tests (e.g. those conducted in accordance with Underwriters Limited UL9540A or the equivalent IEC test method (refer to Table 1). Further, sufficient APZ must be established to ensure the risk of propagation to and from the surrounding bushland is minimised (Ref 3).
Coolant	It is expected that some type of coolant will be used in the HVAC, which is expected to be non-DG and of low hazard. Example of a typical battery coolant would be a mixture of ethylene glycol and water. Pure ethylene glycol is a combustible liquid (Ref 17). However, when mixed as a solution with water in industrial application it becomes non-combustible. If water is driven off in a fire it can participate in the combustion reaction. Further details of the coolant (if present) would be determined at detailed design.
Refrigerant	It is possible that the battery rack would include a refrigerant, expected be composed of a single or a mixture of non-flammable non-toxic compressed gases DG Class 2.2. The chiller unit may explode if heated. Contact with compressed gases may cause frost bite. Exposure is harmful (all routes). Further details of the chiller gases (if present) would be determined at detailed design.
Oil and other petroleum products	Oil is expected to be used and handled, e.g. as insulating oils. The main hazard associated with oils relates to environmental pollution in case of a loss of containment, and with toxicity in case of human exposure. If a spill reaches surface water, petroleum products can kill aquatic wildlife. Oil is combustible and, while difficult to ignite in atmospheric conditions, it can participate in a fire and can pose a serious fire hazard if not contained.

Table 6: Summary of main materials hazards

5.1.2 Identification of potential hazardous incidents and their control

The following factors were considered in order to determine the key potential hazardous incident associated with construction and operation of the BESS:

- BESS infrastructure, location, workforce, local environment, adjacent land use
- Materials and energies, properties and associated hazards
- Type of equipment and known major incidents that have occurred in BESS elsewhere
- Recent developments in research and standards for BESS (Australia and internationally)
- Construction, commissioning, operation and maintenance activities and potential threats
- External factors (bush fire, lightning, land slide, earth quake, strong winds, dust storm etc).

An overview of the types of hazards associated with the BESS and the electrical connection is provided in Table 7.

BESS element	Electrical hazards	Energy hazard	Fire hazard	Explosive hazard	Chemical/pollution hazard	Toxic fume hazard	Reference, see Section 2.7
BESS	✓	Note 1	Note 2	Note 3	Note 4	✓	AS 5139 / NFPA 855
33kV or 66kV electrical connection	✓	✓	✓	✓	-	✓	AS 2067 / AS 1940

Notes:

1. Arc flash incident potential
2. Fire may be caused by thermal runaway, short circuit, over voltage/overcharge
3. If the BESS releases hydrogen under fault conditions it is regarded as an explosive gas hazard (Ref 9)
4. Failure to contain a spill may have a potential to cause pollution, subject to detailed design

In addition, mechanical hazards are associated with the BESS, e.g. weight, sharp edges & corners, moving parts, falling over, tripping, seismic, and lack of lifting or securing

Table 7: Types of hazards associated with the BESS (HIPAP6 hazards only)

By analysing the types of hazards, the key potential hazardous incidents associated with the BESS (including the electrical connection) can be defined, as listed in Table 8 below.

Hazardous incident title	
<i>Construction phase</i>	<i>Commissioning and Operations phases</i>
1. Impact, e.g. due to toppling of major lifting equipment; dropping of heavy equipment; failure to manage traffic etc., leading to injury and initiation of a major incident due to crushing, pinching etc. of the battery	5. Fire in the battery cell (e.g. due to thermal runaway) and generation of toxic and pressurised gases and vapours
2. Hitting above / underground services leading to injury, fire, environmental damage and propagation to neighbouring plant and equipment	6. Loss of containment of pollutant material from the BESS (potentially involving cooling water, refrigerant, oils) with potential exposure and pollution hazards
3. Injury due to loss of control during construction work (work at heights; confined space; trench/pit collapse; struck by; electrocution; rotating equipment; high pressure equipment etc.)	7. External event impacts the BESS with subsequent initiation of major incident scenarios 5-6 (above)
4. Injury or environmental damage or damage to property from general construction works, e.g. failure to manage vehicular access, laydown areas, excavations, loss of water & sediment and loss of containment of fuels, oils, grout, corrosives, pesticides etc.	8. Electrical fault inside battery enclosure or inverters causing fire or injury

Table 8: Key potential hazardous incident scenarios

5.2 RISK ANALYSIS AND ASSESSMENT

The hazardous consequences and associated preventative and mitigating strategy of the above incident scenarios are listed in Table 9 below.

Consequence and likelihood estimation was based on Planager's experience in similar industry and on literature reviews, including the most current research and standards in BESS operation and lessons learned from major incidents that have occurred in BESSs elsewhere.

The likelihood of the event was determined assuming application of preventative and mitigative controls. The risk levels are ranked in accordance with the risk matrix in Appendix 2 which has been calibrated to DPIE risk criteria (HIPAP4, Ref 4).

