APPENDIX L

Hazards and risks assessment

REPORT

HAZARDS AND RISK ASSESSMENT

NEW ENGLAND SOLAR FARM

EMM CONSULTING PTY LTD

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CONTENTS

TABLES

FIGURES

ABBREVIATIONS

AC	Alternating Current
ADGC	Australian Dangerous Goods Code
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AS	Australian Standard
BESS	Battery Energy Storage System
BMS	Battery Management System
BLEVE	Boiling Liquid Expanding Vapour Explosion
CAV	Construction Accommodation Village
DA	Development Application
DC	Direct current
DG	Dangerous Goods
DP	Deposited Plan
DPE	(NSW) Department of Planning and Environment
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency
EMF	Electric and Magnetic Fields
EMM	EMM Consulting Pty Ltd
ENA	Energy Networks Australia
EP&A	Environmental Planning and Assessment
ESD	Emergency shutdown
FRNSW	Fire and Rescue NSW
GHS	Globally Harmonized System
HAZID	Hazard Identification
HIPAP	Hazardous Industry Planning Advisory Paper
HV	High Voltage
HVAC	Heating Ventilation Air Conditioning
Hz	Hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
ISO	International Standards Organization
km	Kilo Metres

kV	kilovolt
LEP	Local Environmental Plan
LGA	Local Government Area
LPG	Liquefied Petroleum Gas
LV	Low Voltage
MCPA	2-methyl-4-chlorophenoxyacetic acid
MV	Medium Voltage
MW	Megawatt
MWh	Megawatt hours
NESF	New England Solar Farm
NMC	Nickel Manganese Cobalt Oxide
O&M	Operations & Maintenance
OH&S	Occupational Health & Safety
PCU	Power Control Unit
PG	Packing Group
PHA	Preliminary Hazard Analysis
PPE	Personal Protective Equipment
PV	Photovoltaic
RFS	Rural Fire Safety
SDS	Safety Data Sheet
SCADA	Supervisory Control and Data Acquisition
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SFARP	So Far As Reasonably Practicable
SRD	State and Regional Development
SSD	State Significant Development
UPC	UPC Renewables Australia Pty Ltd
WHO	World Health Organization
WHS	Work Health and Safety

TERMINOLOGY

Project	New England Solar Farm
Project boundary	Lot or DPs that encompass the development footprint (i.e. the legal property description).
Development footprint	Area within the project boundary on which the project infrastructure will be located.
Risk	The likelihood of a specified undesired event occurring within a specified period or in specified circumstances. It may be either a frequency (the number of specified events occurring in unit time) or a probability (the probability of a specified event following a prior event), depending on the circumstances

1. INTRODUCTION

1.1. Background

UPC Renewables Australia Pty Ltd (UPC) proposes to develop the New England Solar Farm (NESF); a significant grid-connected solar farm and Battery Energy Storage System (BESS) along with associated infrastructure, approximately 6 kilometres (km) east of the township of Uralla, 19 km south of Armidale in the Uralla Shire Local Government Area (LGA) (the project).

The project involves the development, construction and operation of a solar photovoltaic (PV) electricity generation facility. This consists of three arrays of PV modules incorporating transmission infrastructure between each of the three arrays and a grid collector substation to enable connection into the existing electricity transmission network. The project will have a targeted sent out electricity generating capacity of up to 800 Megawatt (MW) Alternating Current (AC) and up to 200 MW (AC) two-hour energy storage. Once operational, the project will generate up to 2,000,000 megawatt hours (MWh) of electricity annually, depending on its final size and design.

The project is a State Significant Development (SSD) under the State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP), which requires a Development Application (DA) to be submitted under the NSW Environmental Planning and Assessment Act 1979.

UPC has commissioned EMM Consulting Pty Ltd (EMM) to prepare an Environmental Impact Statement (EIS) as part of the DA. EMM has retained Sherpa Consulting Pty Ltd (Sherpa) to undertake a Hazards and Risk Assessment as part of the EIS.

1.2. Study objectives

The overall study objective is to address the 'Hazards and Risks' component of the Secretary's Environmental Assessment Requirements (SEARs) (Ref.1), which includes:

1. A preliminary risk screening in accordance with *State Environmental Planning Policy No.33 (SEPP 33) - Hazardous and Offensive Development*. If the preliminary risk screening indicates the development is 'potentially hazardous', a Preliminary Hazard Analysis (PHA) must be prepared in accordance with NSW Department of Planning and Environment (DPE) *Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 – Guidelines for Hazard Analysis* and *Multi-Level Risk Assessment*.
2. An assessment of all potential hazards and risks including but not limited to bushfires, spontaneous ignition, electromagnetic fields or the proposed grid connection infrastructure (including the proposed transmission line and substations) against the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines for limiting exposure to Time-varying Electric, Magnetic and Electromagnetic Fields.

1.3. Scope

The scope of the study includes the following project infrastructures:

- Solar arrays, PV modules, Medium Voltage (MV) cable network and Power Conversion Units (PCUs)
- Solar array substations
- Collector network (overhead transmission lines) and grid substation
- Battery Energy Storage System (BESS)
- Construction Accommodation Village (CAV)
- Supporting infrastructure, including:
    - Operations & Maintenance (O&M) buildings
    - New internal roads and emergency access points
    - Parking and internal access tracks for construction and maintenance
    - Fencing and landscaping around the solar arrays, substations and BESSs.

1.4. Exclusions and limitations

The scope of work is limited to the requirements under the 'Hazards and Risks' component of the SEARs. The study exclusions are summarised as follows:

- Bushfire hazard assessment. A separate bushfire hazard assessment was produced for input to the EIS. Where applicable, identified controls have been referenced (i.e. fire management plan) in this study.
- Construction safety study. This study does not constitute a Construction Safety Study. Requirement for the study at a later stage will be subject to the conditions of consent of the DA approval. For more information, refer to the NSW DPE HIPAP No. 7 *Construction Safety* (Ref.2).

1.5. Structure of report

The remainder of this report is structured as follows:

- Section 2: Project and Development Description
- Section 3: SEPP 33 Risk Screening
- Section 4: Hazards & Risk Assessment
- Section 5: Hazard Identification
- Section 6: Electric and Magnetic Fields (EMFs)
- Section 7: Risk Assessment
- Section 8: References.

2. PROJECT AND DEVELOPMENT DESCRIPTION

2.1. Location and surrounding land use

The New England Solar Farm (the project) will be developed within the Uralla Shire LGA, approximately 6 km east of the Uralla township and 19 km south of Armidale.

