APPENDIX 11
REVISED PRELIMINARY HAZARD ASSESSMENT

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UPC Renewables Australia Pty Ltd

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STUBBO SOLAR FARM
PRELIMINARY HAZARD ANALYSIS

Bright ideas. Sustainable change.

STUBBO SOLAR FARM
PRELIMINARY HAZARD ANALYSIS

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APPENDICES

Appendix 1
Preliminary Hazard Assessment

1. INTRODUCTION

1.1 Background

UPC Renewables Australia Pty Ltd, operating as UPC\AC Renewables Australia (UPC\AC), the Proponent, proposes to develop the Stubbo Solar Farm, a grid-connected photovoltaic solar farm of up to 400 megawatts in the New South Wales (NSW) Central West Orana region (the project). The project would be located approximately 90 kilometres east of Dubbo, in the Mid-Western Regional Council Local Government Area (LGA).

The project is located within the proposed Central-West Orana Renewable Energy Zone, recently identified by the NSW Government to help meet its objective to achieve net zero emissions by 2050. The project would include the construction, operation and decommissioning of a 400 megawatt solar farm that would supply electricity to the National Electricity Market (NEM).

A development application (DA) and environmental impact statement (EIS) were submitted for the project under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) on 11 December 2020. The EIS included a Preliminary Hazard Analysis (PHA) undertaken for the project in accordance with *Hazard Industry Planning Advisory Paper No.6 – Guidelines for Hazard Analysis* (Department of Planning, 2011) (HIPAP) and *Multi-Level Risk Assessment* (Department of Planning, 2011) (refer to Chapter 15 of the EIS). The DA and EIS for the project were publicly exhibited from 12 January 2021 to 19 February 2021.

As a result of ongoing discussions with the local community, project landholders and other stakeholders, UPC\AC has made several further amendments to the project that was the subject of the DA and EIS. Subsequently, a separate amendment report has been prepared to outline the changes to the project that have been made since the public exhibition of the EIS and provide a summary of the impacts associated with the amended project.

Following receipt of the amendment report and the response to submission report, the Department of Planning, Industry and Environment will prepare its assessment report considering the EIS, subsequent amendments and clarifications to the project, and responses to submissions received during the exhibition process to make a determination on the project.

1.2 Purpose of the report

This updated PHA has been prepared to consider and assess the potential hazards and risks posed by the project and the management measures proposed to address these potential hazards and risks in accordance with the requirements of the *Hazardous and Offensive Development Application Guidelines Applying SEPP 33* (Department of Planning, 2011) (SEPP 33 Guideline) associated with the amended Stubbo Solar Farm project.

This PHA is intended to: address comments made by DPIE on the EIS; provide clarification on the potential arrangement for the battery energy storage system (BESS); and to capture the potential hazards and risks associated with both a centralised and de-centralised option for the BESS. This report is intended to replace Chapter 15 of the EIS.

1.3 Scope of works

1.3.1 Secretary's environmental assessment requirements

A list of the Secretary's Environmental Assessment Requirements (SEARs) relevant to the PHA and where they have been addressed in this report is provided in **Table 1-1**.

Table 1-1: SEARs and where each requirement has been addressed in this PHA

Requirement	Where addressed
General Requirements	
• an assessment of the likely impacts of the development on the environment, focusing on the specific issues identified below, including: – a description of the existing environment likely to be affected by the development; – an assessment of the likely impacts of all stages of the development, (which – is commensurate with the level of impact), including any cumulative impacts of the site and existing or proposed developments in the region (including the approved Beryl and Wollar Solar Farms and the proposed Dunedoo Solar Farm), taking into consideration any relevant legislation, environmental planning instruments, guidelines, policies, plans and industry codes of practice; – a description of the measures that would be implemented to avoid, mitigate and/or offset the impacts of the development (including draft management plans for specific issues as identified below); and – a description of the measures that would be implemented to monitor and report on the environmental performance of the development;	**Chapter 4** and **Chapter 5**
Key issues	
The EIS must address the following specific matters:	N/A
• Hazards and Risks – including:	N/A
– Battery Storage – include a Preliminary Hazard Analysis (PHA) prepared in accordance with *Hazard Industry Planning Advisory Paper No.6 – Guidelines for Hazard Analysis* (DoP, 2011) and *Multi-Level Risk Assessment* (DoP, 2011), demonstrating that the battery energy storage system is suitably located and minimises risks to neighbouring land uses and onsite substation(s); and	This report
– an assessment of potential hazards and risks including but not limited to bushfires, spontaneous ignition, electromagnetic fields or the proposed grid connection infrastructure against the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields.	**Section 4**

1.3.2 Environmental impact statement review comments

The Department of Planning, Industry and Environment provided comments from the Department of Planning, Industry and Environment Hazards Group (Hazards Group) on the hazards and risks chapter (Chapter 15) from the EIS. The key issues raised by the Hazards Group and a response to each issue is provided in **Table 1-2**.

Table 1-2: Response to issues raised by Hazards Group

Key Hazards Group Issues	UPC/AC Response
The Hazard Register and Risk Analysis are significant portions of any PHA if prepared to be consistent with the Department's *Hazardous Industry Planning Advisory Paper No. 6, 'Hazard Analysis'* (HIPAP 6)	Refer to **Appendix 1**.
It should be noted that Section 2.2 – General Principles of HIPAP 6 states the PHA must be "… *specifically tailored to address technical controls, operational and organisational issues and locational issues of a particular facility or operation. Judgment is required on the appropriate methodology and depth of analysis required based on the nature and scale of the development, the type of operations being carried out, the location of the facility and external influences*"	This principle has been applied throughout the PHA.
Need to verify if the findings, analysis and assessment are applicable to the Stubbo SSD	It is acknowledged that the previous PHA in the EIS was based on the PHA prepared for the New England Solar Farm EIS. This was largely due to the similarities between the expected technologies, area and scale of the development, and similar land uses. This PHA has been reviewed to confirm it is site and project specific.
Need to confirm that the SSD can comply with the Department's *Hazardous Industry Planning Advisory Paper No. 4, 'Risk Criteria for Land Use Safety Planning'*	**Section 4.1.1** and **Appendix 1**.
Need to provide recommendations specific to this SSD if necessary	**Section 5** includes the updated management and mitigation measures relating to hazards and risks for the project.
There have been significant developments into research and standards for BESS since the 2018. As such, it is expected that the technical advice will consider these developments. Of particular note (not exhaustive) are NFPA 855, AS 5139, IEC 62897, UL 9540, UL 9540A and the FM Global's *Development of Sprinkler Protection*	Refer to **Table 2-2**.

Key Hazards Group Issues	UPC/AC Response
Guidance for Lithium Ion Based Energy Storage Systems. Where certain aspects of the scope or requirements from these publications may not align exactly, best practice should be considered in the design of the BESS while taking into account the principles from these publications	
Of particular importance are separation distances between: • BESS sub-units, ensuring that a fire from a sub-unit do not propagate to neighbouring sub-units; and • the overall BESS and other on-site and off-site receptors, ensuring fire safety	Refer to **Section 2.1.2** and **Section 4.1.5**. The BESS sub-units would be spaced at a suitable distance to provide for safe access, maintenance and operation. The appropriate spacing would be determined during detailed design of the project, would comply with any relevant Australian Standards and guidelines at the time and would be considered in the Fire Safety Study, which would be prepared and submitted to the Department prior to construction.
The technical advice should verify if the proposed BESS capacity would be able to fit within the designated area for BESS	The BESS would be either a centralised 'AC Coupled' BESS adjacent to the grid substation in either location A or B as shown on **Figure 2-1**; or a decentralised 'DC Coupled' BESS with small BESS units connected to some or all of the PCUs distributed throughout the site. The preferred option will be selected during detailed design and would be contained wholly within the designated development footprint.