Safety and Risk Issue	Required Controls	Risk assessment		
		Consequence	Likelihood	Risk
Construction phase		Duration of the phase		
1. Impact at BESS enclosure during construction due to: - toppling of major lifting equipment - dropping of equipment during heavy lift - failure to manage traffic etc. Leading to injury and initiation of a major incident	The Applicant and Contracting Company’s Policies and Procedures, including pre-starts; lift studies; exclusion zones during lifts; PTW, SWMSs, JSEAs, Induction, training & competency The work will be planned such that conflicting tasks in the work area are avoided. Adequate space will be confirmed prior to initiating plant manoeuvring and load and unload operations Traffic Management Plan will be established Adherence to SafeWork NSW and other Codes of Practice Initiation of the Emergency Management Plan for construction activities	SERIOUS OR MAJOR	RARE TO UNLIKELY	MODERATE
2. Hitting above / underground services (e.g. transmission line) leading to injury, fire, environmental damage and propagation to neighbouring plant and equipment	The Applicant and Contracting Company’s Policies and Procedures with requirement for appropriate safety measures to prevent incidents and injury Adherence to SafeWork NSW and other Codes of Practice Clearances for restricted spaces will be maintained and overhead spotter assigned for work near the transmission line The work will be planned such that conflicting tasks in the work area are avoided. Adequate space will be confirmed prior to initiating plant manoeuvring and load and unload operations SWMS / PTW / JSEAs etc. Induction and training; Competency. Services search at set-up (DBYD including utility owners individual requirements) Pre-start and tool boxes Non-destructive pot holing, hand digging close to services, cable location and marking off of all services.	SERIOUS OR MAJOR	RARE TO UNLIKELY	MODERATE

Safety and Risk Issue	Required Controls	Risk assessment		
		Consequence	Likelihood	Risk
3. Injury due to loss of control during construction work incl. during work at height, confined space, slip-trip-fall, trench / pit collapse, bites (snakes, spiders, mosquitos), struck by, electrocution, high pressure equipment, hoses, pumps & rotating equipment, cutting, grinding	The Applicant and Contracting Company's Policies and Procedures with requirement for appropriate safety measures to prevent incidents and injury, including trench management, management of hot works, confined space work and work at heights, SWMS, PTW, JSEAs etc.; Training, Induction & Competency. Overhead spotter assigned for work near overhead transmission line Adherence to WorkSafe and other Codes of Practice Scaffolding / Elevated Works Platform as / if required Testing for potential contaminants in the ground and, if required, establishment of procedures Construction Management Plan (as required), including requirements for prevention and protection to define specific key control measures First Aid kits Safety showers / eye wash stations available as required	SERIOUS OR MAJOR	RARE TO UNLIKELY	MODERATE
4. Injury or environmental damage or damage to property (including initiation of bushfire) due to failure to manage vehicular access, laydown areas, excavations, water & sediment, containment of fuels, oils, grout, corrosive liquids, pesticides, hot works, security breach etc.	Construction Management Plan (as required), including contractors Control Plans to define specific key control measures Erosion and sediment control Prestart including weed control where required, (as per Construction Management Plan Control measures expected to include (not limited to): storage of hazardous substances in accordance with Australian Standards (e.g. AS1940 and AS3780), SDS and other safety specifications including use of bunds and drip trays; spill response equipment kept on site; Emergency Response Plan; regular checks and maintenance of machinery, plant and equipment, pre-start, tool boxes SWMS, JSEAs, PTW including hot work permit Spill kits During construction, the areas would be manned and temporary fences would be installed Emergency Response Plan	MEDIUM TO SERIOUS	UNLIKELY	MODERATE

Safety and Risk Issue	Required Controls	Risk assessment		
		Consequence	Likelihood	Risk
Commissioning and operations phases		Duration of the phase		
5. Thermal runaway in the battery, e.g. due to: - imbalanced charge, - mechanical failure (cell defect, crush, damage), - overtemperature (BMS / HVAC failure, propagation from nearby fire including bushfire or electrical infrastructure failure). Leading to: - fire, explosion and generation of toxic gases; - potential for injury and property damage; - potential propagation to surrounding grassland.	The BESS Units would be designed such that a fire in one Unit (e.g. from a thermal runaway in the battery cells, electrical fault or other cause) would not propagate to other Units. This would be achieved through passive fire protection or active fire suppression system, to be defined in detailed design and tested to UL 9540A and/or IEC 62619 (or equivalent) requirements BESS designed and operated to ASC/ESC 5000: <i>The Australian Battery Guide by the Energy Storage Council</i> requirements and to one or more of the major international BESS Codes, e.g. NFPA855 or IEC equivalent Installation and maintenance by trained personnel using SWMS. Induction of all personnel prior to work. All relevant Australian Standards and the Applicant’s internal requirements met, including procedures, PTW, isolation (including MV/HV), control of modifications, inspection regimes etc. Warning signs (electrical hazards, arc flash, entry procedures into battery enclosure etc.) BMS fully functional including preventing overcharging and current surges in the batteries; maintaining voltage levels; and ensuring automatic shut-down in the event of electrical shorts, overheating or other unplanned events. The BMS will also include and manage signals from fire and gas detection system. Batteries never operated with BMS bypassed with hardwired trips. Preventative maintenance and condition monitoring of electrical equipment and batteries, including thermography as, recommended by the battery manufacturer Battery enclosures with outwardly opening door and battery racks accessed from the outside with no personnel entering the enclosures during operation. Illuminated warning signs on the outside of the enclosure that indicate a hazardous environment inside the enclosure. Key locked cabinets, electrical rooms and battery enclosures. Physical safety functions to ensure that the door is closed during battery operation Ventilation of gases produced in the battery to safe location, including pressure release vent(s) (/panel(s) Toxic combustion products or gas released from battery fault conditions would be evacuated such that people can escape from the area Use of appropriate PPE, including to protect against arc flash. Emergency response including activation of local emergency shutdown (ESD button) as required in Codes and Standards, and initiation of Emergency Response Plan. Emergency services personnel aware of possible toxic gas hazard Asset Protection Zone (APZ) established and maintained	MAJOR	RARE	MODERATE