The land within the project boundary is zoned RU1 Primary Production under the Uralla Local Environmental Plan 2012 (Uralla LEP). The land within the project boundary has been modified by historical land use practices and past disturbances associated with land clearing, cropping and intensive livestock grazing. The properties within the project boundary are primarily used for sheep grazing for production of wool and lambs at present, with some cattle grazing for beef production.

2.2. Development footprint

The development footprint is the area within the project boundary on which infrastructure will be located.

The development footprint encompasses three arrays; (1) northern array area, (2) central array area and (3) southern array area. The development footprint cover the areas for rows of PV modules, PCUs, space between the rows, internal access tracks and associated infrastructure (including substations and BESSs).

The development footprint also includes land required for connection infrastructure between the three array areas as well as land required for new internal roads to enable access to the three array areas from the surrounding road network.

The development is located close to Transgrid's 330 kilovolt (kV) transmission line which traverses through the northern and central array areas.

2.3. Access points

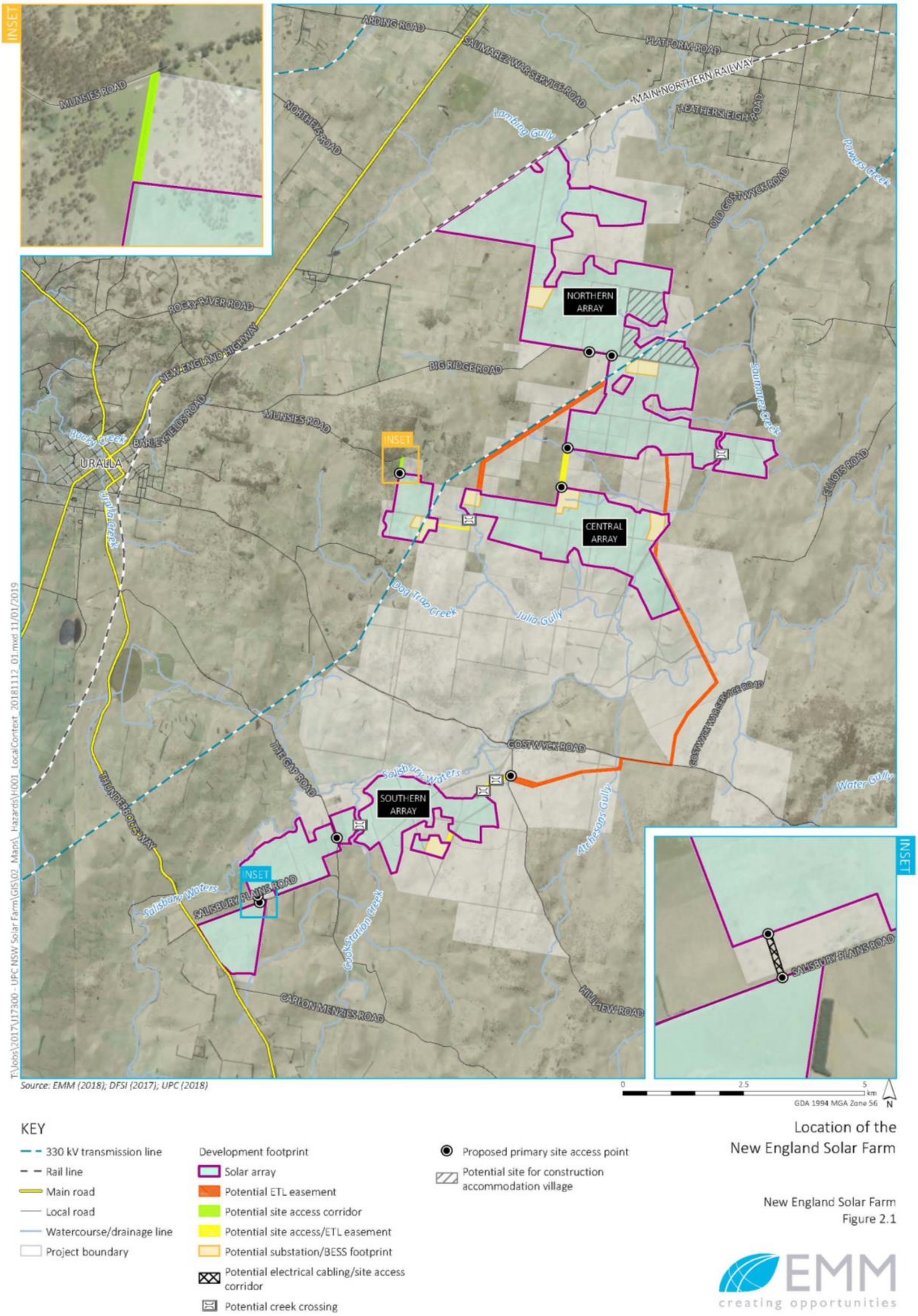
A number of local roads traverse the array areas and their surrounds, including Gostwyck Road, Salisbury Plains Road, The Gap Road, Carlon Menzies Road, Munsies Road, Saumarez War Service Road, Hillview Road, Elliots Road and Big Ridge Road, and will provide access to the three array areas from the regional road network throughout the construction and operation of the project. Access to the regional road network includes the New England Highway and Thunderbolts Way.

The primary access points will be from (1) The Gap Road, (2) Salisbury Plains Road, (3) Hillview Road, (4) Munsies Road and (5) Big Ridge Road. Emergency access points to enable access to the three array areas from the surrounding road network in the case of an emergency will also be required. The location of the emergency access points will be determined during detailed design.

2.4. Development layout

Development layout of the NESF showing the local context and development footprint is presented in Figure 2.1.

Figure 2.1: Project and development layout



2.5. Project infrastructure

2.5.1. Solar arrays, PV modules, MV cable network and PCUs

The project will involve the development of three separate arrays of PV modules and PCUs. The number of PV modules and PCUs required will be dependent on the final detailed design of the project, availability and commercial considerations at the time of construction.

PV modules will be installed in a series of rows to maximise the energy yield that is achievable given the solar resource and the ground area available. Assuming single axis tracking technology is used, the rows of PV modules will be aligned in a north-south direction and spaced out approximately 5-8 m apart. The use of single axis tracking technology would enable the PV modules to rotate from east to west during the day tracking the sun's movement. The height of the PV modules at their maximum tilt angle (typically up to 60 degrees) will be up to 4 m. Additional site-specific clearance of up to around 300 mm may be required to avoid flooding risk or to improve access for sheep to graze underneath the PV modules.

