APPENDIX O PRELIMINARY HAZARDS ANALYSIS

Preliminary Hazard Analysis of Keri Keri Wind Farm and BESS

For Environmental Resources Management Australia Pty Ltd

20 March 2024

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Notation

Abbreviation	Description
ABCB	Australian Building and Construction Board
ABS	Australian Bureau of Statistics
AC	Alternating Current
ACH	Air Changes per Hour
ADG Code	Australian Dangerous Goods Code
AGL	Above Ground Level
APZ	Asset Protection Zone
ARPANSA	Australian Radiation Protection and Nuclear Safety Authority
Arriscar	Arriscar Pty Limited
AS	Australian Standard
AS/NZS	Australian Standard/ New Zealand Standard
BESS	Battery Energy Storage System
BMS	Battery Management System
BoM	Bureau of Meteorology
C_2H_4	Ethylene
C_2H_6	Ethane
C_3H_8	Propane
C_6H_6	Benzene
C_7H_8	Toluene
CCTV	Closed Circuit Television
CH_4	Methane
CO	Carbon Monoxide
CO_2	Caron Dioxide
DC	Direct Current
DPE	NSW Department of Planning and Environment
EES	Electrical Energy Storage
EI	Energy Institute
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency
EMF	Electro-Magnetic Force
EMR	Electro Magnetic Radiation
EP&A	Environmental Planning & Assessment

Abbreviation	Description
ERM	Environmental Resources Management Pty Ltd
ERPG	Emergency Response Guidance Levels
ESS	Energy Storage System
FM	Factory Mutual
ha	hectares
HCl	Hydrogen Chloride
HCN	Hydrogen Cyanide
HF	Hydrogen Fluoride
HIPAP	Hazardous Industry Planning Advisory Paper
HVAC	Heating, Ventilation and Air-Conditioning
Hz	Hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
ID	Identification
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organisation for Standardisation
kg/m^3	kilograms per cubic metre
km	kilometres
km^2	Square kilometres
kph	kilometres per hour
kV	kilovolt
kVA	Kilo-Volt Amps
LEP	Local Environment Plan
LFL	Lower Flammability Limit
LFP	Lithium Iron Phosphate (cathode)
LGA	Local Government Area
LIB	Lithium Ion Battery
LiFeP4	Lithium Iron Phosphate
LiPF6	Lithium Phosphate
LTO	Lithium Oxide (cathode)
m	metres
m/s	metres per second

Abbreviation	Description
MIC	Monitoring, Information exchange and Control
mm	millimetres
MW	Mega Watt
MWh	Mega Watt hour
NFPA	National Fire Protection Association (USA)
Ng	Lightning ground flash density
NMC	Nickel-Manganese-Cobalt (cathode)
O&M	Operations and Maintenance
OSOM	Oversize and Overmass
PHA	Preliminary Hazard Assessment
pmpy	per million per year
PV	Photo Voltaic
RFS	Rural Fire Service (NSW)
RR	Research Report
RSL	Returned Services league
SA	South Australia
SCA	State Conservation Area
SCADA	Supervisory Control and Data Acquisition
SDS	Safety Data Sheet
SEPP	State Environmental Planning Policy
SSD	State Significant Development
UFL	Upper Flammability Limit
UL	Underwriters Laboratories
UN	United Nations
V	Volts
v/v	volume/ volume
WHS	Workplace Health & Safety
WTG	Wind Turbine Generator

1 INTRODUCTION

1.1 Background

Environmental Resources Management Australia Pty Ltd (ERM) was engaged by Acciona Energy Australia Global Pty Ltd (the Proponent) to provide planning and environmental support relating to a proposal to construct and operate the Keri Keri Wind Farm (the Project), a renewable energy development located east of Balranald in the Riverina Murray region of New South Wales (NSW).

Keri Keri Wind Farm includes:

- Up to 155 Wind Turbine Generators (WTG) with a hub height of 200 metres (m) and maximum height tip height of 291.5 m (vertical tip);
- Battery energy storage system (BESS) with capacity of approximately 200 megawatt (MW) / 800 MW hours (MWh) (approximately 4 hours of storage)
- Three 33/330 kV electrical substations with ancillary electrical equipment;
- 64.5 km of overhead 33 kV and 175.3 km of underground 33 kV electrical reticulation connecting the WTGs to the onsite substations;
- 20.0 km of 330 kV overhead transmission line connecting the three substations to a new electrical switchyard and interface to grid.
- Other ancillary infrastructure including (but not limited to) internal access tracks, road upgrades, meteorological masts, and operation and maintenance (O&M) buildings.

Detailed project description is provided in Section 3.

The Proponent is seeking State Significant Development (SSD) consent under Part 4, Division 4.7 of the *Environmental Planning & Assessment Act 1979* (EP&A Act) for the Project.

1.2 Objectives and Scope

This report has been prepared to address the Hazards and Risks requirements of the Planning Secretary's Environmental Assessment Requirements (SEARs) [1]:

Hazards and Risks covering:

- *Battery Storage:*
    - o A preliminary risk screening completed in accordance with the State Environmental Planning Policy (Resilience and Hazards) (SEPP) 2021 [2], [3];
    - o A Preliminary Hazard Analysis (PHA), prepared in accordance with the Hazardous Industry Planning Advisory Paper (HIPAP) No. 6, 'Hazard Analysis' and Multi-level Risk Assessment [4]. The PHA must consider all recent standards and codes and verify separation distances to on-site and off-site receptors to prevent fire propagation and compliance with HIPAQP No.4 [5];
- *Blade Throw* – assess blade throw risks from wind turbine installations.

2 SITE LOCATION AND SURROUNDING USES

2.1 Location

The site is approximately 30 km southeast of the township of Balranald, NSW. The site covers an area of approximately 18,012 hectares (ha) (refer to Figure 1). The Project Area is zoned in its entirety as RU1 – Primary Production under the Wakool Local Environmental Plan (LEP).

2.2 Surrounding Land Uses

The Project Area is situated within the Hay Plains, which is characterised by a relatively flat topography with low relief and slight variation to elevations, which generally differs by only a few metres. The existing land uses surrounding the Project Area are predominantly agricultural and are used for irrigated cropping and grazing and contain an extensive network of irrigation channels.

The locality of Keri Keri recorded a population of 10 people in 2016 (ABS, 2021). The Project Area is also located adjacent to small towns and localities including Maude to the north (population 82), Moulamein to the east and south (population 484), and Yanga to the west (population 37) (ABS, 2021). There are 13 nearby residences located within 8 km of a wind turbine generator.