1.4 Document structure

This report is structures as follows:

- **Section 1. Introduction** – provides background on the project and introduces the document purpose and structure
- **Section 2. The Project** – describes the project including the refinements made following submission of the EIS and the potentially hazardous elements of the project
- **Section 3. Assessment Methodology** - provides an overview of the methodology used to assess the hazards and risks associated with the project
- **Section 4. Potential Impacts** – provides a detailed summary of the potential hazards and risks associated with the project
- **Section 5. Management and Mitigation Measures** – provides an updated summary of management and mitigation measures
- **Section 6. References.**

2. THE PROJECT

2.1 Key project elements

2.1.1 Project overview

The project would include the construction, operation and decommissioning of a 400 megawatt solar farm that would supply electricity to the NEM. Key infrastructure for the project would include:

- photovoltaic modules (solar panels) installed in a series of rows across the development footprint
- power conversion units (PCUs) designed to convert the direct current (DC) electricity generated by the photovoltaic modules into alternating current (AC) form, compatible with the electricity network
- onsite substation containing two main transformers and associated switchgear
- transmission infrastructure including up to 33 kilovolt overhead and/or underground electrical reticulation; and connection from the substation to the existing 330 kilovolt transmission line (Line 79) operated by TransGrid
- a centralised or decentralised battery energy storage system (BESS)
- The decision on whether a centralised or decentralised BESS would be implemented would be determined during the procurement and detailed design phase. As such both options have been considered in this report.
- operational and maintenance ancillary infrastructure including staff office and amenities, car parking, spare parts storage and maintenance facilities; and supervisory control and data acquisition (SCADA) facilities
- access roads, both to the project and internal access roads
- temporary facilities required during the construction and decommissioning phases, such as construction compounds and laydown areas, site office and amenities; and access tracks and associated infrastructure, including gates and fencing.

The permanent and temporary components associated with construction and operation would be located within the development footprint.

Designated environmental exclusion zones have been included within the development footprint, intended to minimise impacts of the development in the areas of highest environmental value.

The project is expected to require up to 400 full-time employees during peak construction and approximately 10 full-time employees would be required during operation and ongoing maintenance of the solar farm.

2.1.2 Project changes following submission of the EIS

The only change to the Project is the upgrade of the intersection of Cope and Blue Springs Roads in accordance with Austroads Guide to Road Design.

2.2 Potentially hazardous project elements

The Hazard Identification and Analysis presented in **Appendix 1** identifies the potential hazards in the project: the locations that they could occur; the potential event that could lead to the hazard; the potential cause/s of the potential event; the potential consequences; and the proposed controls. The following describes the key potential hazards.

2.2.1 Hazardous materials

Table 2-1 lists the hazardous materials to be handled during the project, the expected maximum quantity stored at one time throughout all project stages, the predicted transport movements, and the potential hazards associated with each material.

The vehicle movements presented in **Table 2-1** are those forecast during the construction and/ or commissioning stages. The transportation of the majority of these materials would either: only occur during construction and/ or commissioning of the project; or be substantially lower during operation of the project.

In addition to the hazardous materials described in **Table 2-1** the project would also require storage and use of the following chemicals:

- Transformer oil
- MCPA (2-methyl-4-chlorophenoxyacetic acid) (for use as herbicide/pesticide).

Both of these chemicals are not classified as hazardous material and are therefore excluded from the risk screening. They would not be stored with other flammable materials and therefore they are not considered to be potentially hazardous under *State Environmental Planning Policy No 33—Hazardous and Offensive Development* (SEPP 33).

2.2.2 Other hazards and risks

UPC\AC has undertaken hazard identification with consideration of the following project factors:

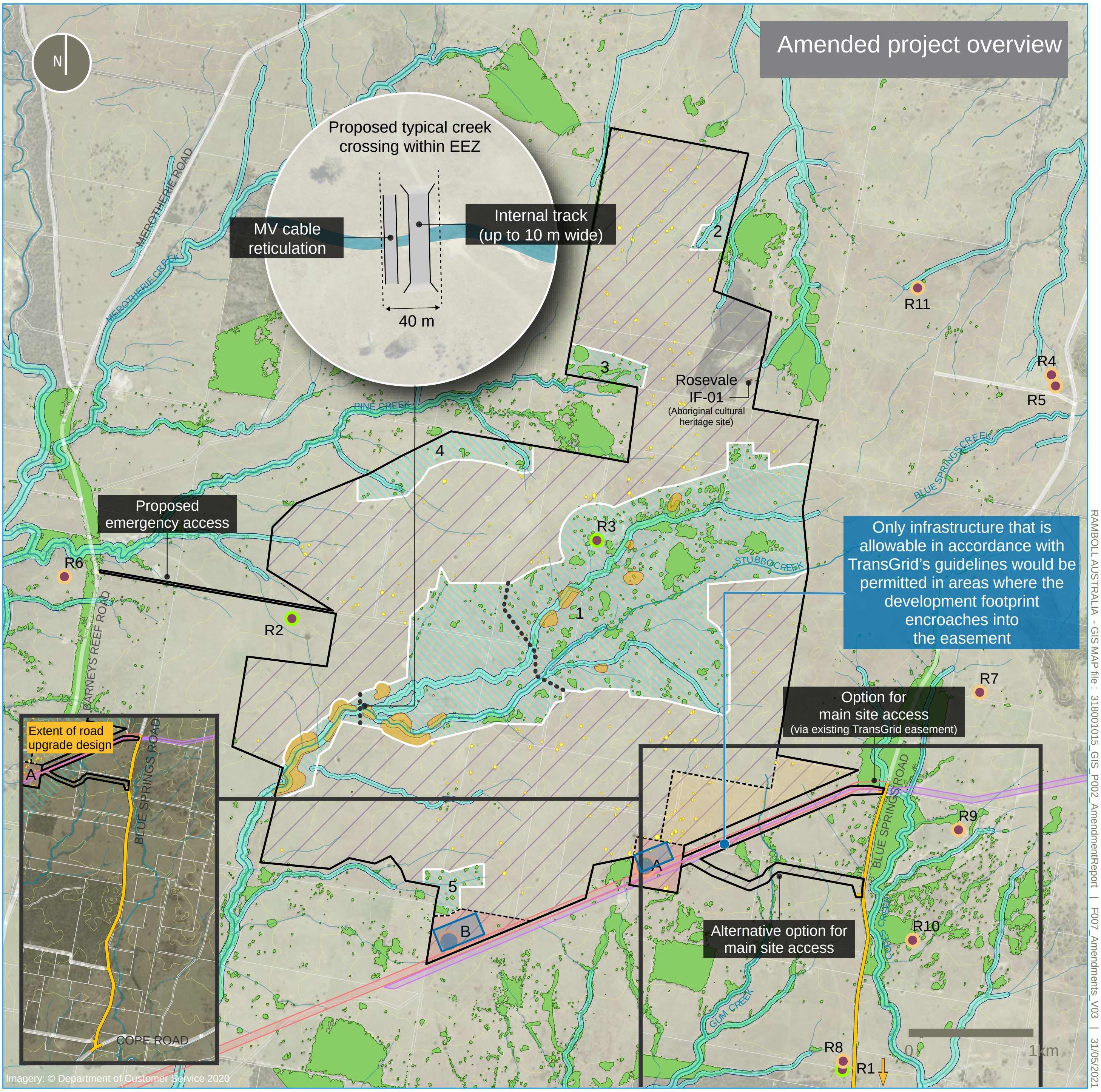
- project infrastructure
- type of equipment
- hazardous materials present
- proposed operation and maintenance activities
- external factors.

Events with the potential to result in major consequence impacts to people (injury and/or fatality), the environment and project assets (excluding workplace health and safety hazards such as slips, trips and falls) were identified:

- **electrical**: exposure to voltage
- **arc flash**: release of energy
- **electromagnetic fields (EMF)**: exposure to EMF
- **fire**: infrastructure fire and bushfire
- **chemical**: release of hazardous materials
- **reaction**: battery thermal runaway
- **external factors**: bushfire, vandalism, lightning storm.