An alternative configuration for the PV modules may be considered for the project, namely a fixed tilt system, with the rows aligned east-west and the PV modules facing north. However, it is noted that single axis tracking is considered more likely due to the recent fall in technology costs and the superior energy yield associated with this technology.

The PV modules will be supported on mounting frames consisting of vertical posts ('piles') and horizontal rails ('tracking tubes'). Rows of piles will be driven or screwed into the ground, depending on the geotechnical conditions, and the supporting racking framework will be mounted on top. Pre-drilling and/or cementing of foundations will be avoided if allowed by the geotechnical conditions.

Direct Current (DC) cables will connect the PV modules to the PCUs.

The PCUs consist of three key components, namely inverter(s), transformer(s) and a ring main unit. The purpose of each PCU is to convert the DC electricity generated by the PV modules into AC form, compatible with the electricity network. PCUs also increase the voltage of the electricity to 11-33 kV.

A MV cable reticulation network will be required to transport the electricity around each of the three arrays. Electricity from the MV cable network will be stepped up to High Voltage (HV) at each of the internal solar array substations (up to three in total).

2.5.2. Solar array substations

Up to three substations will be developed to step up the MV to HV, potentially one within each of the three solar arrays. Based on preliminary designs, each substation will require transformers to step up from 33 kV to 132 kV. Each substation will likely consist of an indoor switchroom to house MV circuit breakers, and an outdoor switch yard to house the transformer(s), gantries and associated infrastructure.

2.5.3. Collector network and grid substation

Up to three new overhead transmission lines will transport electricity from each of the internal solar array substations to the grid substation. Based on preliminary designs, the anticipated voltage is 132 kV.

The alignment of the overhead transmission lines and design, height and style of the structures required to support them will be determined during the detailed design stage of the project; however, it is unlikely that the height of the structures will exceed 45 m. Based on preliminary designs, single concrete, wood, or steel poles are anticipated rather than steel lattice towers. The easement required for the overhead transmission lines will be dependent on the type of structure selected but is likely to be approximately 45 m in width. The distance between each structure will also be dependent on the type of structure selected.

Indicative alignments for each of the overhead transmission lines are presented in Figure 2.1. Three options are being considered for the transmission line between the northern and central array areas (refer to Figure 2.1). The alignment of this transmission line will be determined during the detailed design stage of the project. The proposed alignment for the transmission line to connect the southern and central array areas extends over approximately 9.5 km (refer to Figure 2.1).

The grid substation will be adjacent to Transgrid's 330 kV transmission line, which traverses the northern and central array areas. At the grid substation, the electricity generated by the three solar arrays will be stepped up to 330 kV and injected into the electricity grid via Transgrid's 330 kV transmission line. Three separate areas, one in the northern array and two in the central array, are currently being considered for the grid substation.

2.5.4. Battery Energy Storage System

The purpose of the BESS will be to support the network, introduce a dispatchable capability to the project's energy generation profile and allow for revenue diversification.

The targeted rating for the BESS will be up to 200 MW (AC) two-hour energy storage (i.e. name plate rating of 200 MW/2 hours).

The BESS will be adjacent to one or more substations within the development footprint and will be housed within either (1) a number of small enclosures/cabinets or (2) larger battery buildings. The specific design details for the BESS and their respective enclosure types have not been confirmed; however, it is anticipated that the BESS for the project will consist of either one BESS facility at the grid substation or three BESS facilities (one at the grid substation and two at the internal solar array substations).

The small enclosures will likely be either modified shipping containers, pre-fabricated switchroom structures or smaller outdoor rated cabinets. The modified shipping containers and prefabricated switchrooms will likely be mounted on concrete footings, while the cabinets will be mounted on several concrete slabs. The large buildings will be similar in appearance and construction to agricultural sheds prevalent across the project boundary.

Major components for each BESS include:

- Batteries – the specific battery module manufacturer and model has not been selected; however, it will likely be a type of lithium ion battery similar to the LG Chem Lithium Nickel Manganese Cobalt Oxide (NMC) 2-hour energy module or Tesla Powerpack 2-hour solution.
- Inverters – the inverters will likely be similar to those used within the three array areas as part of the PCUs. An alternative arrangement may be required whereby the inverters would be positioned adjacent to the battery cabinets, with the transformers and switchgear separate to this.
- Transformers – within the BESSs, there will be two types of transformer, namely (1) a Low Voltage (LV) to MV transformer and (2) a MV to HV transformer. The configuration of the transformers will be subject to the type of batteries used and the BESS configuration.
- Heating Ventilation Air Conditioning (HVAC) – one of three types of HVAC will likely be used as part of the BESS to maintain the batteries at a temperature that will optimise their lifetime and performance. This includes either small package units, large chillers or a liquid cooling system (should the battery cabinet configuration be installed).
- Fire protection – the shipping container/pre-fabricated switchroom structures and large building BESS configurations will have active gas-based fire protection systems. Within each of the potential enclosures, there will be thermal sensors and smoke/gas detectors connected to a fire control panel. The Tesla cabinet facilities will not have this feature as the inherent design minimises risk of a fire spreading from one cabinet to another.

The components described above will be similar for each of the BESS structures likely to be constructed as part of the project. As noted above, the specific design details for the BESS have not been confirmed and will not be known until the completion of the detailed design stage of the project.

2.5.5. Construction accommodation village

A construction accommodation village (CAV) for non-local construction employees may be established as part of the early stages of the project's construction. If constructed, the CAV may accommodate up to 500 workers (subject to demand).

A significant proportion of the project's non-local construction workers may be required to reside at the CAV while they are rostered on so as to mitigate the potential impact on tourist accommodation in the surrounding area and reduce potential impacts on the local road network.

The CAV will be located in the northern array area (part of Lot 2 of DP 174053 – refer to Figure 2.1). The CAV will be managed by an experienced operator (most likely the lead contractor appointed for the construction of the project). Where plausible, local businesses will be engaged to supply goods and services to the CAV (e.g. laundry, cleaning and catering).

It is anticipated that up to six diesel generator skids may be required to service the power requirements of the CAV. Each skid is likely to consume approximately 500 litres of diesel per day, which equates to a total of approximately 3,000 litres per day. Based on estimate of the potential usage, a 20,000 litres diesel storage tank will be provided on site. Diesel will be stored in a separate location/bund to other flammable materials (e.g. gasoline).

Storage of diesel will be required within the development footprint and will likely be positioned on Lot 2 of DP 174053 as part of the CAV or within proximity of O&M facilities or the construction site office. Storage of diesel within the development footprint will conform with relevant Australian Standards (i.e. AS 1940:2017 *The storage and handling of flammable and combustible liquids*) and consider best practice safety measures. Diesel storage will be placed away from environmentally sensitive areas, where possible.