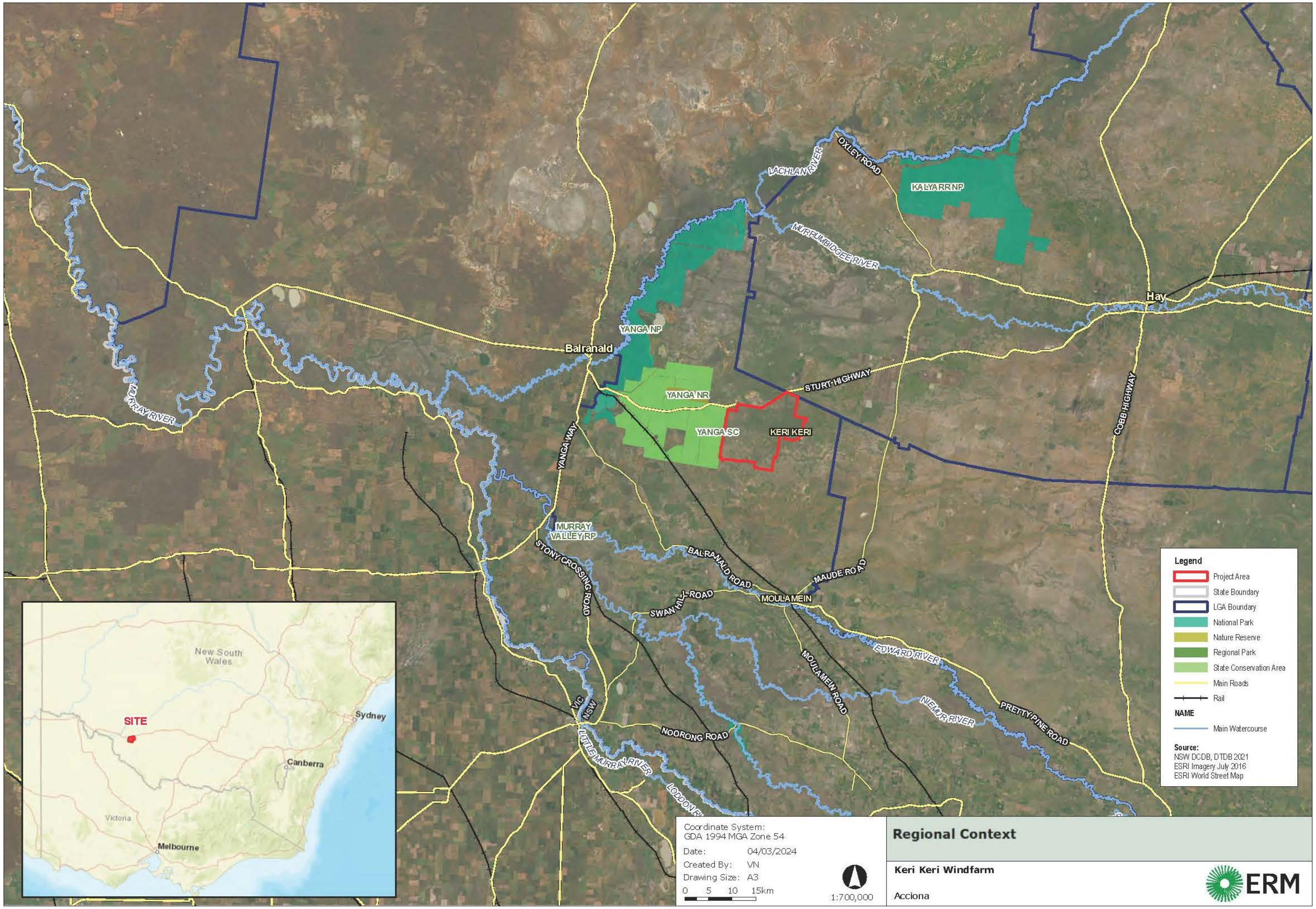
The Yanga State Conservation Area (SCA) is located immediately west of the Project Area and zoned C1 – National Parks and Nature Reserves under the Wakool LEP 2013. Additionally, Yanga Nature Reserve and Yanga National Park are located approximately 20 km to the northwest of the Project Area.

The Yanga Nature Reserve was reserved in 1972. The Yanga National Park and Yanga SCA were reserved in 2007 following the purchase of Yanga Pastoral Station, a 160 year old sheep, cattle, dryland cropping and red gum harvesting property (DPE, 2020c). Further additions to the national park occurred in 2010.

The Yanga National Park, Yanga SCA, and Yanga Nature Reserve are situated along the floodplains of the Lower Murrumbidgee River and on the western edges of the Riverina agricultural region, and together cover an area of approximately 71,700 ha. The area contains numerous woolsheds, camping ground, and homesteads, including the Willows Campground within the Yanga SCA.

There are a number of watercourses within the Murrumbidgee Catchment which are located near the Project Area. At the closest points, the Project Area is located approximately 20 km north of the Edward River, 10 km north of Forest Creek, and 12 km southwest of the Uara Creek. The Murrumbidgee Catchment covers an area of 84,000 km^2 and comprises 8 percent of the total area of the Murray-Darling Basin (MDBA, 2021). The Murrumbidgee Catchment contains a number of sites of international ecological significance, including the Lowbidgee Wetlands and Fivebough and Tuckerbil Swamps (DPE, 2021). The riparian lands throughout the Murrumbidgee Catchment are also highly valued for their uses for recreational tourism.

Figure 1: Location of Keri Keri Solar Farm and BESS



2.3 Access

Access to the Project Area during construction and operations is proposed via the existing road network. Primary access will be via the Sturt Highway, which borders the northern boundary of the Project Area. Secondary access, if required, may be proposed for Keri Keri Road.

Site infrastructure (e.g., BESS, Substations, Switchyards and Operations & Maintenance (O&M) facilities) will be fenced off using security fencing to restrict public access to those areas.

The internal access tracks will typically be 5.5m trafficable width on straights, with localised widening on curves and where required to support transportation of the over-sized WTG component vehicles. The internal access tracks will be constructed using unsealed pavements and will be generally in accordance with the Australian Road Research Board Unsealed Roads Manual.

2.4 Residential Dwellings

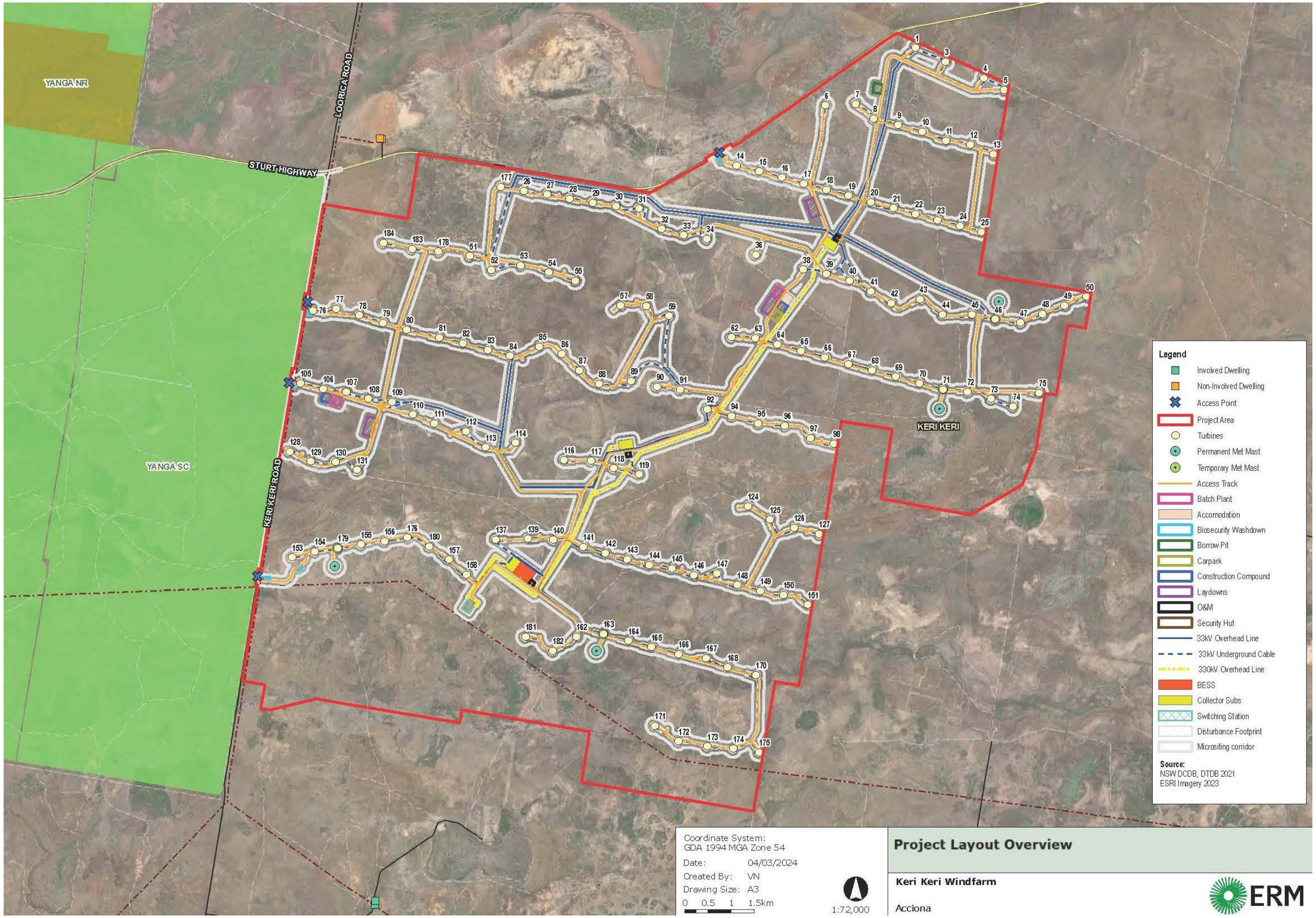
The nearest dwelling are 19 and 99, and the nearest WTG is 184.

- Dwelling 19: 2227m from WTG 184
- Dwelling 99: 2235 m from WTG 184

A further ten dwellings are between 5 km and 8 km of the development footprint.

The locations of dwellings are shown in Figure 2.