Table 2-1: Hazardous materials, expected quantities and potential hazard

Material/ Usage	Dangerous Goods Class	Hazardous material Category	Expected maximum stored quantity (tonnes)	Peak storage project stage	Vehicle movements		Minimum quantity per load (tonne)	
					Cumulative annual	Peak weekly	Bulk	Packages
Liquefied Petroleum Gas (LPG)	2.1	Flammable gas	9.5	Construction	>500	>30	2	5
Refrigerant	2.2	Non-flammable Non-toxic gas	14.3	Operation	-	-	-	-
Gasoline	3 PG II	Flammable liquids	5	Construction	>750	>45	3	10
BESS	9	Miscellaneous dangerous goods	4,800	Operation	>1000	>60	No limit	-



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Key

- Study area
- Indicative temporary construction ancillary facilities (site compound, laydown area and car park)
- Proposed operational infrastructure area including substation, operational facility and BESS
- Indicative connection point to the NEM (option A or B)
- Road upgrade design
- Indicative subdivision area
- Proposed development footprint
- Environmental exclusion zones
- Indicative access across EEZ
- 330kV transmission line easement
- 66kV transmission line easement
- Road
- Creek
- Sensitive receivers: Associated
- Sensitive receivers: Non-associated
- Vegetation to be removed
- Native vegetation to be retained
- Riparian buffer
- Aboriginal cultural heritage sites including buffer

Figure 2-1 | Amended project overview

Electromagnetic fields

EMF occur both naturally in the environment and are produced wherever there is a flow of electricity. Electric fields are associated only with the presence of electric charge, whereas magnetic fields are the result of the physical movement of electric charge.

The 330-kilovolt transmission line that forms part of the southern boundary of the study area is an existing EMF source.

The project includes potential EMF sources. The final EMF levels would depend on the specific technology and supplier selected, however the typical EMF levels recorded during previous field studies for these sources are as discussed below (Sherpa Consulting, 2018).

<u>Solar arrays, photovoltaic modules and PCUs</u>

A field study undertaken at two large scale solar facilities operated by the Southern California Edison Company in Porterville and San Bernardino (Sherpa Consulting, 2018) found the following:

- There was no evidence of magnetic fields created from the photovoltaic modules. The study assumed, however, that the magnetic fields from the photovoltaic module do not exceed the background static magnetic field observed at the study locations (52-62 μT).
- The highest DC magnetic fields were measured adjacent to the inverter (277 μT) and transformer (258 μT). These levels are lower than the ICNIRP's occupational exposure limit.
- The highest AC magnetic fields were measured adjacent to the inverter (110 μT) and transformer (177 μT). These fields were lower than the ICNIRP's occupational exposure limit.
- The strength of the magnetic field attenuated rapidly with distance: within two to three metres away, the fields reduces to background levels.
- Electric fields were negligible to non-detectable. This is mostly likely attributed to the enclosures on the electricity generating equipment.

<u>Underground Medium Voltage cables</u>

Details of the electrical reticulation cable network required for the project is described in Section 2.3.3 of the EIS and has not changed following submission of the EIS. Medium voltage cables would be installed to interconnect the electricity generating infrastructure, being the PCUs, and to transport the electricity to the substation where it is injected into the grid. The medium voltage reticulation network may be installed overhead or buried underground and would have a maximum capacity of 33 kilovolts.

Because the proposed development is split into two portions (northern and southern) there is a need to gather the individual 33 kilovolt cables and then pass them (overhead or underground) through the portion in the south and into the connection point at the substation. The corridor containing the 33 kilovolt transmission lines from the northern portion would cross the main environmental exclusion zone and connect to the onsite BESS and substation.

A typical 33 kilovolt underground cable produces a maximum magnetic field of approximately 1 μT at one metre above ground level. The magnetic field density would be indistinguishable from the background magnetic field at distances greater than 20 metres from the cable.

Substations and transformers

A description of the substation for the project is provided in Section 2.3.4 of the EIS and has not changed following submission of the EIS. The substation is proposed at one of two possible locations shown in **Figure 2-1**. The substation would consist of an indoor switch room to house the medium voltage switchboard and circuit breakers, and an outdoor switch yard to house the transformer(s), gantries and associated infrastructure.

Main sources of magnetic fields within a large substation (such as a transmission substation) include transformer secondary terminations, cables to the switch room, capacitors, reactors, busbars, and incoming and outgoing feeders. In most cases the highest magnetic fields at the boundary come from incoming and outgoing transmission lines.

Generally, the application of electrical safety standards and codes (including the provision of fencing, enclosures and distance) result in exclusion of general public exposures from these sources. This is consistent with the reported typical magnetic field which ranges between 1 to 8 μT at a substation fence.

Transmission lines

From the substation, electricity generated by the solar farm would be injected into the NEM via the existing Wellington to Wollar 330 kilovolt transmission line owned by TransGrid, which crosses the southern boundary of the proposed site. The 330 kilovolt transmission line is shown in **Figure 2-1**.

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

Battery energy storage system

A description of the BESS for the project is provided in Section 2.3.5 of the EIS and has not changed materially following submission of the EIS. The BESS will be either a centralised 'AC Coupled' BESS adjacent to grid substation (one of two locations A or B will be chosen, as shown in **Figure 2-1**) or a decentralised 'DC Coupled' BESS with small BESS units connected to some or all of the solar PCUs distributed throughout the site.

If an AC Coupled solution is selected as the preferred option, the centralised BESS would be housed in a secure compound adjacent to the electrical substation at either location A or B as shown in **Figure 2-1**.

If an AC Coupled solution is adopted, the batteries would be housed in one of the following structures:

- A large building or buildings that would use materials similar in appearance and construction to agricultural sheds prevalent across the study area,
- Modified shipping containers or prefabricated switch rooms, or
- Smaller kiosk or cabinet style enclosures.

If a DC Coupled solution is adopted, the batteries would be housed in:

- Modified shipping containers or prefabricated switch rooms, or
- Smaller kiosk or cabinet style enclosures.

The modified shipping containers and prefabricated switch rooms would likely be mounted on concrete footings, while the cabinets would likely be mounted on concrete slabs.

The electro-magnetic fields associated with a BESS varies depending on several factors including configuration; capacity; and type of housing. Due to the limited information on typical measurement of magnetic fields around utility scale BESS facilities, it has been assumed the typical magnetic field is similar to that of a substation given the proposed designs which include dedicated housing (enclosures).

The BESS would be installed in accordance with the relevant guidelines and standards and other electrical safety standards and codes, resulting in exclusion of public exposures from these sources.

Fire risk

Battery energy storage system

The Hazard Identification and Analysis in **Appendix 1** identifies the potential hazards due to fire risks generated within the BESS and associated infrastructure. The analysis also identifies the controls that would be implemented to (a) minimise the potential for fire ignition and (b) control fires (and the associated environmental and safety impacts) if a fire did occur.

These controls would be implemented through designing, constructing and operating the BESS in accordance with relevant standards and guidelines. **Table 2-2** identifies these standards and guidelines, how they are relevant, and how they are and would be addressed by the project.