The CAV is expected to be dismantled and its footprint rehabilitated once the project is built and it moves into the operational stage. Lot 2 of DP 174053 may also be utilised for PV modules and supporting infrastructure following the removal of the CAV.

2.5.6. Supporting infrastructure

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

1. One or more O&M buildings, to house meeting facilities, a temperature-controlled spare parts storage facility, Supervisory Control and Data Acquisition (SCADA) facilities, a workshop and associated infrastructure.
2. A number of new internal roads to enable access to the three array areas from the surrounding road network including The Gap Road, Salisbury Plains Road, Hillview Road, Munsies Road and Big Ridge Road.
3. Emergency access points to enable access to the three array areas from the surrounding road network in the case of an emergency (e.g. fire or flood).
4. Parking and internal access roads/tracks within the three array areas to allow for construction and ongoing maintenance.
5. Fencing and landscaping around the solar arrays, substations and BESSs.

The locations for the emergency access points will be identified as part of the project's emergency response plan during detailed design.

Temporary infrastructure during the construction stage of the project including laydown and storage areas and a site compound are also likely to be required in each of the three array areas. Laydown areas will likely be in close proximity to the primary site access points and will be placed away from environmentally sensitive areas, where possible.

Chain mesh security fencing will be installed within the project boundary to a height of up to 2.4 m high. The location of the security fencing will be determined in consultation with the project landholders. Fencing will restrict public access to the development footprint. Where possible, fencing will be positioned to minimise disruption to ongoing agricultural operations on land adjacent to the development footprint.

2.6. Construction

The following key activities will be completed during the construction stage of the project:

- Site establishment works and preparation for construction
  - Establishment of temporary construction site compound in a fenced off area including a site office, containers for storage, parking areas and temporary laydown areas
  - Construction of access tracks and boundary fencing installation
  - Site survey to confirm infrastructure positioning and placement
  - Geotechnical investigations to confirm the ground condition.
- Construction activities
  - Drive or screw piles
  - Installation of mounting structures and tracker tubes
  - Securing PV modules to tracker tubes
  - Installation of MV and HV cables
  - Installation of PCUs
  - Completion of substation augmentation
  - Establishment of the BESS compound
  - Testing and commissioning of project infrastructure.

Requirement for heavy civil works (e.g. grading, compaction) will be minimised as much as practicable as the flattest land areas within the three array areas, mostly cleared of vegetation, have been selected. Civil works will be required to prepare the array areas by installing fencing, internal access tracks and minor earth works. Heavier civil works will be required for certain infrastructure where a level pad is necessary (e.g. substation, BESS).

Construction equipment, materials and infrastructure will be transported to the three array areas via road. These will include use of heavy vehicles and oversized vehicles to deliver large equipment (e.g. transformers).

Laydown areas and waste handling, fuel and chemical storage areas will be strategically placed to minimise potential environmental impacts during the construction stage of the project.

The construction stage of the project will take approximately 36 months from the commencement of site establishment works to commissioning of the three array areas. The project will require a peak construction workforce of up to 700 people.

Construction activities will be undertaken from 6am–6pm Monday to Sunday. Exceptions to these hours may be required on limited occasions.

2.7. Operations

The operational lifespan of the project will be in the order of 30 years, unless the facility is re-powered at the end of the PV modules' technical life. The decision to re-power the plant will depend on the economics of solar PV technology and energy market conditions at that time. Should the PV modules be replaced during operations, the lifespan of the project may extend to up to 50 years.

It is anticipated that the facility will require regular maintenance throughout its operational life. This will include the following ongoing tasks:

- Site maintenance
  - Vegetation maintenance
  - Weed and pest management
  - Fence and access road management
  - Upgrading drainage channels
  - Landscaping.
- Infrastructure maintenance
  - PV module cleaning
  - PV module, inverter and tracker system repair (if required)
  - Equipment, cabling, substation and communications system inspection and maintenance.

Throughout operations, a workforce of up to 15 full time employees will be required. The operational workforce will also be responsible for ongoing security monitoring of the three array areas and project infrastructure.

Regular light vehicle access will be required throughout operations. Heavy vehicles may be required occasionally for replacing larger components of project infrastructure (e.g. inverters, transformers, BESS components). O&M activities will typically be undertaken by specialist subcontractors and/or equipment manufacturers.

UPC is currently in discussions with a number of the landholders to enable sheep grazing to resume on portions of the three array areas following the completion of the construction stage of the project. A detailed protocol will be developed to ensure biosecurity is maintained and that grazing does not impact on the safe and efficient operation of the project or result in injury to farm workers or O&M staff.

To ensure the optimal electricity production output for the project is maintained, the PV modules may need to be washed periodically to remove dirt, dust and other matter. Water for PV module cleaning will be transported to the three array areas via water trucks. Washing will not require any detergent or cleaning agents.

2.8. Decommissioning

Once the project reaches the end of its investment and operational life, the project infrastructure will be decommissioned, and the development footprint returned to its pre-existing land use, suitable for grazing of sheep and cattle, or another land use as agreed by the project owner and the landholder at that time.

Project decommissioning will require disturbance of the development footprint during the removal of equipment. A significant number of manpower, including both staff and contractors, and vehicle movements will be required during the decommissioning stage of the project.

Any underground cabling below 500 mm will remain in-situ following project decommissioning.

UPC will attempt to recycle all dismantled and decommissioned infrastructure and equipment, where possible. Structures and equipment that cannot be recycled will be disposed of at an approved waste management facility.

3. SEPP 33 RISK SCREENING

3.1. Overview

For this study, the objective of the SEPP 33 risk screening was to determine whether the project is considered as 'potentially hazardous' in the context of SEPP 33.

SEPP 33 (Ref.3) defines potentially hazardous industry as follows:

> '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 PHA as per the requirements set in HIPAP No. 6 (Ref.4) to determine the risk to people, property and the environment. If the residual risk exceeds the acceptability criteria, the development is 'hazardous industry' and may not be permissible within NSW.

The risk screening process in the *Applying SEPP 33* guideline (Ref.5) considers the type and quantity of hazardous materials to be stored on site, distance of the storage area to the nearest site boundary, as well as the expected number of transport movements.

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

The *Applying SEPP 33* guideline is based on the 7th edition of ADGC (Ref.6) and refers to hazardous chemicals by their DG classification. In this document, substances will be referred to by their DG classification rather than their classification under the Globally Harmonized System (GHS), which is used in the ADGC Edition 7.6 (Ref.7).