Figure 2: Location of Dwellings relative to Keri Keri Solar Farm and BESS



2.5 Meteorology

The nearest weather station to the Keri Keri Wind Farm and BESS Project is Balranald RSL Club, which is approximately 31 km to the northwest [6]. However, this does not contain hourly data [7]. Hourly data has been measured on the site using a site weather mast but is only available for a period of seven months and is not yet statistically significant.

The data for Swan Hill and Mildura airports were reviewed. Both are at approximately similar distances from the Keri Keri site. It was found that the data for Mildura Airport is more comprehensive and available on hourly basis for 25 years. Therefore, the Mildura airport data was used in this assessment.

A comparison of the wind rose for the site and Mildura Airport also showed similar trends.

2.5.1 Monthly Average Temperatures

Table 1: Mean Temperature Data for Balranald RSL

Temp. °C	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	33.1	32.6	29.2	24.1	19.4	16.1	15.7	17.6	21.0	24.6	28.2	31.0
Highest Monthly Mean	38.1	37.1	33.8	28.6	23.3	20.0	20.8	25.4	24.9	30.5	32.8	34.9
Lowest Monthly Mean	29.5	28.6	25.3	16.3	16.4	13.2	12.4	14.7	16.9	19.8	23.4	24.5
Highest Daily	47.7	46.2	42.2	39.0	35.6	25.6	27.0	30.1	37.6	40.8	44.6	46.2
Lowest Daily	20.0	12.5	14.0	13.3	10.6	7.1	7.5	9.1	11.5	11.5	13.9	16.7

2.5.2 Monthly Average Humidity

Table 2: Humidity Data for Balranald RSL

Relative Humidity %	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean 9am	55	59	62	68	81	87	85	78	67	58	58	54
Mean 3pm	30	32	35	41	52	59	57	49	43	38	34	31

2.5.3 Icing Conditions

The most important meteorological parameters for icing are the humidity in the air (liquid water content, mean volume droplet size and cloud base height), air temperature and wind speed.

Meteorological icing is the period during which the meteorological conditions for ice accretion are favourable (active ice formation) and instrumental icing is the period during which ice is present/visible at a structure and/or a meteorological instrument [8]. These periods have been used by the International Energy Agency (IEA) [9] to categorise the relative Ice Class for a site (refer to Table 3).

Instrumental icing commonly refers to stationary (non-rotating) objects. For a rotating turbine rotor, high flow velocity and blade vibrations result typically in shorter incubation and recovery times than for stationary instruments [8]. Rotor icing is defined as the period during which the wind turbine rotor accumulates ice. Ice is accreted continuously on a wind turbine rotor until the meteorological conditions for icing are not present anymore (end of the meteorological icing). Ice will remain on the wind turbine for a certain time – the recovery time – until ice erodes, sublimates, melts, or sheds away from the rotor (end of the rotor icing) [8].

Table 3 IEA Icing Classes for Meteorological and Instrumental Icing [9]

Icing Class	Meteorological Icing (% of year)	Instrumental Icing (% of year)
5	> 10	> 20
4	5 – 10	10 – 30
3	3 – 5	6 – 15
2	0.5 – 3	1 – 9
1	0 – 0.5	0 – 1.5

The determination of the meteorological icing duration is based on the measurement of atmospheric conditions such as air temperature, wind speed, liquid water content of the air and the droplet size distribution [8]. Cloud base height and relative humidity may also be used, but relative humidity is not the primary mechanism of meteorological icing [8]. As the optimal data is not available from the measurement systems within the Project area, the following boundary conditions for the determination of meteorological icing have been considered [8]:

- Above 100% relative humidity (saturation) and temperature below +3°C a very high probability for meteorological icing exists, with the highest probabilities for meteorological icing observed between +2°C and -5°C and extremely low probabilities for meteorological icing observed below -10°C.

A combination of air temperature below 3°C and high relative humidity as criteria for meteorological icing may overestimate the frequency of icing [8]. Data was used from the meteorological masts installed in the Project Area, and it should be noted only seven months of data is available, from April 2022 through to October 2022.

Table 4 Analysis of Potential for Meteorological Icing Conditions

	Met Mast Hub Height
Max Duration Avg Temp. >= -10 to < 3 Deg C and RH >= 100% (hours)	0
Total Duration Avg Temp. >= -10 to < 3 Deg C and RH >= 100% (hours p.a.)	0
% of year Avg Temp. >= -10 to < 3 Deg C and RH >= 100%	0

Based on the data presented in Table 4, the proposed turbine locations may be categorised as IEA Icing Class 1 (lowest Class - refer to Table 3) based on the potential for meteorological icing. This assumption is conservative given that the met mast hub height for icing is zero as per Table 4.

For instrumental icing, direct ice measurement is typically undertaken by observing ice with a camera, measuring the ice mass, etc. As this data is not available from the measurement systems within the Project Area, the following boundary conditions for the determination of instrumental icing have been considered [8]:

- The measured temperature at the reference height is lower than 3˚C.
- The measured relative humidity at the reference height is higher than 95%.

This approach is very conservative and may lead to an over-estimation of the instrumental icing duration [8].

Table 5 Analysis of Potential for Instrumental Icing Conditions

	Met Mast Hub Height
Max Duration Avg Temp. < 3 Deg C and RH > 95% (hours per event)	0
Total Duration Avg Temp. < 3 Deg C and RH > 95% (hours p.a.)	0
% of year Avg Temp. < 3 Deg C and RH > 95%	0

Based on the data presented in Table 5, the proposed turbine locations may be categorised as IEA Icing Class 1 (refer to Table 3) based on the potential for instrumental icing. This assumption is conservative given that the met mast hub height for icing is zero as per Table 5.

The analysis of the potential for both meteorological and instrumental icing indicates that the Project Area may be categorised as IEA Icing Class 1 (refer to Table 3).

Due to the small dataset of weather conditions from the site, a comparison was conducted with larger weather datasets from nearby. Data was selected from the nearest meteorological stations to the Project Area, namely Midura (BOM Site ID 76031, 25 year dataset) and Swan Hill Aerodrome (BOM Site ID 77094, 25 year dataset). Note that this data is at ground level.

Table 6 Comparison Analysis of Potential for Meteorological Icing Conditions

	Swan Hill	Mildura
Max Duration Avg Temp. >= -10 to < 3 Deg C and RH >= 100% (hours)	16	7
Total Duration Avg Temp. >= -10 to < 3 Deg C and RH >= 100% (hours p.a.)	237.7	126.3
% of year Avg Temp. >= -10 to < 3 Deg C and RH >= 100%	2.7	1.4

Table 7 Comparison Analysis of Potential for Instrumental Icing Conditions

	Swan Hill	Mildura
Max Duration Avg Temp. < 3 Deg C and RH > 95% (hours per event)	16.0	13
Total Duration Avg Temp. < 3 Deg C and RH > 95% (hours p.a.)	238.4	126.9
% of year Avg Temp. < 3 Deg C and RH > 95%	2.7	1.5

The analysis of the potential for both meteorological and instrumental icing, considering both site and nearby datasets indicates that the Project Area may be categorised as IEA Icing Class 1 to Class 2 (refer to Table 3).

This analysis is based on an approach that is very conservative and may lead to an over-estimation of the icing duration; however, the potential for ice formation does appear to be credible for the wind turbines in the Project Area.

The different forms of atmospheric icing include [10]:

- **Rime** – This type of icing is caused by the instantaneous freezing of supercooled water droplets (liquid water at temperatures below 0°C) upon contact with a structure. This type of ice most often forms in a homogeneous, cloudy environment and will accumulate on the structure's surface exposed to the wind.

  Soft rime has a density ranging from 200 to 600 kg/m^3, has a white colour, and has low to medium adhesion to structures. Conversely, hard rime has a density ranging from 600 to 900 kg/m^3, has an opaque colour, and has strong adhesion to structures.

- **Glaze** – This type of ice is also known as clear ice and is caused by different types of supercooled precipitation that freezes upon contact with a cold structure.