Table 2-2: Guidelines relevant to BESS and how addressed

Standard/ Guideline	Relevance	How addressed
NFPA 855: *Standard for the Installation of Stationary Energy Storage Systems* (US National Fire Protection Association)	This standard provides the minimum requirements for mitigating the hazards associated with energy storage systems. It defines the design, construction, installation, commissioning, operation, maintenance, and decommissioning of stationary energy storage systems including BESS.	UPC\AC and its contractors will consider this standard in preparing the detailed design, where the designer determines the standard is relevant to the project. This has been included as an additional management measure (ID H8) in **Section 5**. Any relevant requirements from the standard would be documented in the Fire Safety Study to be prepared following the detailed design and after the project is granted development consent.
Australian Standard AS 5139:2019: *Electrical installations - Safety of battery systems for use with power conversion equipment* (Standards Australia)	This standard specifies requirements for general installation and safety requirements for BESS, where the battery system is installed in a location, such as a dedicated enclosure or room, and is connected with power conversion equipment (PCE) to supply	UPC\AC will consider this standard in preparing the detailed design where the standard is relevant to the project. This has been included as an additional management measure (ID H8) in **Section 5**. Any relevant requirements from the standard would be documented in the Fire Safety

Standard/ Guideline	Relevance	How addressed
	electric power to other parts of an electrical installation.	Study to be prepared following the detailed design and after the project is granted development consent.
IEC 62897: *Stationary Energy Storage Systems with Lithium Batteries - Safety Requirements* (International Electrotechnical Commission)	This standard specifies general safety requirements for BESS with lithium batteries.	UPC/AC procurement procedures would require any lithium batteries to comply with this standard.
UL 9540: *Energy Storage Systems and Equipment* (Underwriters Laboratories)	This applies to energy storage systems intended to receive and store energy in some form so that the BESS can provide electrical energy to loads or to the local/area electric power system (EPS) when needed. The types of energy storage covered under this standard include electrochemical, chemical, mechanical and thermal.	UPC/AC procurement procedures would require batter suppliers to comply with this standard.
UL 9540A: *Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems* (Underwriters Laboratories)	The test methodology in this document evaluates the fire characteristics of a BESS that undergoes thermal runaway. The data generated will be used to determine the fire and explosion protection required for an installation of a BESS.	Item 8 of the Hazard Identification and Analysis (**Appendix 1**) discusses the controls to be applied to avoid and mitigate thermal runaway. Further detail would be provided in the Fire Safety Study to be prepared following the detailed design and after the project is granted development consent.
Development of Sprinkler Protection Guidance for Lithium Ion Based Energy Storage Systems (FM Global)	This document provides protection recommendations for Lithium-ion (Li-ion) BESS located in commercial occupancies, which have been developed through fire testing.	This standard primarily focuses on lithium ion based BESS installed within existing commercial operations, and the need to assess: • whether existing fire sprinkler systems are suitable • what needs to be considered in the location of BESS within such a facility

Standard/ Guideline	Relevance	How addressed
		• what upgrades to the fire sprinkler system would be required. While this appears to not be directly applicable to the project, the principles of the guideline (in relation to space separation from combustible and non-combustible elements) will be considered during detailed design of the project. This has been included as an additional management measure (ID H8) in **Section 5**.

Bushfire risk

The *Guideline for Bush Fire Prone Land Mapping* (NSW Rural Fire Service, 2015) requires councils to record grassland vegetation as being bushfire prone and Australian Standard A.S. 3059 – 2009 also includes grassland vegetation as bushfire prone vegetation.

RPS (2019) prepared the *Bushfire Due Diligence Threat Assessment Report* (RPS, 2019) (RPS Assessment) that included a Bushfire Hazard Assessment and Bushfire Assessment of three areas that UPC\AC Renewables investigated for solar farms, including the study area. While no land within the study area is mapped as bushfire prone, the RPS Assessment concluded that the site constitutes a bushfire risk. The RPS Assessment found the land surrounding the project contains vegetation consistent with grassland and woodland. The vegetation that forms a bush fire threat exists in all direction on and surrounding the study area.

The study area has low relief, rolling hills with a slope gradient not greater than 5 degrees. It does include small patches woodland vegetation downslope with a gradient of 0 to 5 degrees, as well as upslope with a flat gradient.

The project is situated in the Northern Slopes of NSW within the NSW Mid-western Regional Council area. In accordance with *Planning for Bushfire Protection 2019* construction of buildings in bushfire-prone areas is designated a Fire Danger Index (FDI) of 80. Bushfire weather is therefore associated with long periods of drought, high temperatures, low humidity and gusty often north-westerly winds.

3. ASSESSMENT METHODOLOGY

3.1 Preliminary risk screening

A PHA is required to be prepared in accordance with SEPP 33 for a potentially hazardous or offensive development. Appendix 3 of the SEPP 33 Guideline lists industries that may be potentially hazardous or offensive development. Appendix 3 of the SEPP 33 Guideline does not include solar farms and energy storage facilities.

For developments where the applicability of SEPP 33 is not immediately apparent, a risk screening procedure is provided in Appendix 2 of the guideline as a checklist to identify other potentially developments that may be hazardous or offensive. The risk screening process considers the type and quantity of hazardous materials to be stored onsite, distance of the storage area to the nearest site boundary, as well as the expected number of transport movements.

'Hazardous materials' are defined in the SEPP 33 guideline as substances that fall within the classification of the Australian Dangerous Goods Code (ADGC) and have a Dangerous Goods (DG) classification. A development which exceeds the screening thresholds in the guidelines would be considered potentially hazardous and a PHA would be required. The *Large-Scale Solar Energy Guideline for State Significant Development* (NSW Government, 2018) identifies battery storage (and associated chemicals) as a key element of a solar farm to be considered.

As described in **Section 2.2.2**, the project is considering two BESS options:

- **Centralised system**: a centralised "AC Coupled" BESS adjacent to one the grid substation within the development footprint.
- **Decentralised system**: a distributed "DC Coupled" BESS with small BESS units connected to some or all of the solar inverters.

The major components of the BESS would comprise:

- **Batteries** – most likely a lithium-ion technology type
- **Inverters** – convert the DC electricity generated by the photovoltaic modules into AC. The decentralised DC Coupled arrangement will utilise battery DC to DC converters connected to the solar inverters rather than additional battery inverters. DC to DC converters are a simplified version of an inverter missing components such as the AC to DC transformation equipment
- **Transformers** – there would be two types of transformers within the centralised AC Coupled BESS if this option is chosen: low-voltage to medium-voltage transformers (similar to those included with the PV PCUs) and medium-voltage to high-voltage transformers (33kV/330kV) at the grid connection point (substation). The BESS connection will either share a transformer with a section of the solar farm, or may be tied to a separate transformer within the substation, but this will only be determined in the detailed design. The decentralised BESS option does not require any additional transformers at the connection point. In this option, transformation from low voltage DC to low voltage AC to medium voltage AC will be performed by the PV inverters and transformers
- **Heating ventilation air conditioning** (HVAC) – the HVAC would maintain the batteries at a suitable temperature to optimise their lifetime, performance and to ensure safe operation. This could include small package units, large chillers or a liquid cooling system
- **Fire protection** – where required active gas-based fire protection systems would be installed within the BESS enclosure and thermal sensors and smoke/gas detectors would be installed and connected to a fire control panel.

The final BESS design would be assessed by a Fire Safety Study and other risk assessments post approval (and submitted for DPIE approval prior to construction). As a conservative assessment, this PHA has considered the maximum quantities of hazardous materials that would be onsite, as well as the potential for multiple locations.

3.2 Preliminary hazard analysis

The PHA was undertaken for the project in accordance with the HIPAP and *Multi-Level Risk Assessment* (Department of Planning, 2011). A qualitative assessment has been undertaken for the PHA. The SEPP 33 Guideline says that a qualitative assessment can be undertaken if the criteria listed in **Table 3-1** are met (which is achieved by the project and this assessment).

Table 3-1: PHA qualitative assessment criteria and how achieved

PHA qualitative assessment criteria	How criteria has been achieved
Screening and risk classification and prioritisation indicate there are no major offsite consequences and societal risk is negligible	The quantities of hazardous materials to be stored onsite do not exceed the SEPP 33 threshold levels
The necessary technical and management safeguards are well understood and readily implemented	Technical and management safeguards are inherent to the project elements that store and use the hazardous materials
There are no sensitive surrounding land uses	The nearest residence is more than 1500 m from the proposed location of the hazardous material storage areas

The methodology applied for the PHA included:

- identification and analysis of potential hazards associated with the project
- analysis of the potential consequence of each of the identified hazards
- estimate the likelihood of each of the potential hazards occurring
- determination of a risk level for the project
- assessment against risk criteria
- outline relevant operational, maintenance and management procedures required to manage potential hazards associated with the project.

Details of the definitions used to define the consequence, likelihood and overall risk of identified hazards are included in **Appendix 1**.