Safety and Risk Issue	Required Controls	Risk assessment		
		Consequence	Likelihood	Risk
6.. Loss of containment of pollutant material from the BESS (e.g. the cooling water from the HVAC system) due to: - mechanical failure - damage - abnormal heating. Leading to release of pollutant material and potential for hazardous exposure and environmental pollution	Equipment and systems designed and tested to comply with the relevant Australian and international Standards and guidelines Battery design such that there is no releasable pollutant / hazardous material with the exception of low hazard cooling and/or refrigeration medium. Design of cooling and refrigeration systems such that a loss of containment is prevented, and the cooling medium has low toxicity and irritation potential. Low volumes of pollutant material Detection and automatic shut-down and automatic safety shut-down in case of failure of the HVAC system which would result in safe battery operational limits being exceeded The battery is housed in contained enclosures PPE in use. Need for safety shower / eye wash station to be determined in detailed design Emergency response to be determined in detailed design and may include spill clean-up using dry absorbent material and activation of Emergency Response Plan for major spills	MEDIUM	UNLIKELY	LOW
7. External event impacts the BESS including from: - bush/grass fire - natural event (lightning strike, wind, flood) - impact by on-site vehicular traffic - vandalism, security breach with subsequent initiation of incident scenario(s) number(s) 1 to 4 (above)	APZ established and maintained. Ground surface within BESS maintained as per APZ. Requirements for brush / bush firefighting to be defined in detailed design and in consultation with Fire Services. Construction activities undertaken using PTW, including for hot work Earthing and bonding of electrical equipment Lightning protection to be determined in detailed design Equipment housed in IP rated enclosures constructed in accordance to relevant Standards and above flood level. Low earthquake risk at the Project Area, and design to earthquake requirements as per AS5139 Wind damage prevented through bracing, fixing and/or tie-downs for the conditions and design to AS1170.2 <i>Structural design actions - Wind actions</i> Speed restrictions enforced on site including through Contract WHS requirements. Mandatory Induction for all persons coming onto the Site. Traffic management plan established Fenced area prevents wildlife, cattle, etc. accessing the site Security protocol and CCTV Need for fire suppressant (inside the battery enclosures and potentially using fire water from outside of the enclosure) to be determined during detailed design Fire water to be available to combat bush / grass fire in accordance with the requirements in the bushfire risk assessment (Ref 3) Activation of the Emergency Response Plan	MAJOR	RARE	MODERATE

Safety and Risk Issue	Required Controls	Risk assessment		
		Consequence	Likelihood	Risk
8. Electrical fault at electrical equipment causing - fire - arc flash - pressure wave - toxic combustion products, - burns and injury - exposure to intense light/ noise - exposure to voltage - pollution Leading to injury or potential for propagation to adjacent infrastructure and areas (e.g. surrounding grassland)	Equipment and systems designed and tested to comply with the relevant Australian and international Standards and guidelines Installation and maintenance by trained personnel using SWMS. Induction prior to work PTW (including hot work) and control of modifications Preventative maintenance and condition monitoring including thermography, following manufacturer's recommendations Automatic activation of local emergency shutdown through equipment management system (e.g. BMS) The equipment housed in dedicated enclosures. Only restricted personnel allowed. Key locked cabinets and electrical rooms. Warning signs (electrical hazards, arc flash) Use of appropriate PPE Separation distance between infrastructure in accordance with Codes and Standards minimises the risk of escalation Infrastructure is located in open area which minimises the risk of accumulation / ingress and exposure of toxic combustion products. No normally occupiable buildings as part of the BESS (except for the temporary office during the construction period) Toxic combustion products or gas released from fault conditions would be evacuated such that people would be able to escape from the area and not be exposed at adjacent egress routes Bunding and containment of oils or other pollutants as per Code requirements, including AS1940, AS3780 Emergency response including activation of local emergency shutdown (ESD button) as required in Codes and Standards, and initiation of Emergency Response Plan. Fire extinguishers available to combat small electrical fires Asset Protection Zone (APZ) established and maintained. Vegetation management near the battery enclosures	MAJOR	RARE	MODERATE

Table 9: Key potential hazardous incidents and associated controls, construction and operations phases

The risk profile for the BESS project is consistently between *Low* and *Moderate* risk, as per the definition in the matrix in Appendix 2. Out of the eight (8) risk identified for this BESS, the following risk levels apply:

- Construction phase
 - All four (4) scenarios are of *Moderate* risk.