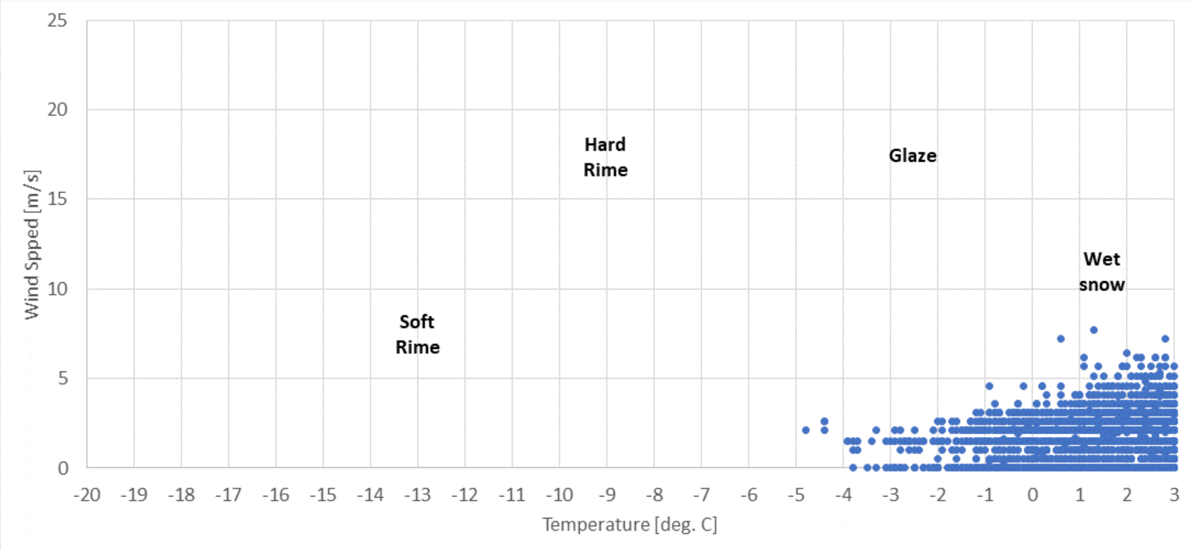
  This type of ice has a density of approximately 900 kg/m^3. It is generally produced at temperatures ranging from 0°C to -6°C, combined with freezing rain. On roads, a thin and transparent layer of glaze is often referred to as black ice.

- **Wet Snow** – When temperatures fluctuate between 0 °C and 3°C, snow crystals with a high water content can adhere and bond to structures. When the temperature drops, accumulated wet snow freezes to form ice that has a density varying between 300 and 600 kg/m^3. Visually, it resembles rime.

- **Hoar Frost** - At very low temperatures, the likelihood of ice formation diminishes, as the water droplets no longer exist in a supercooled state. However, another phenomenon may occur, namely the solid condensation of water vapor in the air. This type of ice, known as hoar frost, is produced when relative air humidity is high (above 90%) and winds are low. Its density and bond strength are low, which limits the mechanical loads imparted on structures. As a result, hoar frost is also less dangerous in terms of ice shed.

Figure 3 shows typical ice type as a function of air temperature and wind speed [10]. The plotted data is from the nearest meteorological stations to the Project Area, namely Midura (BOM Site ID 76031) and Swan Hill Aerodrome (BOM Site ID 77094). The data is at ground level rather than wind turbine height. This will impact wind speed rather than temperature. This data suggests that glaze ice is more likely to occur than rime ice for the wind turbines in the Project Area.

Figure 3 Average Wind Speed vs Minimum Temperature when RH >=95%



2.5.4 Rainfall

The nearest weather station for rainfall data to the Keri Keri project is Balranald, which is approximately 31 km to the northwest. This has been assumed to be representative of rainfall at the Project Area.

Table 8 Rainfall Data for Balranald

Rainfall mm	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean monthly for all years	22.6	24.6	21.9	24.1	31.3	29.3	26.1	29.4	29.3	31.4	29.2	25.8
Highest Monthly	137.6	141.5	133.3	125.7	117.4	137.5	82.3	85.2	106.6	184.6	125.0	145.3
Highest Daily for all years	71.8 *14 Jan 2011*	81.3 *05 Feb 2011*	62.7 *06 Mar 1956*	93.3 *21 Apr 1990*	57.9 *07 May 1881*	70.6 *04 Jun 1923*	39.4 *30 Jul 1923*	53.3 *15 Aug 1958*	55.6 *11 Sep 1881*	61.0 *24 Oct 1975*	84.7 *16 Nov 2017*	61.0 *04 Dec 1954*

2.5.5 Flooding

Flooding was a consideration in the site selection and project design process. Available flood mapping indicates the site is not subject to inundation from a 100-year average recurrence interval flood event. The infrastructure to be established within the development footprint is unlikely to have a significant impact on local or regional flooding, as it will not require significant earthworks or changes to the general topography of the site. Therefore, existing flow paths are expected to be maintained.

At the closest points, the Project Area is located approximately 20 km north of the Edward River, 10 km north of Forest Creek, and 12 km southwest of the Uara Creek.

2.5.6 Prevailing Winds

The following figures shows the comparison between Balranald and Mildura Airport. Balranald wind speed appears to be consistently between 4-5 kph lower than that at Mildura Airport. The wind directions are consistent between Balranald RSL station and Mildura Airport.

For the purposes of consequence and risk modelling the meteorological data for Mildura Airport was used as it is available on hourly basis over a 25-year period (1/1/1990 to 31/12/2014).