3.2.1 Electromagnetic risk

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is a federal government agency with the responsibility for protecting the health and safety of people and the environment from EMF. The ARPANSA website notes that "*exposure to ELF* (extremely low frequency) *EMF at high levels can affect the functioning of the nervous system*" but that "*Most of the research indicates that ELF EMF exposure normally encountered in the environment, including in the vicinity of powerlines, does not pose a risk to human health*". Generally, distances beyond 50 metres from a high voltage powerline are not expected to have higher than typical magnetic fields and for substations magnetic field levels at distances of 5 to 10 metres away are no higher than background levels in a typical home.

Therefore, the EMF risk assessment presented in this section addresses predominantly the effects of exposure to ELF magnetic fields associated with the proposed project infrastructure.

Typical exposure levels to EMF for the project infrastructure have been assessed against the International Commission on Non-Ionizing Radiation Protection (ICNIRP) *Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields* (ICNIRP, 2020) (the ICNIRP Guidelines).

The ICNIRP Guidelines defines general public and occupational exposures as follows:

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

The ICNIRP Guidelines reference levels for exposure to EMF at 50 Hz are presented in **Table 3-2**.

Table 3-2: Reference levels for EMF levels at 50 Hz

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

3.2.2 Fire risk

The *Large-Scale Solar Energy Guideline for State Significant Development* (NSW Government, 2018) lists fire hazard and risk associated with construction and operation of a solar farm as an issue to be considered. In particular:

- The potential for fire spreading to the solar development
- Fire being caused by the onsite solar equipment and associated infrastructure such as cables, panels or transmission lines.

RPS (2019) prepared the *Bushfire Due Diligence Threat Assessment Report* (RPS Assessment) that included a Bushfire Hazard Assessment and Bushfire Assessment of three areas that UPC\AC Renewables investigated for solar farms, including the study area. The RPS Assessment was prepared in accordance with the methodology and procedures outlined in Appendix 1 of *Planning for Bushfire Protection 2019* (NSW RFS, 2018) and clause 44 of the *Rural Fire Regulation 2013* (RF Regulation).

The bushfire risks assessed in this section is based on the findings of the RPS Assessment, with consideration of the *Planning for Bushfire Protection 2019* (NSW Rural Fire Service, 2019) that was published since the RPS Assessment was prepared.

3.2.3 Statutory context, policy and guidelines

The hazard and risk assessment was undertaken in accordance with the following guidelines:

- *State Environmental Planning Policy No 33—Hazardous and Offensive Development* (SEPP 33)
- *Hazardous and Offensive Development Application Guidelines Applying SEPP 33* (Department of Planning, 2011)
- *Hazard Industry Planning Advisory Paper No.6 – Guidelines for Hazard Analysis* (Department of Planning, 2011)
- *Multi-Level Risk Assessment* (Department of Planning, 2011)
- *AS/NZS ISO 31000:2018 Risk Management – Principles and Guidelines*
- *Planning for Bushfire Protection* (NSW Rural Fire Service, 2019)
- *Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields* (ICNIRP, 2020).

4. POTENTIAL IMPACTS

4.1 Preliminary hazard analysis

4.1.1 Risk screening

Table 4-1 identifies the hazardous materials to be stored on and transported to the study area and consideration of the applicable SEPP 33 threshold. As this shows none of the SEPP 33 threshold levels are predicted to be exceeded during any phase of the project.

Table 4-1: SEPP 33 Risk screening summary – storage and transport

Material/ Usage	Project storage (tonne)	Minimum quantity per transport load (tonne)		SEPP 33 threshold (tonne)	Exceed threshold?
		Bulk	Packages		
LPG	9.5	2	5	For above ground storage, the screening threshold is 10 tonnes.	No
Refrigerant	14.3	N/A	N/A	No threshold identified based on SEPP 33 and excluded from risk screening. Class 2.2 are not considered to be potentially hazardous with respect to offsite risk.	No
Gasoline	5	3	10	For quantity up to 5 tonnes, the amount is unlikely to represent a significant risk and therefore is not potentially hazardous.	No
BESS	4,800	No limit		No threshold identified based on SEPP 33 and excluded from risk screening. Class 9 is not classified as potentially hazardous material as per SEPP 33.	No

Despite the conclusions of the preliminary risk screening, the SEARs require that a PHA be prepared, demonstrating that the BESS is suitably located and minimises risks to neighbouring land uses. The PHA includes consideration of the potential hazards presented by the BESS and the other materials in **Table 4-1**.

4.1.2 Potential hazards

Hazardous materials

The key risks associated with the materials are:

- **LPG**: flammable; containerised gas (under pressure) presents a risk of explosion if heated
- **refrigerant**: containerised gas (under pressure) presents a risk of explosion if heated
- **gasoline**: extremely flammable; may cause lung damage if swallowed; skin irritation; vapours can cause drowsiness and dizziness
- **BESS**: adverse reaction with water; contents harmful if swallowed or in contact with skin
- **transformer oil**: may be fatal if swallowed and enters airways
- **MCPA**: harmful if swallowed; causes serious eye irritation; toxic to aquatic life

Other hazards and risks

Appendix 1 presents the detailed outcome of the hazard identification process undertaken by UPC\AC. The Hazard Identification and Analysis table in **Appendix 1** identifies the following:

- the type of hazard:
  - electrical
  - arc flash
  - EMF
  - fire
  - chemical
  - reaction
  - external factors
- the infrastructure or area of the potential hazard
- the hazard event (for example, a switch room fire as a form of Fire hazard)
- the cause/s of the hazard event
- the potential consequences of the hazard event
- the Consequence Rating
- the controls to be implemented to mitigate or minimise the potential of the hazard event
- other comments (to assist in informing the basis of the analysis)
- the Likelihood Rating.

4.1.3 Consequence analysis

Hazardous materials

Table 4-2 identifies the hazardous materials that would be handled during construction and operation of the project, the key management approach and the potential residual consequence using the consequence assessment methodology described in the *Multi-level Risk Assessment* (Department of Planning, 2011) and defined in **Appendix 1.**

Table 4-2: Proposed management and potential residual consequence of hazardous materials

Hazardous material	Management approach	Potential residual consequence	
		Onsite	Offsite
LPG	Protect from sunlight and store in a cool, well-ventilated place. Keep away from heat, sparks, open flames and hot surfaces. No smoking in the vicinity of the storage area.	Major	Insignificant

Hazardous material	Management approach	Potential residual consequence	
		Onsite	Offsite
	Use of personal protective equipment. Compliance with Safety Data Sheet.		
Refrigerant	Protect from sunlight and store in a cool, well-ventilated place. Use of personal protective equipment. Compliance with Safety Data Sheet.	Major	Insignificant
Gasoline	Store in a segregated and cool, well-ventilated place. Use of personal protective equipment. Compliance with Safety Data Sheet.	Major	Insignificant
Lithium batteries (BESS)	Store in a cool (preferably below 30°C) and ventilated area away from moisture, sources of heat, open flames, food and drink. Use of personal protective equipment. Compliance with Safety Data Sheet.	Moderate	Insignificant
Transformer oils	Use of personal protective equipment. Compliance with Safety Data Sheet.	Minor	Insignificant
MCPA	Use of personal protective equipment. Compliance with Safety Data Sheet.	Moderate	Insignificant

Other hazards and risks

The detailed outcome of the hazard identification process in **Appendix 1** presents the consequence rating of the potential hazard events. These ratings are based on the consequence definitions in **Appendix 1**.

Likelihood analysis

The detailed outcome of the hazard identification process in **Appendix 1** presents the likelihood rating of the potential hazard events. These ratings are based on the consequence definitions in **Appendix 1**.

Risk level

Table 4-3 presents a summary of the key hazards from those detailed and assessed in **Appendix 1** and the associated risk levels. The highest Risk Level associated with the project is medium. Medium level risks can be managed with the measures inherent to the project (refer to **Section 2**), the controls described in **Appendix 1** and the additional measures described in **Section 5**.