The scenarios identified for the construction phase are typical for such activities, with the fact that it involves a BESS has very little impact on the risk profile of the construction phase.

- Commissioning and operations phases:
 - Three (3) scenarios are of *Moderate* risk
 - One (1) scenarios is of *Low* risk.

Scenarios. numbers 5. to 7 are specific to a BESS and involve a potential for a fire or an environmental release involving the battery or associated functions (e.g. the HVAC). Scenario 8 involves electrical hazards and is typical to any major electrical installations.

The consequences level assigned to the *Moderate* risk scenarios is associated with major injury or major environmental damage, in line with the focus of this PHA.

The analysis found that the likelihoods of all events can be managed to *Rare* or *Unlikely* levels as per the definition in the matrix in Appendix 2. This should be verified in detailed design.

6 CONCLUSION AND RECOMMENDATIONS

6.1 OVERVIEW RESULTS AND ALARP CONDITION

The following factors must coincide to give rise to an exposure to a dangerous dose – the combination of the likelihood of the hazardous event and the probability of the last two dot points give rise to the risk of the event:

- Failure must occur causing a release of hazardous material or energy.

There are several possible causes of failure, with the primary ones being failure to manage operation conditions, thermal runaway within a battery, failure to maintain the integrity of plant and equipment and damage to the equipment by external impact

- Depending on the release conditions, including the energy generated, e.g. from a BESS runaway reaction, the results may be localised within the battery rack or enclosure, or extend past the local area and
- Finally, for there to be an exposure, people, property or the environment must be present within the harmful range (consequence distance) of the hazardous doses. How close the sensitive receptors are would determine whether any injuries, fatalities, pollution or damage results.

The main hazards identified for the BESS are associated with a fire event affecting the batteries:

- A BESS fire has the theoretical potential to propagate to areas outside of the battery enclosure and even to initiate a bushfire in the surrounding grass land.
- This presents the only potential impact from the BESS to society outside of the Project Area.
- Provided the batteries and the battery enclosures are designed and tested to withstand a credible fire scenario, and that sufficient separation is established within the BESS and between the BESS and the surrounding grassland (through an APZ, Ref 3), the risk of propagation from one battery enclosure to another, and to surrounding grassland, can be managed ALARP.

Environmental pollution may be possible, subject to detailed design, in the event of a failure to contain pollutants at the BESS:

- If a spill is not contained, there is a potential to affect adjacent land use.
- Measures to prevent a loss of containment from occurring, and for secondary containment, would be addressed in the detailed design phase for the BESS.

-
- Provided that the likelihood of a serious loss of containment event associated with this BESS are eliminated or designed to *Unlikely* or *Rare* levels (refer to the risk matrix in Appendix 2), the risk of environmental pollution can be managed to ALARP principles.

The analysis conducted as part of this PHA has found that the BESS can be managed in accordance with the established risk criteria and in accordance with ALARP principles.

Most hazards can be prevented by employing a combination of common measures, including following all applicable AS/NZ Standards, separation distances and setbacks, physical protection and control systems measures.

Mitigation measures are available, to reduce the severity of the hazards should they occur, including specific secondary containment, e.g. as built into the battery enclosure, and the BESS operational training.

Provided the commitment for safety and environmental protection, and the recommendations in this PHA are adhered to, the risk profile for the BESS is consistently within the *Low* or *Moderate* risk ranking and ALARP can be established.

An overview of the risks associated with the BESS is provided in Table 10. This table also includes a brief summary of the ALARP condition – more details are provided under each hazardous event in Section 5.2.

BESS element and hazard	Finding	Risk and ALARP evaluation
Risk of major injury or environmental damage during construction	Construction risks are well known and understood. Existing Codes and Standards are established within the industry to manage construction risk to ALARP principles. The risk arises from typical construction activities and the impact of the BESS on the risk is minimal.	MODERATE RISK: Can be managed to ALARP principles provided general construction Codes and Standards are adhered to.
Fire and pollution at the BESS as initiated by an internal or external event during commissioning or operation	Codes and Standards provide clear guidance as to how to prevent and protect against a fault in a battery escalating into a fire at a battery enclosure. Key controls include continuous BMS with automatic shut-down; battery fire proven not to propagate in accordance with international methodologies (e.g. UL9540, IEC 62619, IEC 63056 or similar); and establishment of minimum separation distances within the BESS and between the BESS and external boundaries. As a precautionary approach, a fire water tank should be installed at the boundary, for firefighting in the surrounding grassland. The need for external firefighting is unlikely, to be reviewed in the detailed design in consultation with RFS, FRNSW and DPIE. On-site hazardous effects are possible in case of a battery fire, and the risk associated with of generation of toxic gas and toxic combustion products should be minimised in design, safe evacuation from the facility should be considered, and should be considered in emergency response (e.g. by external authorities). Environmental pollution may be possible, subject to detailed design, from a failure to pollutants, and the need for secondary containment of a spill should be considered in detailed design. Provided all key controls are established, the risk associated with the BESS can be managed ALARP.	MODERATE RISK: Can be managed to ALARP principles provided the battery and the enclosure designed such that a credible fire will not propagate; the requirements in Codes and Standards are adhered to; and the minimum separation distances within the BESS and an appropriate APZ are established and maintained
Fire and pollution at the electrical infrastructure during commissioning or operation of the BESS	Provided the requirements under the Australian Standards (e.g. AS 2067 & AS 1940) and the Applicant's management practices for Low Voltage and Medium Voltage systems are adhered to, the risk associated with fire and with environmental pollution at the electrical infrastructure associated the Battery Energy Storage System can be managed ALARP.	MODERATE RISK: Conforms to ALARP provided the requirements in Codes and Standards & the Applicant's management practices are adhered to