Risk screening is undertaken by comparing the storage quantity and the number of road movements of the hazardous materials with the screening threshold specified in the guideline. The screening threshold presents the quantities below which it can be assumed that significant off-site risk is unlikely.

3.2. Risk screening

3.2.1. Storage and handling

Summary of the expected types and quantities of hazardous materials to be stored or handled within the development footprint, together with the relevant SEPP 33 screening threshold is presented in Table 3.1.

3.2.2. Transport

Summary of the expected types of hazardous materials to be transported to-and-from the development footprint, together with the relevant SEPP 33 screening threshold is presented in Table 3.2.

3.2.3. Other materials

Other materials considered as part of the SEPP 33 risk screening include:

- Transformer oil – not classified as hazardous material and excluded from risk screening.
- MCPA (2-methyl-4-chlorophenoxyacetic acid) (for use as herbicide/pesticide) – not classified as hazardous material and excluded from risk screening.

Additionally, these materials will not be stored with other flammable materials and hence not considered to be potentially hazardous under SEPP 33.

Table 3.1: SEPP 33 Risk Screening Summary - Storage

Material/Usage	DG Class	Category	Project storage (tonne)	SEPP 33 threshold (tonne)	Exceed threshold?
Liquefied Petroleum Gas (LPG)	2.1	Flammable gas	9.5	For above ground storage, the screening threshold is 10 tonnes.	No
Refrigerant	2.2	Non-flammable Non-toxic gas	10	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	3 PG II	Flammable liquids	5	For quantity up to 5 tonnes, the amount is unlikely to represent a significant risk and therefore is not potentially hazardous	No
Diesel	C1	Combustible liquids	17 (20,000 litres)	No threshold identified based on SEPP 33. Diesel will be stored in different location/bund to other flammables (e.g. gasoline), hence it is not considered to be potentially hazardous based on SEPP 33 and excluded from risk screening.	No
BESS battery	9	Miscellaneous dangerous goods	4,800	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

Table 3.2: SEPP 33 Risk Screening Summary - Transport

Material/Usage	DG Class	Category	Vehicle movements		Minimum quantity per load (tonne)		Exceed threshold?
			Cumulative annual	Peak weekly	Bulk	Packages	
Liquefied Petroleum Gas (LPG)	2.1	Flammable gas	>500	>30	2	5	Threshold will not be exceeded. Movements are expected to occur during construction only, for use in the CAV (should it be required).
Refrigerant	2.2	Non-flammable Non-toxic gas	-	-	-	-	No threshold identified based on SEPP 33 and excluded from risk screening.
Gasoline	3 PG II	Flammable liquids	>750	>45	3	10	Threshold will not be exceeded. Movements are expected to occur mainly during construction and commissioning. Number of movements will be lower for operation.
Diesel	C1	Combustible liquids	-	-	-	-	No threshold identified based on SEPP 33 and excluded from risk screening.
BESS battery	9	Miscellaneous dangerous goods	>1000	>60	No limit	-	Threshold will not be exceeded. Movements are expected to occur during construction/commissioning only and will be less than the threshold level. Minimal movement expected during operation and maintenance (e.g. battery replacement).

3.3. Other risk factors

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

A review of these risk factors was undertaken and it was noted that the project would not involve:

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

3.4. Industries that may fall within SEPP 33

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

3.5. Conclusions

The main findings of the SEPP 33 risk screening are summarised as follows:

- The storage and transport of hazardous materials for the project will not exceed the relevant risk screening threshold.
- There is no other risk factor identified that could result in significant offsite impacts.
- The project is not considered as ‘potentially hazardous’ with respect to storage and transportation within the meaning of SEPP 33 and does not require a PHA.

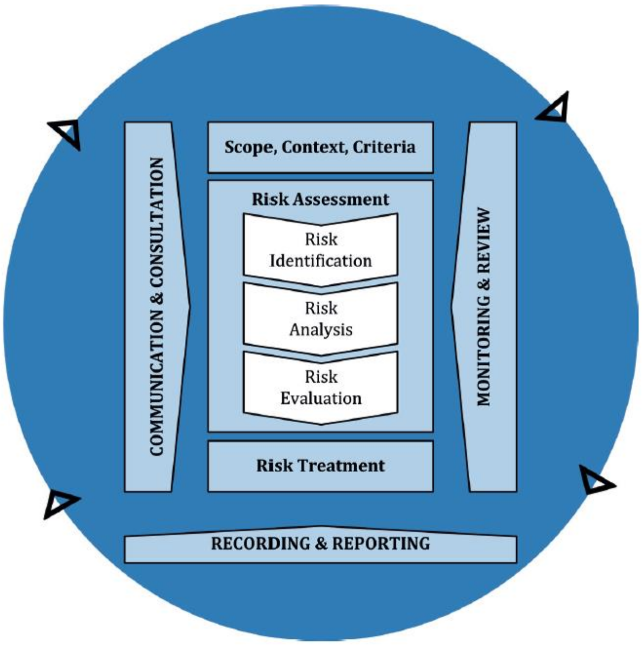
4. HAZARDS AND RISK ASSESSMENT

An assessment of all potential hazards and risks associated with the project was undertaken as part of the preparation of the EIS and to address the SEARs.

The overall objective of the hazards and risks assessment was to identify and assess all reasonably foreseeable hazards and risk events associated with the project infrastructure and proposed operations.

The hazard and risk assessment followed the risk management process outlined in *ISO 31000 Risk Management Guidelines* (Ref.8), illustrated in Figure 4.1.

Figure 4.1: Risk Management Process



The activities completed as part of the hazards and risks assessment including their objectives are presented as follows:

1. <u>Hazard Identification</u>
   - Identify all hazards associated with the project.
   - Identify credible events associated with the hazards.
   - Identify credible causes and potential consequences for the identified events.
   - Identify proposed controls to prevent and mitigate against the events.
   - Determine the likelihood of the events.
2. <u>Risk Assessment</u>
   - Determine the risk of the identified events.
   - Assess the risks associated with the project.

5. HAZARD IDENTIFICATION

5.1. Overview

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

To reduce the chance that something is missed, the HAZID was carried out in a workshop setting. Additionally, the workshop also features as consultation with the stakeholders as part of the risk management process.

Prior to the workshop, a desktop HAZID was undertaken by Sherpa for input to the study. The desktop HAZID reviewed hazards and risk events around the project infrastructure information based on similar developments (i.e. operational solar PV energy generating facilities).