Table 4-3: Hazard and risk analysis summary

Hazard	Event	Consequence (to People)	Likelihood	Risk
Electrical	Exposure to voltage	Major	Very Unlikely	Medium
Arc flash	Arc flash	Major	Very Unlikely	Medium
EMF	Exposure to EMF	Insignificant	Extremely Unlikely	Low
Fire	Fire – Transformers and PCUs	Major	Very Unlikely	Medium
	Fire – Switchrooms	Major	Extremely Unlikely	Medium
	Fire – Construction compound	Major	Very Unlikely	Medium
	Bushfire	Major	Very Unlikely	Medium
Reaction	Thermal runaway in battery	Major	Very Unlikely	Medium
Chemical	Release of electrolyte from the battery cell (liquid/vented gas) resulting in fire and/or explosion	Major	Very Unlikely	Medium
	Battery coolant leak	Minor	Very Unlikely	Low
	Refrigerant leak (BESS and refrigeration/chiller units)	Minor	Very Unlikely	Low
	Exposure to hazardous material (herbicide/pesticide)	Minor	Very Unlikely	Low
	Release of LPG from storage vessel or filling point resulting in fire and/or explosion	Major	Very Unlikely	Medium
	Release of gasoline from storage tank or filling point resulting in fire	Major	Very Unlikely	Medium
External factors	Water ingress resulting in fire (BESS, PCUs or Switchrooms)	Major	Extremely Unlikely	Medium
	Vandalism due to unauthorised personnel access	Moderate	Unlikely	Medium
	Lightning strike	Major	Very Unlikely	Medium

4.1.4 Electromagnetic risks

The project includes the following key elements designed to limit exposure to EMF to below the general public and occupational exposure limits:

- the design, selection and procurement of electrical equipment for the project would comply with relevant international and Australian standards for generation of and exposure to EMF
- selection of suitable locations for EMF-generating project infrastructure (through provision of separation distance to surrounding land uses including neighbouring properties and agricultural operations) and fencing along the project boundary would limit the exposure to EMF for the general public
  As identified in **Figure 2-1** the key EMF sources (transformers and substations) are more than 2 kilometres from the nearest residence, and 1.5 kilometres from the nearest public road.
- exposure to EMF (specifically magnetic fields) from electrical equipment would be localised and the strength of the field attenuates rapidly with distance
- fencing around key EMF generating infrastructure (substations, inverters and transformers) within the project to limit occupational exposures
- duration of exposure to EMF for personnel onsite would be transient. Where personnel need to undertake maintenance activities on infrastructure with higher EMF emissions, work would be undertaken in accordance with Safe Work Method Statements describing the required safety procedures and personal protective equipment.

4.1.5 Fire risk

The main potential sources of ignition of, and fuel for, unplanned fires caused by construction and operation of the project are:

- vehicle and machine movement over long, dry grass
- human error, such as non-compliance with hot works procedures (and associated generation of sparks) or incorrect disposal of cigarette butts
- diesel (stored and used in generators)
- flammable liquids (stored and used in machinery).

Other potential sources outside of the project include escaped back burning; lightning strikes; incorrect disposal of cigarette butts and litter; arson; and arcing, sagging or damaged to the adjacent transmission lines.

Several Bushfire Protection Measures would be inherent to the project design and layout, and would also be incorporated into the construction and operating procedures:

- vegetation control along and around access roads, parking areas and temporary assets (such as site offices) during construction and for permanent assets during operation
- minimising vehicle movements off access roads and through long grasses
- the construction induction would highlight the bushfire risks and the importance of compliance with construction procedures, in particular hot works procedures, vehicle movement restrictions, material storage requirements and the bushfire emergency response procedures.
- the construction induction would also discuss the importance for the correct disposal of cigarette butts. In times of high fire risk, restrictions on where and when smoking can occur may be implemented
- establishment and maintenance of one of the following Asset Protection Zones (APZ) strategies:
  - a 50 metre APZ to provide a Low Bushfire Attack Level (BAL), which would result in "*minimal attack from radiant heat and flame due to the distance of the site*

  - *from the vegetation, although some attack by burning debris is possible. There is insufficient threat to warrant specific construction requirements*" (*Planning for Bushfire Protection 2019*)
  - to establish a BAL of 12.5 (as defined under AS3959) a 20 metre APZ to grassland, 22 metre APZ to woodland (where vegetation is upslope of flat from infrastructure) and a 28 metre APZ to woodland (where woodland is downslope) would be required. A BAL of 12.5 requires a construction level of BAL-12.5 under Australian Standard AS 3959 *Construction of buildings in bushfire prone areas* or the National Association of Steel Framed Housing (2014) *Steel Framed Construction in Bush Fire Areas* (NASH Standard). and section 7.5 of *Planning for Bushfire Protection 2019* is applied
- no combustible fencing would be installed within 10 metres of any structure
- the ground below the individual photovoltaic modules would be fuel reduced to both prevent direct flame contact from grassfires and reduce the likelihood of sparking from the modules, potentially causing ignition
- internal roads would be maintained within the study area to allow for the safe movement of construction and operation personnel in the event of a fire event, and designed to accommodate emergency services vehicles
- static water tanks would be provided in strategic locations throughout the project infrastructure, and in accordance with the requirements of *Planning for Bushfire Protection 2019*
- wherever possible electricity supply and distribution within the study area would be underground and so not contribute to fire risk
- any fuels and chemicals stored as part of the project would be stored in accordance with their Safety Data Sheet and *Planning for Bushfire Protection 2019*
- The BESS sub-units would be spaced at a suitable distance to ensure that any fires from a sub-unit do not propagate to neighbouring sub-units or to other onsite and offsite infrastructure. This would be determined during detailed design of the project and considered in the Fire Safety Study, both of which would be prepared by UPC\AC or its contractors and submitted to the Department prior to construction (refer to management and mitigation measure H7 in **Chapter 5**).

5. MANAGEMENT AND MITIGATION MEASURES

Proposed measures to manage and/or mitigate hazards and risks (in addition to those that form part of the project) are detailed in **Table 5-1**. This includes the additional management and mitigation measures identified in the response to submissions report (H5, H6 and H7).

Table 5-1: Management and mitigation measures – hazards and risks

ID	Management/mitigation measure	Timing
H1	A Construction Bushfire Management Plan (BMP) will be prepared in consultation with the Rural Fire Service, and to the satisfaction of the Secretary. The BMP will include the management and mitigation measures described in **Section 4.1.5**.	Prior to construction
H2	An Operation BMP will be prepared in consultation with the Rural Fire Service, and to the satisfaction of the Secretary. The BMP will include the management and mitigation measures described in **Section 4.1.5**.	Prior to operation
H3	A Bush Fire Emergency Management and Evacuation Plan will be prepared consistent with *'Development Planning A Guide to Developing a Bush Fire Emergency Management and Evacuation Plan* (NSW Rural Fire Service, 2014) and Australian Standard *AS3745 2010 'Planning for Emergencies in Facilities'*. A copy of the plan will be displayed and available for review in a prominent location directly adjacent to the site's main entry point/s.	Prior to construction / prior to operation
H4	The operator will contact Mid-Western Local Emergency Management Committee (LEMC) to discuss how the site will be considered under the Mid-Western Local Disaster Plan (DISPLAN).	Prior to operation
H5	Prior to construction, a Fire Safety Study will be prepared by a suitably qualified bushfire expert providing full details of the required water storage for fire-fighting requirements. The report will include location and capacity of tanks, methods of pumping to provide sufficient pressures, and details of any proposed internal reticulation or hydrant network.	Prior to construction
H6	From the start of building works, the property around all buildings will be managed as an asset protection zone for a distance of 50 metres in accordance with the requirements of Appendix 4 of *Planning for Bush Fire Protection* 2019. Road access to the site, power transmission, fencing and any other services to the site are excluded from this requirement. The following requirements will apply when establishing and maintaining an asset protection zone: • tree canopy cover should be less than 15% at maturity • trees at maturity should not touch or overhang the building • lower limbs should be removed up to a height of 2 metres above the ground • tree canopies should be separated by 2 to 5 metres	During construction and operations