Table 10: Overview of risks assessment results and ALARP conditions

6.2 RECOMMENDATIONS

The following recommendations are made as part of this PHA:

1. The separation distance between infrastructure within the BESS is to be determined in accordance with Codes and Standards and manufacturer's recommendations so that the preferred strategy of allowing a fire in one battery enclosure or inverter to burn without the risk of propagating to other infrastructure can be maintained without the need for external firefighting
2. The separation distance within the BESS is to be determined in accordance with Codes and Standards and manufacturer's recommendations to allow safe escape from the BESS in case of a fire
3. All relevant requirements in the Australian Standard 5139 (2019) are to be adhered to at the BESS. The BESS should also adhere to requirements in international Standards applicable to major BESS, for example, to the US NFPA 855 (2020).
4. Procurement of a battery system that is certified to UL 9540 and/or IEC 62619, proving that a credible fire within a battery unit will not propagate to other battery units
5. Detailed firefighting response and need for fire water containment should be assessed and reported (e.g. in the format of a Fire Safety Study) post development approval, for review by the DPIE, NSWFR and the RFS
6. Measures to prevent a leak occurring at the BESS, and for containment of a spill of pollutant from the BESS, should be addressed in the detailed design phase for the BESS
7. The specific risk associated with the potential for dust storms and ingress of dust causing damage to infrastructure needs to be integrated into the design and the BESS manufacturers, Project contractors and the Applicant's staff need to be aware of this threat during BESS design, construction and operation
8. The register of commitment (Appendix 1 of the PHA) is integrated into the BESS. This includes integration of 29 individual commitments, including for the design, installation and maintenance of the BESS automatic shutdown system on exceedance of safe limits; installation of deflagration venting and fire protection inside the battery enclosures; design of the BESS such that the risk of pollution from a release is reduced to ALARP; installation of protective barriers e.g. at the transformers and fire resistance of the battery enclosures; and application of a rigorous and formal management of change process for the BESS, including detailed hazard identification and risk assessment processes.

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Appendix 1

Register of commitments

Preliminary Hazard Analysis for Maryvale Battery Energy Storage System, NSW

Appendix 1 – Register of commitments

This PHA has been developed on the bases that the following commitments by the Applicant will be integrated into the BESS Project:

Type of safeguard	Register of commitments: Preventative and protective safeguards
Prevention and detection	1. All equipment and systems would be designed and tested to comply with the relevant Australian / International Standards and Codes 2. Equipment would be procured from reliable and internationally recognised supplier with proven track-record 3. Equipment would be installed by Contractors following the Applicant's internal requirements for Contractor management, PTW, control of modifications and other established systems 4. All installation and maintenance would be performed by trained persons using SWMS 5. The BESS would follow rigorous Management of Change process throughout its life. This will include management of protective systems including trips and alarms within the BMS 6. Induction of all personnel would occur prior to works commencing 7. Electrical isolation protocol would be in place during construction and installation as well as during commissioning and operation of the BESS 8. PTW, including hot work permits would be in place during construction and installation as well as during commissioning and operation of the BESS 9. Preventative maintenance practices would be put in place, including maintenance schedules and calibration of equipment, instruments and sensors, APZ and vegetation control within the BESS, and thermography and other Non-Destructive Testing (NDT) 10. Impact barriers would be installed to prevent damage from vehicles and heavy machinery 11. Warning signs would be installed as per Code and Standards requirements, including DG signage and MV warnings (including arc flash) 12. Earthing of electrical equipment would be established 13. Need for lightning protection would be determined in accordance with the Applicant's requirements and Australian Codes at the detailed design stage 14. The BESS would be housed within a secure fenced area. On-site security protocols developed. Temporary fences would be installed during construction where appropriate