During the workshop, a brainstorming session involving scenario based discussions and the 'what-if' hazard identification technique were used. The minutes were recorded and projected on the screen for agreement by the team during the workshop.

For each identified hazard, the discussion was structured to consider:

- Event – the mechanism by which the hazard potential is realised.
- Causes – the potential ways in which the event could arise.
- Consequences – the outcome or impact of the event.
- Controls – any existing aspects of the design which prevent and/or mitigate against the event and resulting consequences.

5.2. Workshop

The workshop was held at UPC's Sydney Office on 19 September 2018. The workshop team included representatives with appropriate project design and development knowledge, planning and environmental support. The workshop team is presented in Table 5.1.

Table 5.1: Hazards & Risk Assessment Workshop Team

Name	Company	Role
Killian Wentrup	UPC	Head of Solar Development
Tim Kirk	UPC	Project Development Manager
Max Willrath	UPC	Project Developer
David Richards	EMM Consulting	Planning & Environmental Support
Ossy Alim	Sherpa Consulting	Facilitator
Giles Peach	Sherpa Consulting	Technical Approval

5.3. Identified hazards and events

The following factors were considered to identify the hazards:

- 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 the asset were identified. The study excluded hazards related with Occupational Health & Safety (OH&S) (i.e. slips, trips and falls).

The identified hazards and events for the project are presented in Table 5.2. A summary of the hazards and the relevant project infrastructure (where the hazards are applicable) is provided in Table 5.3 .

Table 5.2: Identified Hazards and Events

Hazard	Event
Electrical	Exposure to voltage
Arc flash	Release of energy
EMF	Exposure to EMF
Fire	Infrastructure fire
Chemical	Release of hazardous materials
Reaction	Battery thermal runaway
External factors	Bushfire, vandalism, lightning storm

5.4. Bushfire assessment

The hazards and risks assessment considered bushfire both as a result of encroachment of an off-site bushfire impacting the project and an escalated event due to fire from the project infrastructure.

Separate bushfire assessments were completed for input to the EIS. These include:

- Preliminary Bushfire Report for the Temporary Construction Workforce Accommodation Village on Lot 2 in DP 174053 (Ref.9). This report was prepared to consider bushfire risk specifically on the land within the northern array area that may be used for the CAV.
- New England Solar Farm Bushfire Hazard Assessment (Ref.10).

Identified controls have been referenced (i.e. fire management plan) in the hazards and risks assessment study where applicable.

5.5. Exposure to EMF

The SEARs for 'Hazards and Risks' include a requirement to assess potential hazards and risks associated with exposure to EMF against the ICNIRP guidelines. Details on exposure to EMF and assessment against ICNIRP guideline and reference levels is presented in Section 6.

Table 5.3: Hazards by Project Infrastructure

Project Infrastructure	Hazards					
	Electrical	**Arc Flash**	**EMF**	**Fire**	**Chemical**	**Reaction**
1. Solar arrays (PV modules, MV cable network, PCUs)	✓	✓	✓	✓	-	-
2. Solar array substations	✓	✓	✓	✓	-	-
3. Collector network and grid substation	✓	✓	✓	✓	-	-
4. Battery Energy Storage System (BESS)	✓	✓	✓	✓	✓	✓
5. Construction Accommodation Village	✓	-	-	✓	-	-
6. Supporting Infrastructure • O&M buildings • Internal roads, emergency access point • Parking and internal access tracks • Fencing and landscaping	-	-	-	-	✓	-

5.6. Consequence

For each identified event, the resulting consequence was qualitatively described. These include impacts to personnel (e.g. fatality/injury), environment and/or assets.

5.7. Likelihood

Using a qualitative approach, the likelihood of an event was estimated using the category scale shown in Table 5.4. During the workshop, the likelihood ratings were assigned with consensus from the team based on knowledge of historical incidents in the industry and the team's experience. The likelihood ratings were assigned accounting for the initiating causes, resulting consequences with controls (prevention and mitigation) in place.

Table 5.4: Likelihood Category

Category	Description
1. Extremely Unlikely	Never heard of in the industry, not realistically expected to occur
2. Very Unlikely	Heard of in the industry, but not expected to occur
3. Unlikely	Could occur in the next 10 years
4. Likely	Could occur in the next year

5.8. Hazard register

The identified hazards, events, applicable infrastructure and the relationships with causes, consequences, controls and likelihood ratings are summarised in the hazard register. Information contained in the hazard register is provided in Table 5.5.

The hazard register for the project is presented in Table 5.6.

Table 5.5: Hazard Register – Information Description

Column Heading	Description
Hazard	Description of the source of potential harm
Infrastructure/Area	Project infrastructure or area the hazard/event is applicable to
Event	Description of mechanism by which the hazard potential is realised
Cause	Description of the potential ways in which the event could arise
Consequence	Description of consequences of the event and potential impact to people, environment and/or asset
Controls	Any existing aspects of the design which prevent and/or mitigate against the event and resulting consequences
Other Comments	This field is dedicated for miscellaneous comments from the team for the respective line item
Likelihood Rating	Likelihood rating assigned for the event accounting for the initiating causes, resulting consequences with controls in place.

Table 5.6: Hazard Register

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Controls	Other Comments	Likelihood Rating
1	Electrical	PV modules PCUs MV cable reticulation network Substation BESS Transformers Overhead transmission lines Construction Accommodation Village (CAV)	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	- 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 & 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	- 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	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
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	- 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

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Controls	Other Comments	Likelihood Rating
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	- 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	- 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) - 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)	-	Extremely Unlikely
6	Fire	Construction Accommodation Village (CAV)	Fire in CAV	- Kitchen fire - Paper fire - Smoking	- Injury/fatality - Asset damage	- Fire Management Plan - Cooling water supply on-site - 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 off-site bushfire - Escalated event from NESF fire	- Injury/fatality - Asset damage	- Fire Management Plan - Cooling water supply on-site - Defendable boundary for firefighting will be established - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS) - Use of appropriate PPE	-	Very Unlikely

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	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	- 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) - 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)	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 (e.g. substation, transformer)	- 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	- 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 - HVAC system (regulate air flow) - BESS fire protection system (enclosure/building)	Vented gases are early indicator of a thermal runaway reaction	Very Unlikely
10	Chemical	Battery	Coolant leak (Tesla Power Pack)	- Mechanical failure/damage - Incorrect maintenance	Irritation/injury for personnel on exposure (inhalation)	- 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	Tesla PowerPack Coolant is 50/50 mixture of ethylene glycol and water. A typical Powerpack system includes about 26 L of coolant. The Tesla Inverter includes about 11 L of coolant. The fluid does not emit a strong odor.	Very Unlikely