ID	Management/mitigation measure	Timing
	• preference should be given to smooth barked and evergreen trees • large discontinuities or gaps in vegetation should be provided to slow down or break the progress of fire towards buildings • shrubs should not be located under trees • shrubs should not form more than 10% ground cover • clumps of shrubs should be separated from exposed windows and doors by a distance of at least twice the height of the vegetation • grass should be kept mown (as a guide grass should be kept to no more than 100mm in height) • leaves and vegetation debris should be removed.	
H7	UPC\AC will prepare a Fire Safety Study (FSS) for the battery energy storage system in consultation with Fire and Rescue NSW as required under the development consent for the project. The FSS would be prepared prior to construction of the battery energy storage system.	Prior to construction
H8	The principles from NFPA 855, AS 5139, IEC 62897, UL 9540, UL 9540A and the FM Global's *Development of Sprinkler Protection Guidance for Lithium Ion Based Energy Storage Systems* will be considered during detailed design of the BESS, where they are appropriate for the project and feasible.	During detailed design/ prior to construction

6. REFERENCES

Department of Planning. (2011). *Hazard Industry Planning Advisory Paper No.6 – Guidelines for Hazard Analysis .*

Department of Planning. (2011). *Hazardous and Offensive Development Application Guidelines Applying SEPP 33 .*

Department of Planning. (2011). *Multi-Level Risk Assessment.*

ICNIRP. (2020). *Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields.*

NSW Government. (2018). *Large-Scale Solar Energy Guideline for State Significant Development.*

NSW Rural Fire Service. (2014). *'Development Planning A Guide to Developing a Bush Fire Emergency Management and Evacuation Plan.*

NSW Rural Fire Service. (2015). *Guideline for Bush Fire Prone Land Mapping.*

NSW Rural Fire Service. (2019). *Planning for Bushfire Protection.*

RPS. (2019). *Bushfire Due Diligence Threat Assessment Report .*

Sherpa Consulting. (2018). *Hazards and Risk Assessment New England Solar Farm.*

APPENDIX 1
PRELIMINARY HAZARD ASSESSMENT

Likelihood definitions

Likelihood	Description
Very likely	The event is expected to occur in most circumstances
Likely	The event will probably occur in most circumstances
Unlikely	The event could occur
Very Unlikely	The event could occur but not expected
Extremely unlikely	The event occurs only in exceptional circumstances

Consequence definitions

Consequence	Description
Catastrophic	One or more fatalities or permanent disabilities.
Major	Minor injury or illness to between 100 and 1000 individuals/ Major injury or illness to between 10 and 100 individuals.
Moderate	Minor injury or illness to 10 to 100 individuals/ Major injury or illness to between 1 and 10 individuals.
Minor	Minor injury or illness to less than 10 individuals/ Major injury or illness to one individual.
Insignificant	No injury or illness associated with the Project

Risk Level Definitions

Risk Level	Definition
Negligible	Will have minimal impact, which requires no or minimal implementation of standard management measures
Low	Will have low impacts, which can be managed by standard management measures.
Medium	May have moderate impacts that can be mitigated by the application of standard management measures.
High	May have moderate to high impacts. Detailed assessment necessary to determine the level of potential impact and to develop appropriate measures to mitigate and manage the impacts.
Extreme	May have significant impacts. Detailed assessment necessary to determine the level of potential impact and to develop appropriate measures to mitigate and manage the impacts.

Risk assessment matrix

Likelihood	Consequence				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Very likely	Low	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Unlikely	Negligible	Low	Medium	High	High
Very Unlikely	Negligible	Low	Medium	Medium	High
Extremely unlikely	Negligible	Negligible	Low	Medium	Medium

Hazard Identification and Analysis

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Consequence Rating	Controls	Other Comments	Likelihood Rating
1	Electrical	PV modules PCUs MV cable reticulation network Substation BESS Transformers Overhead transmission lines	Exposure to voltage	Short circuit/ electrical connection failure - Faulty equipment - Incorrect installation - Incorrect maintenance - Human error during maintenance - Safety device/circuit compromised - Battery casing/enclosure damage	- Electrocution - Injury and/or fatality - Fire	Major	- Equipment and systems will be designed and tested to comply with international standards and guidelines - Engagement of reputable contractors - Independent certifiers/owner's engineers - Installation and maintenance will be done by trained personnel - Electrical switch-in and switch-out protocol (pad lock) - BESS BMS fault detection and safety shut-off - BESS fire protection system (enclosure/building) - Warning signs (electrical hazards, arc flash) - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS) - Use of appropriate PPE - Rescue kits (i.e. insulated hooks)		Very Unlikely
2	Arc flash	PV modules PCUs MV cable reticulation network Substation BESS Transformers Overhead transmission lines	Arc flash	- Incorrect procedure (i.e. installation/ maintenance) - Faulty equipment (e.g. corrosion on conductors) - Faulty design (e.g. equipment too close to each other) - Insulation damage - Human error during maintenance	- Burns - Injury and/or fatality - Exposure to intense light and noise - Arc blasts and resulting heat, may result in fires and pressure waves	Major	- Equipment and systems will be designed and tested to comply with international standards and guidelines - Engagement of reputable contractors - Independent certifiers/owner's engineers - Site induction/substation training (i.e. high voltage areas) - Installation and maintenance will be done by trained personnel - Maintenance procedure (e.g. deenergize equipment) - Preventative maintenance (insulation) - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS) - Warning signs (arc flash boundary) - Use of appropriate PPE for flash hazard - Distance between BESS sub-units and the BESS infrastructure and other internal and external infrastructure	An arc is produced by flow of electrical current through ionized air after an initial flashover or short circuit, resulting in a flash that can cause significant heating and burn injuries to occur. Arc flash may result in rapid rise in temperature and pressure in the air between electrical conductors, causing an explosion known as an arc blast.	Very Unlikely

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Consequence Rating	Controls	Other Comments	Likelihood Rating
3	EMF	PV modules PCUs MV cable reticulation network Substation BESS Transformers Overhead transmission lines	Exposure to electric and magnetic fields	Operations of power generation equipment	- High level exposure (i.e. exceeding the reference limits) may affect function of the nervous system (i.e. direct stimulation of nerve and muscle tissue and the induction of retinal phosphenes) - Personnel injury	Insignificant	- Location siting and selection (incl. separation distance) - Optimising equipment layout and orientation - Reducing conductor spacing - Balancing phases and minimising residual current - Incidental shielding (i.e. BESS building/enclosure, switchroom) - Equipment and systems will be designed and tested to comply with international standards and guidelines - Exposure to personnel is short duration in nature (transient) - Warning signs - Studies found that the EMF for commercial solar power generation facilities comply with ICNIRP occupational exposure limits	Adverse health effects from EMF have not been established based on findings of science reviews conducted by credible authorities (ENA, 2016). No established evidence that ELF EMF is associated with long term health effects (ARPANSA).	Extremely Unlikely
4	Fire	PCUs Transformers	Fire (Transformers, PCUs)	- Transformer oil leak - Faulty equipment - Arc flash - External fire (e.g. bushfire, adjacent infrastructure)	- Fire in switchyard and escalation to switchroom - Release of toxic combustion products - Injury/fatality - Asset damage - Interruption in power supply	Major	- Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - All relevant Transgrid's requirements will be met - PCUs and transformers are located in designated area - Installation, operations and maintenance by trained personnel (e.g. reputable third party) in accordance with relevant procedures - Preventative maintenance (e.g. insulation, replacement of faulty equipment) - Activation of emergency shutdown (ESD button) - Fire Management Plan - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS)	-	Very Unlikely
5	Fire	Collector substation	Switchroom fire	- Equipment failure - Arc flash - Vandalism - External fire (e.g. bushfire, adjacent infrastructure)	- Fire in substation and escalation to switchyard - Release of toxic combustion products - Injury/fatality - Asset damage - Interruption in power supply	Major	- Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - All relevant Transgrid's requirements will be met - PCUs and transformers are located in designated area	-	Extremely Unlikely