Type of safeguard	Register of commitments: Preventative and protective safeguards
	15. Battery Management System (BMS) would be installed, including voltage control, charge/discharge current control and temperature monitoring to battery manufacturer's specifications. Automatic safety shut-down function would be initiated in case of safe limits exceeded 16. Secondary detection would be installed in the enclosure, to manufacturer's recommendations (e.g. smoke/heat), with information transferred to the BESS control room so that, if there is a fire, smoke or excessive temperature the battery module would isolate and shut down 17. Alarms would be available to provide hazard warning on operations upset conditions, and fault conditions would be transmitted to permanently staffed control room located remotely. The control room would be permanently staffed and operators would be able to manually shut down and isolate a battery enclosure 18. The batteries would be housed within dedicated enclosures. Personnel entry during a hazardous event such as a run-away would be prevented 19. BESS enclosure venting would be achieved to reduce concentrations inside the enclosure as per requirements in Codes and Standards 20. Escape from the BESS would be assured in accordance with Code requirement 21. Explosion venting and venting of toxic or flammable gases, would be achieved as per Codes and Standards and in accordance with manufacturer's instructions 22. Fire water would be available at the BESS, to combat bush / grass fire in accordance with the requirements in the bushfire risk assessment (Ref 3) 23. Fire suppressant inside the battery enclosures, and any need for fire water at the BESS (e.g. hydrants and hoses), would be determined during detailed design and through consultation with FRNSW and RFS 24. The risk of seismic activity, dust storm and severe winds would to be integrated into the design for this BESS 25. Separation distances would be established between infrastructure at the BESS, to minimise risk of propagation of a fire event in accordance with Codes and Standards and manufacturer's recommendations 26. APZ would be established in accordance with the Bushfire Assessment (Ref 3)

Appendix 2

Risk Matrix

Preliminary Hazard Analysis for Maryvale Battery Energy Storage System, NSW

Appendix 2 – Risk assessment risk matrix

LIKELIHOOD		CONSEQUENCES						
		% chance	Frequency (t/year)	Minor	Medium	Serious	Major	Catastrophic
		Probability of occurrence in the period evaluated	Duration of construction or life of operation of the BESS	No physical injury / work stress or environmental consequences	Medical treatment / First aid injury or environmental clean up	Serious injury - LTI or serious environmental damage	Permanent disability or minor environmental damage	Fatal injury, existential threat, or environmental destruction
	Almost certain	90%	>0.04	MODERATE	HIGH	EXTREME	EXTREME	EXTREME
	Likely	50%-89%	0.02-0.04	MODERATE	HIGH	HIGH	EXTREME	EXTREME
	Possible	15%-49%	0.006-0.02	LOW	MODERATE	HIGH	HIGH	EXTREME
	Unlikely	5%-15%	0.002-0.006	LOW	LOW	MODERATE	HIGH	HIGH
	Rare	<5%	0.002-1x10 ⁻⁶	LOW	LOW	LOW	MODERATE	HIGH
	Hypothetical	N/A	<1x10 ⁻⁶	LOW	LOW	LOW	MODERATE	MODERATE

RANGES - GROUPED BY PRIORITY AND ACTION

Risk rating	Action
LOW	Risk considered acceptable - proceed with work
MODERATE	The proposed task or process can proceed provided that: - the risk level has been reduced as low as reasonably practicable using the hierarchy of controls - The risk assessment has been reviewed and approved - All administrative controls are in place
HIGH	The proposed activity can only proceed provided that: - the risk level has been reduced as low as reasonably practicable using the hierarchy of controls - The risk controls must include those identified in legislation, AS/NZ Standards, Code of Practice - The risk assessment has been reviewed and approved - All administrative controls are in place The effectiveness of the implemented control measures must be reviewed and documented
EXTREME	The proposed task or process activity must not proceed. Steps must be taken to lower the risk level to as low as reasonably practicable using the hierarchy of controls

Appendix 3

Assumptions and justification

Preliminary Hazard Analysis for Maryvale Battery Energy Storage System, NSW

Appendix 3 – Assumptions and justification

Assumption No. 1: Generation of hazardous energies and gases in a battery fire

Assumption:

- A fire event within a battery would generate heat, deflagration overpressure and toxic gas and combustion products
- Depending on the design and manufacture of battery, this may lead to projectiles or cell explosions in case of failure to vent off-gases
- Toxic gas and combustion products formed during a fire event may contain decomposition products which can vaporise and be vented from cells, and the vented electrolyte may be flammable, and may ignite
- BESS cell vent gas composition would depend upon a number of factors, including cell composition, cell state of charge, and the cause of cell venting
- Depending on battery manufacture, vent gases may include volatile organic compounds (VOCs), hydrogen gas, carbon dioxide, carbon monoxide, soot, and particulates containing oxides of nickel, aluminium, lithium, copper, and cobalt, and phosphorus pentafluoride (PF5), phosphoryl fluoride (POF3), and hydrogen fluoride (HF) vapours
- Vented gases may irritate the eyes, skin, and throat. Cell vent gases are typically hot and upon exit from a cell, can exceed 600°C

Justification and impact/s of assumption/s:

- Latest available data by the NFPA and the Fire Protection Research Foundation (an affiliate of NFPA)
- Review of research report into Li-ion battery safety in the programs conducted by DNV; the large-scale battery tests conducted by FM Global; and the research by the Victoria University in conjunction with the Maritime Division, Defence Science & Technology Group

Incidents Affected:

- Battery fires, scenarios 5 and 7

Reference/s:

- Blum A, Long T, *Hazard Assessment of Lithium Ion BESS Energy Storage Systems*, Fire Protection Research Foundation, February 2016
- NFPA 855-2020 *Standard for the Installation of Stationary Energy Storage Systems*, (US) National Fire Protection Association, 2002

Assumption No. 2: Potential for propagation

Assumption:

- If the battery cells on fire are located close to other batteries or combustible material within the enclosure or if the enclosure is located close to other infrastructure, there is a potential for escalation to other battery racks, the enclosure, to adjacent infrastructure and, potentially, to the entire BESS
- The result would be increasing generation of heat and toxic gases and combustion products
- In the case of more than one battery enclosure being involved in a fire the rate of failure, and hence rate of evolving heat and toxic combustion products, would be randomised and staggered, limiting the heat release and toxic release rate of the fire
- If the BESS is located close to the surrounding environment, including to neighbouring bushland, the fire may propagate to this, potentially initiating fire in the surrounding area
- The heat and toxic gases and combustion products generated by the fire involving only one battery/battery enclosure are unlikely to cause any significant hazardous effects off-Site.
- If the fire continues to spread to other enclosures then further hazardous effects may occur, potentially affecting land use outside of the Site boundary.
- Risk of propagation of a fire between battery enclosures is eliminated or at least minimised provided that the battery enclosure has been designed and tested in accordance UL9540 and/or IEC62619 / IEC63056 and the BESS layout adheres to Australian and international Codes and standards
- APZ determined and maintained as per Australian Code minimises risk of propagation to and from the surrounding bush

Justification and impact/s of assumption/s:

- NFPA 1-2021 *Fire Code*
- NFPA 855-2020 *Standard for the Installation of Stationary Energy Storage Systems*
- Test methods (UL and IEC, refer References below) developed as large-scale fire tests for battery energy storage systems. These methods provide data to validate BESS design and installations
- UL9540 is referenced in NFPA 855, ICC IFC and NFPA 1 as the large scale fire test to use if required per these codes
- UL 9540A includes: *Cell level test*: whether the battery cell can exhibit thermal runaway, thermal runaway characteristics and the gas composition and properties. *Module level test*: propensity for propagation of thermal runaway, heat and gas release rates (severity/duration) and flaming/deflagration hazards. *Unit level test*: fire spread, heat and gas release rates (severity/duration), deflagration hazards and re-ignition hazards. *Installation level test*: effectiveness of fire protection system(s), heat and gas release rates (severity/duration), deflagration hazards and re-ignition hazards.
- Detailed comparison between UL test and IEC test shows similar outcomes between test methods.

Incidents Affected:

- Battery fire

Reference/s:

- 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 63056 *Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries for use in electrical energy storage systems (recently published)*
- UL 9540 *Standard for Energy Storage Systems and Equipment, for the basis for documenting and validating the safety of an ESS as an entire system or product*

- UL 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems, for a test method for evaluating thermal runaway propagation in battery ESS*
- Florence L, *UL and IEC Standards: A Comparison in the Approach to Safety of Energy Storage Systems*
- Hill D, Warner N, Kovacs W, *Considerations for ESS Fire Safety*, Consolidated Edison and NYSEDA New York, NY, DCN: OAPUS301WIKO(PP151894), Det Norske Veritas (USA) Inc. (DNV GL), Rev. 4, 9 February 2017
- Ditch B, Zeng D, *Development of Sprinkler Protection Guidance for Lithium Ion Based Energy Storage Systems*, FM Global, Project ID RW000029, June 2019
- Mohammadmahdi G, Novozhilov V, Burch I, Suendermann B et al, *A Review of Lithium-Ion Battery Fire Suppression*, Institute of Sustainable Industries and Liveable Cities, Victoria University, Melbourne and the Maritime Division, Defence Science & Technology Group, : 1 October 2020

Assumption No. 3: Fire suppression and fire fighting

Subject: Likelihood and risk

Assumption:

- APZ established and maintained
- Ground vegetation maintained to APZ levels
- Fire water would be available for combatting grass fires
- The need for further active firefighting measures within the BESS will be determined during detailed design and in consultation with DPIE, FRNSW and RFS
- AS 2419 Fire Hydrant Code does not apply to a BESS

Justification and impact/s of assumption/s:

- Australian and International Codes and Standard do not prescribe firefighting measures for BESSs
- Battery manufacturer's recommendations for fire suppression would be provided in detailed design
- A Fire Safety Study, developed in consultation with the FRNSW, RFS and the DPIE, would determine any need for further fire suppression or fire fighting

Incidents Affected:

- Battery fire

Reference/s:

- HIPAP2 *Fire safety study*, DPIE 2011
- NFPA 855-2020 *Standard for the Installation of Stationary Energy Storage Systems*
- ASC/ESC 5000: *The Australian Battery Guide by the Energy Storage Council*
- AS 2419.1 Fire hydrant installations - System design, installation and commissioning
- RFS' *Planning for Bushfire Protection*
- AS3959 *Construction of buildings in bushfire prone areas*

Appendix 4

Estimated footprint of the BESS

Preliminary Hazard Analysis for Maryvale Battery Energy Storage System, NSW

Appendix 4 – Estimated footprint of the BESS

Format 1 - Centralised BESS Option

The BESS would consist of a number of battery enclosures. The images below are indicative of the general appearance of a *Format 1 - Centralised BESS Option* when coupled with a solar farm, where all of battery units and ancillary buildings are located together.