Figure 4: Balranald Wind Rose 9am

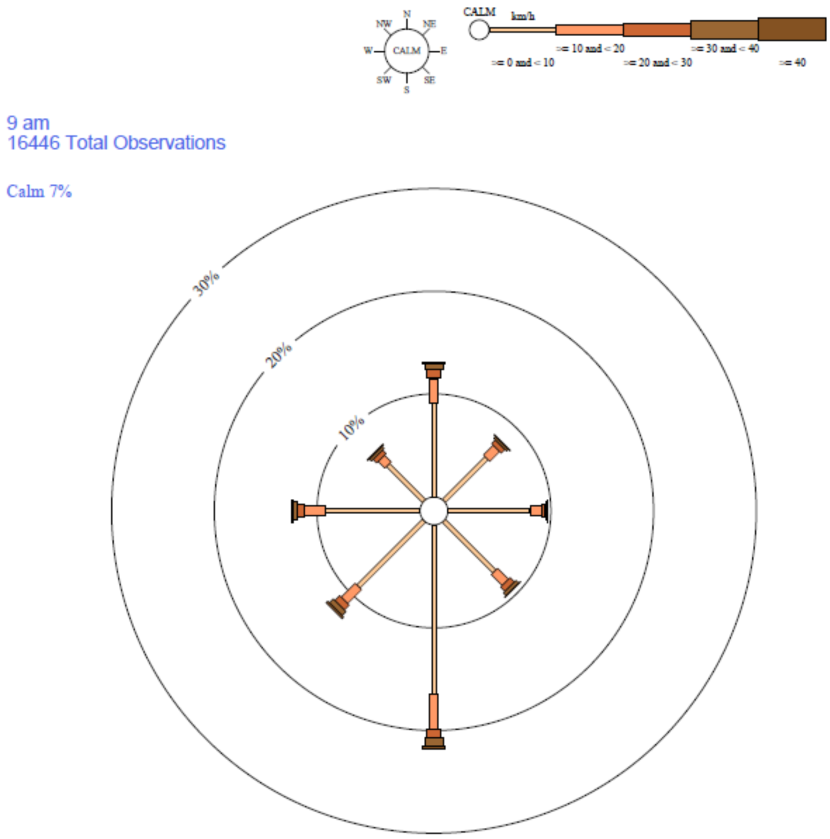


Figure 5: Balranald Wind Rose 3pm

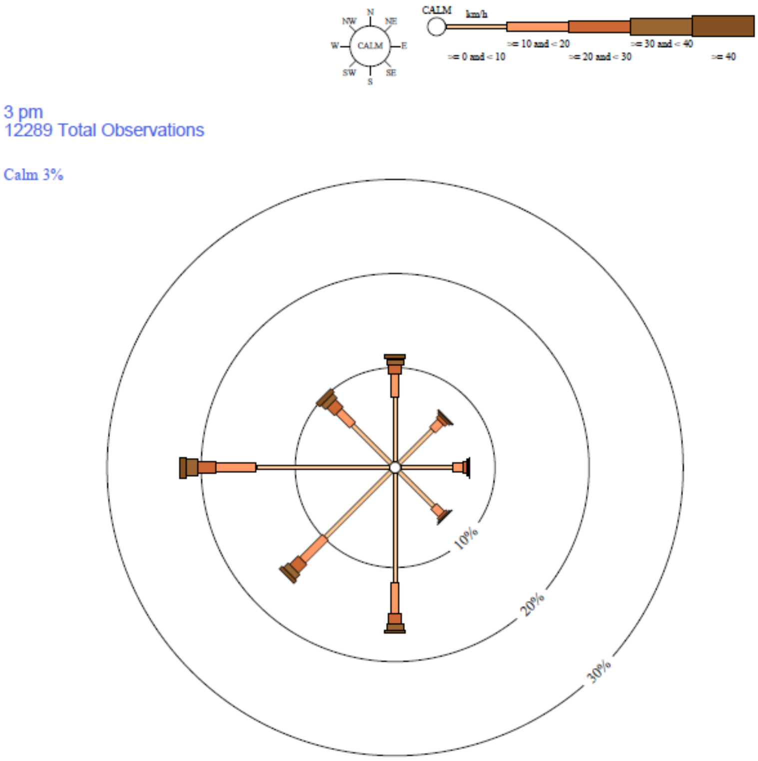


Figure 6: Mildura Airport Wind Rose 9am

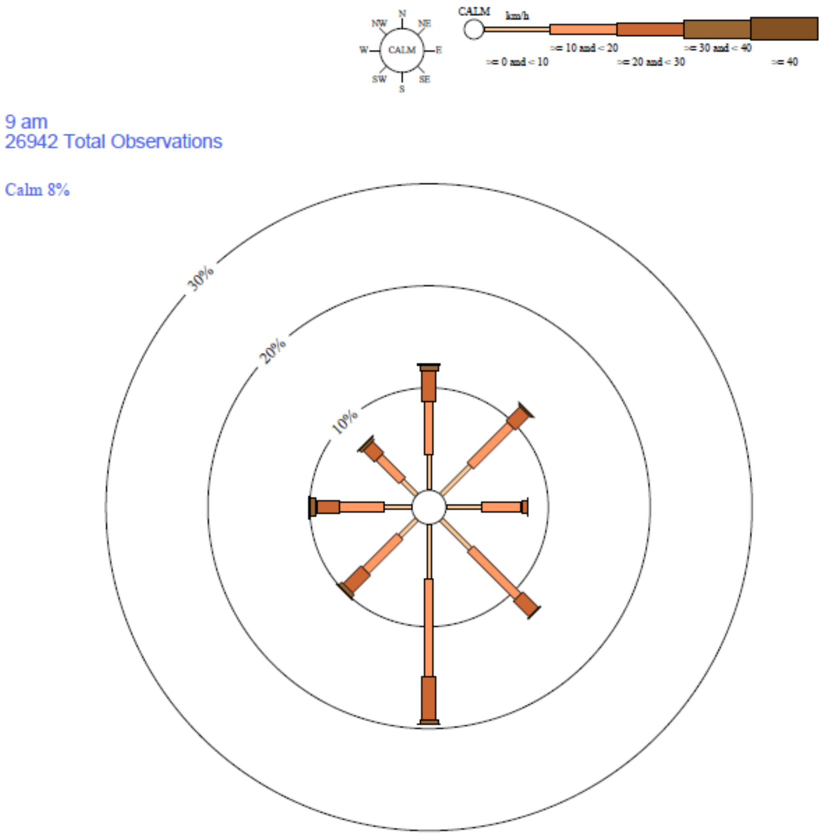


Figure 7: Mildura Airport Wind Rose 3pm

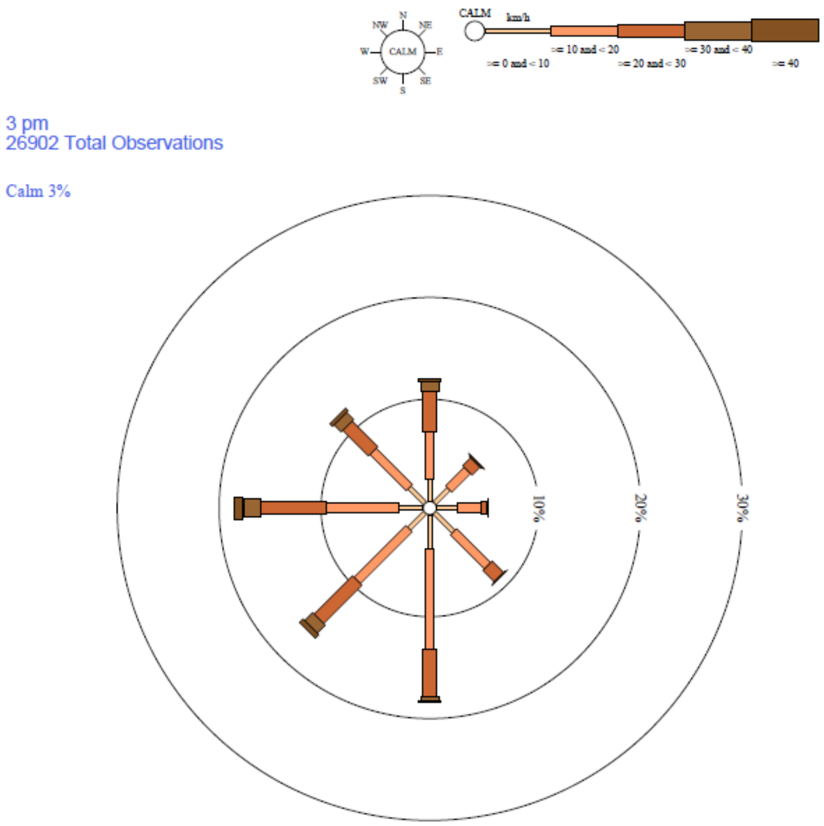
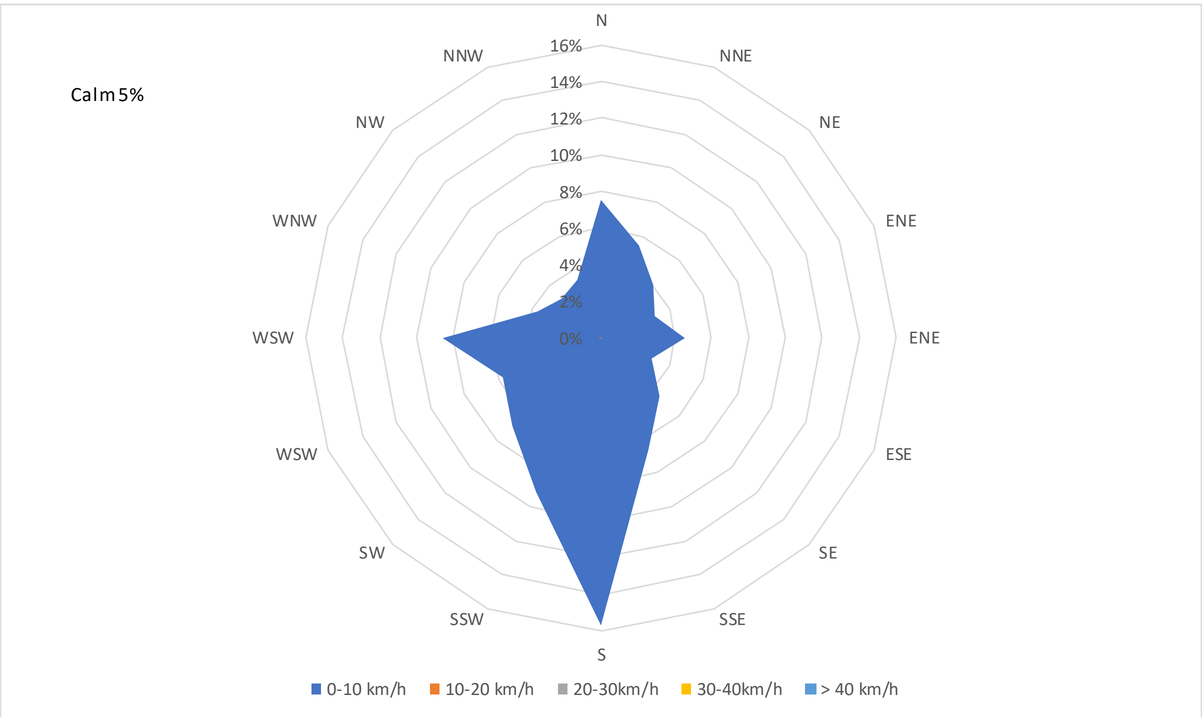