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Controls	Other Comments	Likelihood Rating
11	Chemical	BESS refrigeration Chiller units	Refrigerant leak	- Mechanical failure/damage - Incorrect maintenance	Irritation/injury for personnel on exposure (skin contact)	- 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	Tesla Power Pack The Powerpack thermal management system includes 400g of R134a refrigerant in a sealed system. Mechanical damage of a Powerpack 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	- 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 be used for more targeted weed treatment.	Very Unlikely
13	LPG	Construction Accommodation Village (CAV)	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	- 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 CAV.	Very Unlikely
14	Diesel	Construction Accommodation Village (CAV)	Release of diesel from storage tank or filling point Release of diesel during handling/ transfer to generator set	- Mechanical failure - Human error during transfer	- Fire (if ignited) - Injury/fatality	- 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 - Diesel is a combustible liquid and will be stored away from other flammable materials (e.g. gasoline) - Secondary containment (i.e. bunding) - Warning signs (combustible material) - Fire Management Plan - Defendable boundary for firefighting will be established - Emergency Response Plan - External assistance for firefighting (FRNSW & RFS) - Use of appropriate PPE	Diesel will be provided on-site for generator set use in the CAV.	Very Unlikely

ID	Hazard	Infrastructure/Area	Event	Cause	Consequence	Controls	Other Comments	Likelihood Rating
15	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	- 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 on-site for refuelling of vehicles.	Very Unlikely
16	External factors	BESS PCUs Substation	Fire (BESS, PCUs, Substation Switchrooms)	Water ingress (e.g. rain, flood)	- Electrical fault/short circuit - Fire - Injury/fatality	- 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
17	External factors	PV modules PCUs Substation BESS	Vandalism	Unauthorised personnel access	- Asset damage - Potential hazard to unauthorised person (e.g. electrocution)	- 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
18	External factors	All project infrastructure	Lightning strike	Lightning storm	- Injury/fatality - Fire - Asset damage	- Earthing - Lightning protection mast (Substations) - PPE	-	Very Unlikely

6. ELECTRIC AND MAGNETIC FIELDS (EMF)

6.1. Overview

EMF are naturally present in the environment. They are present in the earth's atmosphere as electric fields, while static magnetic fields are created by the earth's core. EMF are also produced wherever electricity or electrical equipment is in use (e.g. household appliances, powerlines) (Ref.11).

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

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

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

Use of electricity means that people are exposed to EMF as part of daily life. The background EMF in a typical home is around 20 V/m and 0.1 µT, respectively. These may vary depending on the number and type of appliances, configuration and positioning and distances to the other sources (e.g. powerlines). Typical EMF strengths for common household electrical appliances (at distance of 30 cm) are presented in Table 6.1 (Ref.12).

EMF associated with the generation, distribution and use of electricity power systems in Australia which have a frequency of 50 Hertz (Hz) are classified by Energy Networks Australia[1] (ENA) as Extremely Low Frequency[2] (ELF) EMF (Ref.11).

Table 6.1: Typical EMF strengths for household appliances

Electric appliance	Electric field strength (V/m)	Magnetic field density (µT)
Refrigerator	120	0.01 – 0.25
Iron	120	0.12 – 0.3
Hair dryer	80	0.01 – 7
Television	60	0.04 – 2
Vacuum cleaner	50	2 – 20
Electric oven	8	0.15 – 0.5

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

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

6.2. Effects of exposure to EMF

6.2.1. Acute effect

Studies have been conducted to determine the effects of EMF exposure. There have been a number of well-established acute effects on the nervous system due to exposure to high levels of EMF. These include direct stimulation of the nerve and muscle tissue, and induction of retinal phosphene (i.e. sensation of ring or spot of light on eye ball). However, it should be noted that exposure to high levels of EMF is not normally found in everyday environment from electrical sources. There is also indirect scientific evidence that EMF can transiently affect visual processing and motor coordination. For certain occupational instances, the ICNIRP considered that with appropriate training, it is reasonable for workers to voluntarily experience transient effects such as retinal phosphene and minor changes in brain function since these are not believed to result in long term or pathological health effects (Ref.13).

6.2.2. Chronic effect

Numerous studies have been conducted to understand the effects of long-term exposure to EMF. Some studies have linked prolonged exposure of EMF to increased rates of childhood leukemia. Based largely on limited evidence, the International Agency for Research on Cancer has classified ELF magnetic fields as 'possibly carcinogenic to humans'. The ICNIRP views that the current existing scientific evidence is too weak to ascertain a causal relationship that prolonged exposure to ELF magnetic fields is related with increased risk of childhood leukemia (Ref.13).

6.2.3. Advice from public authority

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is a federal government agency assigned with the responsibility for protecting the health and safety of people and the environment from EMF (Ref.11).

ARPANSA advises that:

- *"The scientific evidence does not establish that exposure to ELF EMF found around the home, the office or near powerlines and other electrical sources is a hazard to human health."*
- *"There is no established evidence that ELF EMF is associated with long term health effects. There is some epidemiological research indicating an association between prolonged exposure to higher than normal ELF magnetic fields (which can be associated with residential proximity to transmission lines or other electrical supply infrastructure, or by unusual domestic electrical wiring), and increased rates of childhood leukaemia. However, the epidemiological evidence is weakened by various methodological problems such as potential selection bias and confounding. Furthermore this association is not supported by laboratory or animal studies and no credible theoretical mechanism has been proposed".*

6.3. Study approach

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

Note: A task group assembled by the World Health Organisation (WHO) to assess any potential health risks from exposure to ELF EMF in the frequency range of 0 to 100,000 Hz found that there are no substantive health issues related to ELF electric fields at levels generally encountered by the general public (Ref.14). Therefore, the information presented in the following sections address predominantly the effects of exposure to ELF magnetic fields.

6.4. Guidelines for limiting EMF exposure

The ICNIRP has produced a publication to establish guidelines for limiting EMF exposure to assist in providing protection against adverse health effects. Separate guidance is given for general public and occupational exposure within the guideline.

The guideline has defined general public and occupational exposures as follows:

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

The ICNIRP reference levels for exposure to EMF at 50 Hz is presented in Table 6.2 (Ref.13). The guideline adopted more stringent exposure restrictions compared to occupational exposures recognising that in many cases general public are unaware of their exposure to EMF.