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Consequence Rating	Controls	Other Comments	Likelihood Rating
							- Installation, operations and maintenance by trained personnel (e.g. reputable third party) in accordance with relevant procedures - Preventative maintenance (e.g. insulation, replacement of faulty equipment) - Electrical switch-in & switch-out protocol (pad lock) - Circuit breakers - Substation is locked and located in designated area - Security fence and controlled access - Activation of emergency shutdown (ESD button) - Fire Management Plan - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS)		
6	Fire	Construction Compound	Fire in compound	- Kitchen fire - Paper fire - Smoking	- Injury/fatality - Asset damage	Major	- Fire Management Plan - Cooling water supply onsite - Defendable boundary for firefighting will be established - Dedicated smoking area - Fire protection system in the CAV - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS) - Use of appropriate PPE	-	Very Unlikely
7	Fire	All infrastructure	Bushfire	- Encroachment of offsite bushfire - Escalated event from NESF fire	- Injury/fatality - Asset damage	Major	- Fire Management Plan - Cooling water supply onsite - Defendable boundary for firefighting will be established - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS) - Use of appropriate PPE - Establishment and maintenance of Asset Protection Zone	-	Very Unlikely

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Consequence Rating	Controls	Other Comments	Likelihood Rating
8	Reaction	Battery	Thermal runaway in battery	Elevated temperature - Bushfire - External fire (e.g. substation, transformer) Electrical failure - Short circuit - Excessive current/voltage - Imbalance charge across cells Mechanical failure - Internal cell defect - Damage (crush/penetration/puncture) Systems failure - BMS failure - HVAC failure	- Fire in the battery cell - Injury/fatality - Escalation to the enclosure/ building - Escalation to the entire BESS	Major	- Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - Battery Management System (BMS) * Voltage control * Charge-discharge current control * Temperature monitoring * Safety shut-off function - HVAC system - Cell chemistry selection (minimise runaway) - Battery cell/pack design - BESS is housed in dedicated enclosure /building - BESS is located in designated area - BESS will be equipped with fire walls (this is applicable for building option only) - BESS fire protection system (enclosure/building) - Distance between BESS sub-units and the BESS infrastructure and other internal and external infrastructure - Activation of emergency shutdown (ESD button; outside of BESS or remotely from the O&M building) - Fire Management Plan - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS) - Establishment and maintenance of Asset Protection Zone	Thermal runaway refers to a cycle in which excessive heat, initiated from inside/outside the cell, keeps generating more heat. Chemical reactions inside the cell in turn generate additional heat until there are no reactive agents left in the cell.	Very Unlikely
9	Chemical	Battery	Release of electrolyte (liquid/ vented gas) from the battery cell	Mechanical failure/damage - Dropped impact (installation/maintenance) - Damage (crush/penetration/puncture) Abnormal heating/elevated temperature - Thermal runaway - Bushfire - External fire	- Release of flammable liquid electrolyte - Vapourisation of liquid electrolyte - Release of vented gas from cells - Fire and/or explosion in battery enclosure/building - Release of toxic combustion products - Injury/fatality	Major	- Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - Engagement of reputable contractors - Installation and maintenance will be done by trained personnel - Layers of battery case (pod and external casing) - Spill cleanup using dry absorbent material - BMS fault detection and shut-off function	Vented gases are early indicator of a thermal runaway reaction	Very Unlikely

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Consequence Rating	Controls	Other Comments	Likelihood Rating
				(e.g. substation, transformer)			- HVAC system (regulate air flow) - BESS fire protection system (enclosure/building) - Distance between BESS sub-units and the BESS infrastructure and other internal and external infrastructure		
10	Chemical	Battery	Coolant leak	- Mechanical failure/damage - Incorrect maintenance	Irritation/injury for personnel on exposure (inhalation)	Minor	- Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - Engagement of reputable contractors - Maintenance will be done by trained personnel - Layers of battery case (pod and external casing) - Spill cleanup using dry absorbent material - BMS fault detection and shut-off function - PPE	Typically Coolant is 50/50 mixture of ethylene glycol and water. A typical system includes about 37 L of coolant but this can vary depending on the detail design and configuration. The fluid does not emit a strong odor.	Very Unlikely
11	Chemical	BESS refrigeration Chiller units	Refrigerant leak	- Mechanical failure/damage - Incorrect maintenance	Irritation/injury for personnel on exposure (skin contact)	Minor	- Equipment and systems will be designed and tested to comply with the relevant international standards and guidelines - Equipment will be procured from reputable supplier - Independent certifiers/owner's engineers - Engagement of reputable contractors - Maintenance will be done by trained personnel - (BESS) Layers of battery case (pod and external casing) - (BESS) BMS fault detection and shut-off function - (Chiller Unit) Separation distance to other equipment - PPE	The thermal management system typically includes 400g of R134a refrigerant in a sealed system. Mechanical damage of could result in a release of the refrigerant. Such a release would appear similar to the emission of smoke.	Very Unlikely
12	Chemical	Vegetation management and landscaping	Exposure to hazardous material	Inappropriate storage use and handling of pesticides/herbicides for vegetation management and landscaping	Irritation/injury for personnel on exposure	Minor	- Product will be stored in dedicated storage area - Quantity kept in work area will be minimised - No spraying will be done during high wind conditions - Limited usage prior to and during rain events - PPE (as required by Safety Data Sheet)	Herbicide/pesticide will likely be MCPA (widely used phenoxy herbicide). Other types of herbicides/pesticides may used for more targeted weed treatment.	Very Unlikely

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Consequence Rating	Controls	Other Comments	Likelihood Rating
13	LPG	Construction compound	Release of LPG from storage vessel or filling point	- Mechanical failure - Human error during transfer	- Fire and/or explosion - Boiling Liquid Expanding Vapour Explosion (BLEVE) – escalated event - Injury/fatality	Major	- Equipment and systems will be designed and tested to comply with Australian standards & guidelines (e.g. AS 1596) - Engagement of reputable contractors - Independent certifiers/owner's engineers - Installation and maintenance will be done by trained personnel - Warning signs (flammable material) - Fire Management Plan - Defendable boundary for firefighting will be established - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS) - Use of appropriate PPE	LPG may be provided for utility purposes during construction for use in the construction compound	Very Unlikely
14	Gasoline	Supporting infrastructure (Gasoline tank and filling system)	Release of gasoline from storage tank or filling point	- Mechanical failure - Human error during transfer	- Fire - Injury/fatality	Major	- Equipment and systems will be designed and tested to comply with Australian standards & guidelines (e.g. AS 1940) - Engagement of reputable contractors - Independent certifiers/owner's engineers - Installation and maintenance will be done by trained personnel - Secondary containment (i.e. bunding) - Warning signs (flammable material) - Fire Management Plan - Defendable boundary for firefighting will be established - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS) - Use of appropriate PPE	Gasoline may be provided onsite for refuelling of vehicles.	Very Unlikely
15	External factors	BESS PCUs Substation	Fire (BESS, PCUs, Substation Switchrooms)	Water ingress (e.g. rain, flood)	- Electrical fault/short circuit - Fire - Injury/fatality	Major	- Location siting (i.e. outside of flood prone area) - Switchrooms and BESS are housed in dedicated enclosure/building. which will be constructed in accordance to relevant standards - Drainage system - Preventative maintenance (check for leaks)	-	Extremely Unlikely
16	External factors	PV modules PCUs Substation BESS	Vandalism	Unauthorised personnel access	- Asset damage - Potential hazard to unauthorised person (e.g. electrocution)	Moderate	- Project infrastructures are located in secure fenced area - Onsite security protocol - Warning signs - During construction, the area will be manned and fence will be installed	-	Unlikely

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Consequence Rating	Controls	Other Comments	Likelihood Rating
17	External factors	All project infrastructure	Lightning strike	Lightning storm	- Injury/fatality - Fire - Asset damage	Major	- Earthing - Lightning protection mast (Substations) - PPE	-	Very Unlikely