Figure 8: Mildura Airport Wind Rose all data

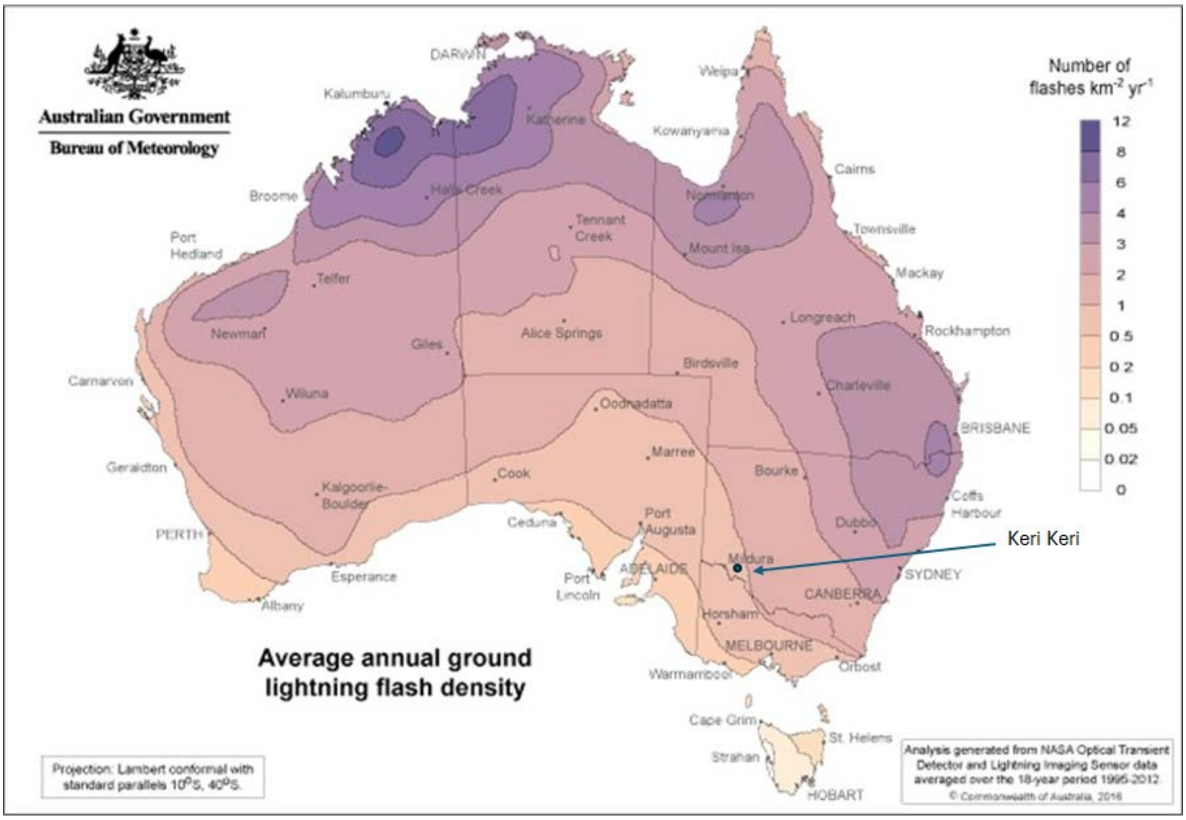


2.5.7 Thunderstorm Activity

The Bureau of Meteorology has mapped the lightning ground flash density (Ng) across Australia using data over an 18-year period (1995-2012) (refer to Figure 9). The lightning ground flash density (Ng) at the Project Area is 1 to 2 flashes per km^2 per year. The Project Area is 18,012 hectares or 180.12 km^2, and so the Project Area should expect up to 361 lightning ground flashes per year.

The approximate location of the Keri Keri facility is shown on Figure 9.

Figure 9: Average Annual Ground Lightning Flash Density [11]



2.5.8 Seismic Activity

The site is in an area of relatively low seismic activity with a peak ground acceleration of 0.01-0.02 g [12]. Peak ground acceleration is related to the expected severity of earthquake ground motion.

Seismic activity in the area is considered low. The Munich Reinsurance World map of Natural Hazards [13] categorises the area as Zone 1, i.e., Modified Mercalli Scale VI with an exceedance probability of 10 % in 50 years (equivalent to a return period of 475 years) for medium subsoil conditions. Overall, this exposure would be considered low.

2.5.9 Summary of Meteorological Data for Mildura Airport

The data (mean cloud cover, temperature, wind speeds) was collected by the Bureau of Meteorology at Mildura Airport. This raw data was rationalised in a form appropriate for BESS off gases dispersion calculations.

The data has been processed into a rationalised form consisting of six wind speed/Pasquil stability group classes arranged into sixteen wind direction groups. The arrangement into wind speed/ stability group classes followed the criteria set out below in the table below and the rationalised wind weather data is shown in the following table.

Table 9: Rationalised Weather Data (Day time)

Direction/ Stability Class	B3.1	D7.3	D1.6	D4.1	E3	F1.4	Total
N	0.0115	0.026	0.006	0.047	0.001	0.002	**0.094**
NNE	0.0077	0.012	0.004	0.032	8E-04	6E-04	**0.057**
NE	0.007	0.005	0.003	0.02	7E-04	8E-04	**0.037**
ENE	0.0067	0.002	0.004	0.015	3E-04	7E-04	**0.029**
E	0.0108	0.002	0.005	0.021	4E-04	0.001	**0.041**
ESE	0.0096	0.002	0.003	0.018	2E-04	6E-04	**0.033**
SE	0.0127	0.005	0.004	0.03	3E-04	8E-04	**0.053**
SSE	0.013	0.008	0.005	0.038	8E-04	0.001	**0.066**
S	0.0262	0.018	0.011	0.083	0.002	0.004	**0.144**
SSW	0.0125	0.011	0.005	0.044	0.001	0.002	**0.076**
SW	0.008	0.014	0.004	0.035	7E-04	0.001	**0.063**
WSW	0.0071	0.019	0.003	0.035	7E-04	0.001	**0.067**
W	0.0108	0.031	0.006	0.051	0.001	0.002	**0.102**
WNW	0.0064	0.014	0.003	0.023	7E-04	9E-04	**0.048**
NW	0.0066	0.008	0.003	0.021	7E-04	0.001	**0.041**
NNW	0.0083	0.01	0.003	0.027	7E-04	0.001	**0.05**
TOTAL	**0.1648**	**0.187**	**0.072**	**0.542**	**0.013**	**0.021**	**1.000**

Table 10: Rationalised Weather Data (Night time)

Direction/ Stability Class	B3.1	D7.3	D1.6	D4.1	E3	F1.4	Total
N	0	0.0063	0.0015	0.0243	0.0141	0.0183	**0.0644**
NNE	0	0.0043	0.0006	0.0244	0.0143	0.0117	**0.0553**
NE	0	0.0019	0.0010	0.0167	0.0141	0.0152	**0.0490**
ENE	0	0.0006	0.0012	0.0108	0.0100	0.0158	**0.0384**
E	0	0.0006	0.0022	0.0141	0.0173	0.0231	**0.0572**
ESE	0	0.0004	0.0012	0.0080	0.0079	0.0134	**0.0309**
SE	0	0.0007	0.0014	0.0113	0.0116	0.0175	**0.0425**
SSE	0	0.0032	0.0017	0.0229	0.0232	0.0219	**0.0728**
S	0	0.0072	0.0035	0.0574	0.0619	0.0564	**0.1863**
SSW	0	0.0057	0.0020	0.0395	0.0418	0.0258	**0.1148**
SW	0	0.0061	0.0015	0.0290	0.0219	0.0204	**0.0789**
WSW	0	0.0045	0.0017	0.0201	0.0127	0.0149	**0.0539**
W	0	0.0062	0.0019	0.0295	0.0225	0.0193	**0.0794**
WNW	0	0.0030	0.0009	0.0109	0.0079	0.0086	**0.0313**
NW	0	0.0012	0.0006	0.0079	0.0054	0.0076	**0.0228**
NNW	0	0.0011	0.0010	0.0077	0.0050	0.0071	**0.0220**
TOTAL	**0**	**0.0529**	**0.0238**	**0.3346**	**0.2917**	**0.2970**	**1.000**

3 DESCRIPTION OF FACILITIES

The Project involves the construction, operation, maintenance and decommissioning of a wind farm, with up to 155 WTGs, together with associated and ancillary infrastructure.

The Project design has been revised and refined in response to the identification and assessment of environmental constraints, constructability requirements, and consideration of the outcomes of agency, landowner, and community consultations.