Table 6.2: 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

6.5. Project infrastructure EMF

6.5.1. Solar arrays, PV modules and PCUs

A field study was undertaken to characterise the EMF between the frequencies of 0 – 3 GHz at two large scale solar facilities operated by the Southern California Edison Company in Porterville and San Bernardino (Ref.15).

The field study findings were adopted to estimate the EMF measurements for the project (i.e. large scale solar farm and power generating facilities). The findings are as follows:

- There is no evidence of magnetic fields created from the PV modules. For conservatism, it is assumed that the magnetic fields from the PV module do not exceed the background static magnetic field observed at Porterville and San Bernardino (i.e. 52-62 µT).
- The highest DC magnetic fields were measured adjacent to the inverter (277 µT) and transformer (258 µT). These fields were lower than the ICNIRP's occupational exposure limit.
- The highest AC magnetic fields were measured adjacent to the inverter (110 µT) and transformer (177 µT). These fields were lower than the ICNIRP's occupational exposure limit.
- The strength of the magnetic field attenuated rapidly with distance (i.e. within 2-3 metres away, the fields drop to background levels).
- Electric fields were negligible to non-detectable. This is mostly likely attributed to the enclosures provided for the electricity generating equipment.

6.5.2. Underground MV cable

A typical 33 kV underground cable will produce a maximum magnetic field of approximately 1 µT at one metre above ground level. The magnetic field density will be indistinguishable from the background magnetic field at distances greater than 20 m away from the source (Ref.16).

6.5.3. Substations and transformers

Main sources of magnetic fields within a large substation (e.g. transmission substation) include transformer secondary terminations, cable runs to the switch room, capacitors, reactors, bus-bars, and incoming and outgoing feeders. For the majority of the cases, the highest magnetic fields at the boundary come from the incoming and outgoing transmission lines.

Generally, the application of electrical safety standards and codes (e.g. fence, enclosure, distance) will result in exclusion of general public exposures from these sources. This is consistent with the measurement of typical magnetic field reported which ranges between 1-8 µT at substation fence (Ref.17).

6.5.4. Transmission lines

The magnetic field from transmission lines will vary with configuration, phasing and load. The typical magnetic fields near overhead transmission lines measured at one metre above ground level range between 1-20 µT (directly underneath) and 0.2-5 µT (at the edge of easement) (Ref.17).

6.5.5. BESS

The magnetic field associated with a BESS will vary depending on a number of factors including configuration, capacity and type of housing. Due to the limited information on typical measurement of magnetic fields around BESS associated with large scale solar energy generating facilities, the study has assumed the typical magnetic field is not too dissimilar with that of a substation given the proposed designs which include dedicated housing (e.g. enclosures/large building) (refer to Section 2.5.4). The study also assumed that the BESS will be designed in accordance with electrical safety standards and codes which will result in exclusion of general public exposures from these sources.

6.6. Controls to limit exposure to EMF

The following controls were identified to limit exposure to EMF:

- The design, selection and procurement of electrical equipment for the project will comply with relevant international and Australian standards.
- Location selection for the project infrastructure (i.e. accounts for separation distance to surrounding land uses including neighbouring properties and agricultural operations) and fencing within the project boundary will assist to limit the exposure to EMF for the general public.
- Exposure to EMF (specifically magnetic fields) from electrical equipment will be localised and the strength of the field attenuates rapidly with distance.
- Duration of exposure to EMF for personnel on-site will be transient.

6.7. Conclusion

Based on the review completed in the preceding sections, the study concludes that:

- EMF created from the project will not exceed the ICNIRP occupational exposure reference level.
- As the strengths of EMF attenuate rapidly with distance, the study determined that the ICNIRP reference level for exposure to the general public will not be exceeded and impact to the general public in surrounding land uses will be negligible.
- For the risk assessment, consequence from exposure to EMF was assumed to result in 'Slight injury' (in reference to the study matrix shown in Figure 7.1).

7. RISK ASSESSMENT

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

Using a qualitative approach, the risk of an event was estimated using the study risk matrix shown in Figure 7.1.

For each identified hazard and associated event, the resulting consequences and likelihood pair was determined from the Hazard Register. The consequence and likelihood of the identified events are presented in Table 7.1.

Figure 7.1: Qualitative risk matrix

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

Risk Acceptance Criteria

High	Unlikely to be tolerable - review if activity should proceed.
Medium	Tolerable, if so far as reasonably practicable
Low	Broadly acceptable

Table 7.1: Risk analysis

Hazard	Event	Consequence (Impact 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 – CAV	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 (Tesla Power Pack)	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 diesel from storage tank, filling point or during handling resulting in fire	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

Summary of the risk analysis and assessment are as follows:

- Consequence: The worst case consequence for the identified events is a fire event which may result from a variety of causes (e.g. release of flammable materials, battery thermal runaway, transformer fire). These fires may have the potential to initiate bushfire to surrounding grasslands.
- Likelihood: The highest likelihood rating for the identified events is Unlikely (i.e. could occur in the next 10 years). The associated event relates to unauthorised personnel access to the development footprint resulting in vandalism/asset damage to the project infrastructure. During the workshop, the team noted that asset damage/theft is the most credible consequence for the event. For risk analysis, the consequence impact to people due to potential hazard on-site to unaware trespassers was rated as Moderate (i.e. severe injury).
- Risk analysis: A total of 18 risk events were identified. The breakdown of these events according to their risk ratings are as follows:

  - 14 Medium risk events
  - 4 Low risk events.

  Based on the risk acceptance criteria used for the study, the risk profile for the project is considered to be tolerable if So Far As Reasonably Practicable (SFARP).

  The majority of the Medium risk events relate to fire events resulting from a variety of causes (e.g. release of flammable materials, battery thermal runaway, transformer fire, bushfire, etc). The study identified proposed prevention controls to reduce the likelihood of these fire events and mitigation controls to contain the fires to minimise potential for escalated events (e.g. fire management plan). Based on the identified controls, the highest likelihood for these events were rated as Very Unlikely (i.e. heard of in the industry, but not expected to occur).

  Based on the (1) size of the development footprint, (2) proposed location for project infrastructure within the development footprint, (3) proposed controls and (4) separation distance to neighbouring land uses (including neighbouring properties and agricultural operations), the study noted that the exposure to fire events will primarily be to the project's construction and operations workforce and offsite impacts will be minimal.
- Risk assessment: The risk assessment concluded that there is no potential for offsite fatality or injury identified and therefore the project meets the land use planning criteria. Risk events identified are onsite impacts and assessed against Work Health and Safety (WHS) Act requirements to reduce risk to SFARP. Risks were assessed by the project as tolerable if SFARP.

8. REFERENCES

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