The BESS proposed for the Maryvale Solar Farm will be approximately five times the size of this system shown in Image 1, containing approximately 180 battery enclosures. An example configuration of the battery enclosures is provided in Image 2. .



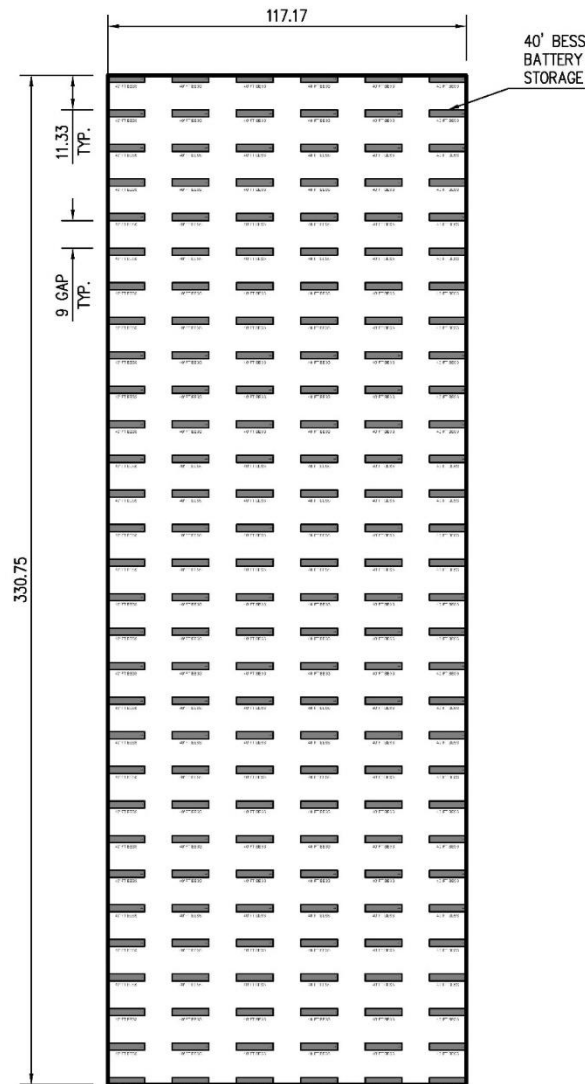
Image 1: Illustration of a Centralised BESS (referred to as *format 1* in this report) coupled with a solar farm (5 times smaller than the Maryvale BESS) – for illustrative purposes only



Image 2: Example configuration of battery enclosures (units) – for illustrative purposes only

A generic layout of the Maryvale *Format 1 – Centralised BESS Option* is provided in Image 3.

- The Centralised BESS is shown, with 180 battery enclosures (units) providing the building blocks for the BESS.
- Additional to this, there would be car parking area as well as internal and perimeter roads, security fence and APZ.



Note: All measurements in meters

Legend:	
	Battery enclosures (180 in total), Length x Width: 12.2m x 2.4m
	Centralised BESS Option footprint, Length x Width 330.75m x 117.17m

Image 3: Generic layout for the Centralised BESS

While the separation distances between enclosures would be determined during detailed design, the concept design separation distance between the enclosures is 9 metres.

This would enable safe access for lifting equipment.

It would also allow for access and egress of personnel, providing in excess of the clearance for the case where the doors in adjacent cubes are in the open position.

Provided the battery enclosure is certified to UL9540A⁴ or to other internationally recognised test methods (e.g. IEC 63056 and/or IEC 62619), this separation distance is regarded as sufficient to prevent a runaway fire in one battery from propagating to adjacent batteries, or to adjacent enclosures.

Using the dimensions and separation distances in Image 3, the total footprint for the BESS development would be 9.6 acres (or about 3.9 hectares). Additional to this would be a access roads, APZ, car parks, security fence, CCTVs etc.

The Applicant's expected dimensions for the *Format 1 – Centralised BESS Option* is 10 acres (4 hectares) which would fit in comfortably within the available land.

Format 2 - Distributed BESS Option

The images below are indicative of the general appearance of a solar farm with a distributed Battery Energy Storage System (BESS), where the battery units (approx. 180 units) are distributed throughout the solar farm.

These images are of existing constructed projects for illustration purposes.

⁴ UL 9540A provides an internationally recognised Test Method for evaluating the potential for thermal runaway fire propagation in BESSs. The NFPA 855 allows BESS units to be installed at less than 1 metre separation distance provided they have been designed and installed such that large scale fire testing, conducted in accordance with the UL 9540A *Test Method* shows that runaway fire will not occur.



Image 3: Illustration of a Distributed BESS (referred to as *format 2* in this report) coupled with a solar – for illustrative purposes only



Image 4: Close up of example of battery unit with inverter adjacent to solar panels – for illustrative purposes only

The *Format 2 - Distributed BESS Option* would fit in comfortably within the available land.