The Project consists of the following key components:

- Up to 155 WTGs, each comprising:
  - Three blades mounted to a rotor hub (hub height of 200 m) on a nacelle above a tubular steel tower, with a blade tip height (blade length plus hub height) of up to 291.5 m AGL;
  - A gearbox and generator assembly housed in the nacelle; and
  - Adjacent hardstands for use as crane pads, assembly and laydown areas;
- Electrical infrastructure comprising:
  - A battery energy storage system (BESS) of up to 200 MW/800 MWh (approximately four hours of storage);
  - Three 33/330 kV electrical substations, including control room, communications tower, transformers, circuit breakers, switches, lighting protection and other ancillary equipment;
  - 64.5 km of overhead 33 kV and 175.3 km of underground 33 kV electrical reticulation connecting the WTGs to the onsite substations (where practicable, these are generally following site access tracks);
  - 20.0 km of 330 kV overhead transmission line connecting the three substations to a new electrical switchyard (including circuit breakers, switches and other ancillary equipment) to provide connection to the planned NSW-SA interconnector, Project EnergyConnect currently under construction;
- Ancillary infrastructure:
  - Four site access points with one along Sturt Highway and three along Keri Keri Road;
  - Three operations and maintenance (O&M) facilities and four security huts;
  - Four biosecurity wash bays;
  - Internal access tracks connecting the WTGs and associated Project infrastructure with the public road network;
  - Decommissioning of four temporary meteorological monitoring masts and installation of up to four permanent meteorological monitoring masts for power testing. The permanent monitoring masts will be located close to a WTG location and will have a maximum height of approximately 159 m AGL; and

- Upgrades to public roads and intersections required for the delivery of oversize and overmass (OSOM) WTG components, transformers and associated construction-phase materials and vehicular movements.
- The following temporary elements will be required during the construction phase of the Project:
  - Two temporary construction site compounds, comprising site buildings and facilities for construction contractors / equipment, site offices, car parking and amenities for the construction workforce;
  - Mobile concrete batching plants to supply concrete for WTG footings and substation construction works;
  - Earthworks for access tracks, WTG platforms and foundations;
  - Borrow pit and rock crushing facilities for the generation of suitable aggregate for concrete batching and/or for access track and hardstand construction;
  - One workers' accommodation compound and carpark;
  - Hardstand laydown areas for the storage of construction materials, plant, and equipment;
  - Up to four temporary meteorological monitoring masts. The temporary monitoring masts will be located close to a WTG location with a maximum height of approximately 159 m AGL;
  - External water supply and storage for concrete batching and construction activities;
  - The transport, storage and handling of fuels, oils and other hazardous materials for construction and operation of wind farm infrastructure; and
  - Beneficial reuse of materials won from within the Disturbance Footprint during cut and fill and WTG foundation excavation works for use in access track, hardstands and foundation material.

Ultimately the project will be decommissioned and the Project Area will be rehabilitated.
The proposed layout is shown in Figure 2.

3.1 Wind Farm

The WTGs have a generating capacity of approximately 6 MW and include:

- Three blades mounted to a rotor hub on a tubular steel tower;
- A gearbox and generator assembly housed in a nacelle; and
- Adjacent hardstands for use as crane pads and assembly and laydown areas.

The indicative WTG model selected for the Project is the Nordex N163-5.X 5.7 MW. The WTGs will be semi-variable speed, pitch-regulated machines with the rotor and nacelle mounted on a tower with an internal ladder or service lift. The exact size and type of WTG will be based on subsurface soil conditions and the results of geotechnical surveys undertaken during the detailed design phase, prior to commencement of construction at each WTG site. The dimensions and operating parameters vary for the models being considered; therefore, conservative values have been assumed for the hazard analysis (e.g., blade throw analysis) as listed in the table below.

Table 11 Wind Turbine Generators

Dimension or Operating Parameter	Range	Data Selected for Hazard Analysis
Rotor Diameter	Up to 183 m	183 m
Blade Length	Up to 91.5 m	91.5 m (including nacelle)
Tower / Hub Height	Up to 200 m	200 m
Tip Height	Up to 291.5 m	291.5 m AGL
Start-up wind speed	3 m/s	3 m/s
Shut down wind speed	26 m/s	26 m/s
Rotational speed	Up to 11.8 rpm	6.0 -11.8 rpm (Nominal) and 23.6 rpm (Emergency)

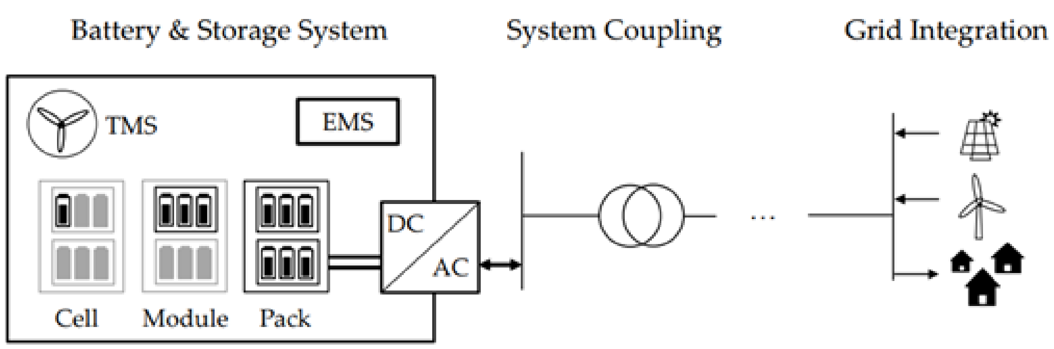
3.2 Battery Energy Storage System (BESS)

A BESS is an advanced technology developed for storing the electricity generated by solar or wind power by using specially developed batteries.

The BESS includes battery cells, assembled into modules and packs, and stored in cabinets inside buildings or containers (ISO containers) in the open. The DC electricity from the packs is fed through energy converters (inverters) to convert to AC, voltage boosted through power transformers and fed to the power grid.

A schematic of an example BESS is shown in Figure 10 [14].

Figure 10: Schematic of Example Battery Energy Storage System



3.2.1 Lithium-Ion Battery

The most common BESS consists of an array of lithium-ion batteries (LIB). There are different LIBs, but they all use the technology of transferring lithium ion between an anode and cathode. The anode is mainly carbon, due to its cost effectiveness and higher energy density. The differences are in the cathodes.

The cathode accepts lithium ions during discharge and releases them during the charge cycle. The cathode consists of metal oxides such as Nickel-Manganese-Cobalt oxide (NMC), Lithium-Iron Phosphate (LFP) and Lithium Oxide (LTO) [14], [15].

The electrolyte is typically composed of an organic solvent and a lithium-based salt, commonly Lithium Fluorophosphate (LiPF6). In between the anode and cathode is a polymer membrane separator.

Because of the mixture of a range of chemicals, a decomposition reaction from overheating of the cell can result in the evolution of flammable and toxic gases. Ignition of these gases can result in a battery fire or explosion in the confined volume.

It is assumed that the BESS will be based on Lithium-Iron Phosphate (LFP) [16].

3.2.2 Battery Storage

Multiple cells are typically assembled into a module by connecting them in series and parallel arrangements. The modules are stacked and interconnected in a battery rack. The racks are stored in a cabinet for small installations and containerised storage for large installations. Depending on the capacity of BESS, several containers can be stored.

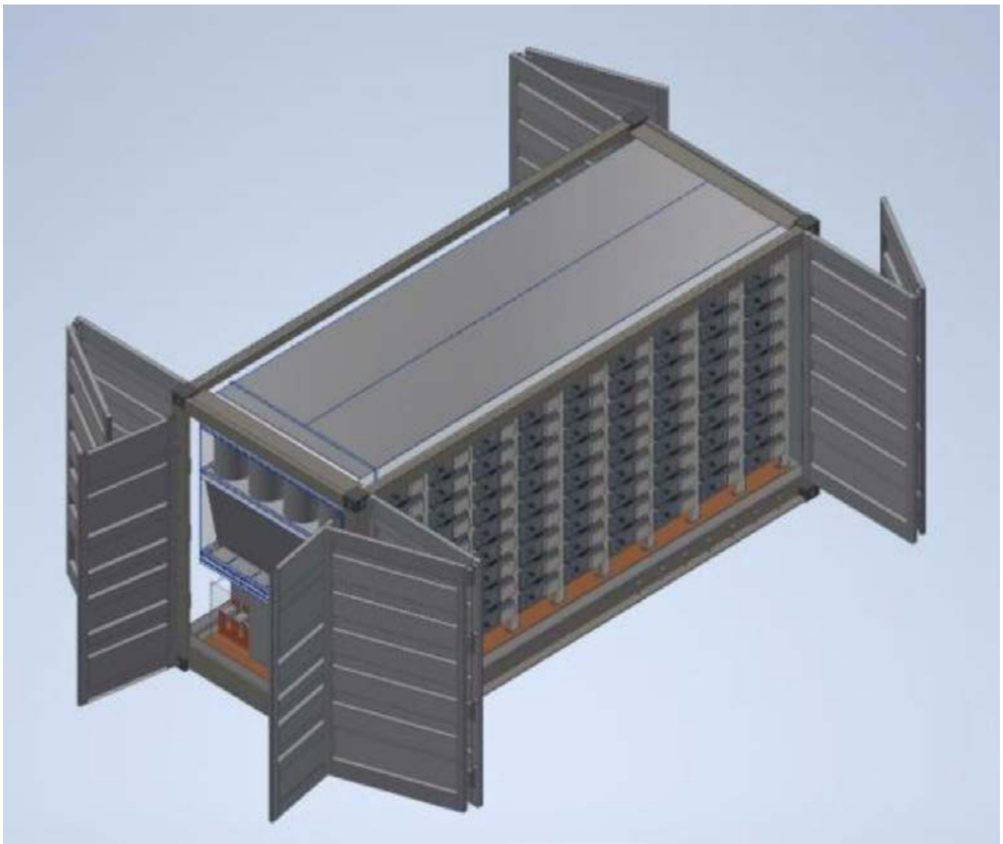
The BESS will consist of several storage containers. An existing facility similar to the proposed development shown in Figure 11.

Figure 11 Example of an Existing BESS

An example BESS container is shown in

Figure 12. The container itself is an ISO shipping container, 20’ long.

Figure 12: Concept BESS Container



The container is typically modified for the following purposes:

- Cable penetrations.
- Fire protection system installation.
- HVAC installation
- Strengthening of the walls for blast protection, where required.

The batteries are stacked and connected to the Battery Management System (BMS). The BMS is typically designed with a range of safeguards, such as:

- Prevention of overcharging and current surges.
- Maintaining voltage levels.
- System trip in the event of electrical shorts or overheating.
- A HVAC system maintaining the container temperature within safe operating limits.

3.3 BESS Arrangements

The proposed development will have a centralised alternating current coupled BESS of up to 200 MW providing energy for 4 hours (800 MWh).

Each individual BESS is containerised, and the preferred BESS will use LFP cell. The BESS will be AC Coupled and consist of up to 270 containers and associated infrastructure i.e., BESS HVAC, inverters, transformers and connecting electrical wires.

It is assumed that each container will have its own BMS, power converter and HVAC system and that the BESS will be monitored by a SCADA system with remote monitoring facility. The detailed design of the BESS is unavailable currently.

The BESS would be in the southern portion of the site, adjacent the South Substation and South O&M Building (see Figure 2).

3.4 HVAC System

Maintaining the temperature within limits is critical to the safety of the operations and this is typically achieved by dedicated HVAC system for each container and controlled by the BMS.

It is assumed that the BMS can shut down the BESS if the temperature limits are exceeded.

3.5 Electrical Transmission and Reticulation

3.5.1 Transmission Line

3.5.1.1 High voltage transmission

The transmission infrastructure will consist of the following:

- Three 33/330 kV electrical substations, including control room, communications tower, transformers, circuit breakers, switches, lighting protection and other ancillary equipment;
- 20.0 km of 330 kV overhead transmission line connecting the three substations to a new electrical switchyard (including circuit breakers, switches and other ancillary equipment) to provide connection to the planned NSW-SA interconnector, Project EnergyConnect currently under construction;

For the safe operation of the transmission line, certain activities will be restricted within the easement area such as planting and growing trees, construction of buildings, or erection of antennae or masts. The transmission line will not affect the ongoing use of the land for agricultural purposes such as grazing.

3.5.1.2 Medium voltage reticulation

The internal electrical reticulation network, which connects the WTGs to the substations, will comprise approximately 175.3 km of underground and 64.5 km of overhead 33 kV electrical reticulation cables connecting the WTGs to the onsite substations (where practicable, these are generally following site access tracks); Where possible the cabling will be in underground trenches, which run parallel to the access track.

The trenching for underground electrical cabling will be approximately 0.6m wide per circuit by 1m deep, located within a works area of approximately 5m to accommodate the mobile plant and stockpiling of spoil and bedding sand. Trenches will be progressively backfilled during the construction works.

Cables will be protected in accordance with Australian Standard (AS) 3000:2007 Electrical Installations.

3.5.1.3 Telecommunications

Telecommunications ensure the secure control of the WTGs and substations. This includes emergency shutdowns and management of any maintenance requirements. Fibre optic cables will be installed with the electrical reticulation system.

3.5.2 Onsite Substations

One 330 kV main substation and two 330 kV collector substations will be constructed in the Project Area to transform the 33 kV received from the internal electrical reticulation network to the 330 kV transmission voltage. The location of the substations is shown in Figure 13.

While the design is yet to be finalised, it is expected that each substation would occupy an area of 200m x 300m (approximately 6 ha) and will contain transformers, associated high voltage switchgear and control and protection equipment as well as a communication tower, and drainage and oil containment system. A security fence will surround the substations. Gravel hardstand will be placed under and around the substation compounds to restrict vegetation growth and provide a safe working environment in accordance with the relevant Australian Standards.

Internal structures within the fenced substation compounds will include:

- Control building/control room, switch room with a height of 5m;
- Two 33/330 kV power transformers with a height of 10m;
- Lightning protection masts which are 25m high;
- Associated high voltage switchgear including busbars, circuit breakers, disconnectors – approximately 10m high; and
- A communication tower (up to 80m high).

A 20 m bushfire asset protection zone (APZ) will surround the substation [17].

3.5.3 Switchyard

A switchyard with approximate dimensions of 200m x 300m for physical electrical components including required earth works will be located within a site with a maximum expected area of 6 ha. The switchyard will connect the Project transmission line to the planned NSW-SA interconnector, Project EnergyConnect currently under construction. The location of the switchyard is shown in Figure 13. A 20m bushfire asset protection zone (APZ) will surround the switchyard.

3.5.4 Battery Energy Storage System

A BESS will be located adjacent to the south substation, occupying an area of approximately 400m x 300m. Indicatively, the BESS would utilise lithium-ion technology with a rated capacity of up to 200 MW/800MWh (4 hours) (subject to detailed economic and technical considerations). The BESS will likely utilise a pre-assembled and pre-tested, fully integrated system that includes the battery modules, inverters, thermal management system, circuit breakers and other controls.

A battery HVAC system will actively cool each BESS container. The BESS will be temperature monitored, and the automated control system will stop its operation if the temperature exceeds pre-set levels to prevent overheating (e.g., if all air conditioning units fail). The BESS will include a gravel surface and a 20m APZ to minimise the risk of fire escaping from the facility and the risk of external fire affecting the facility.

The model and design specification of the BESS will be determined during detailed design. However, the final model and design specifications will remain within the specifications assessed in this PHA.

3.6 Permanent Operations and Maintenance Facility

Three permanent site O&M facilities, approximately 50m by 40 m, will be constructed to provide for all operations and maintenance activities associated with the Project. The O&M facilities will be in the:

- South of the Project Area, adjacent to the BESS;
- Middle of the Project Area adjacent to the southern collector substation; and
- North of the Project Area adjacent to the northern collector substation.

The buildings of the O&M facility will contain the control room, switch room, and storage shed with workshops.

The control room will contain an office, communications equipment, and staff amenities (toilet, kitchen, first aid, potable water supply, etc.). Guttering and a water tank will collect rainwater.

The compound will include a static water supply for firefighting/bushfire management (may be part of above water supply) as well as a septic system. The control room, switch room and storage shed will each contain essential fire safety equipment, including fire extinguishers and hose reels [18, 17].

Adequate rubbish waste/facilities providing appropriate waste stream separation using onsite skip bins emptied weekly or as required. Waste will not be retained permanently onsite.

Car parking facilities for employee and service vehicles will be located adjacent to the building. The parking and vehicle manoeuvring areas will be sealed with crushed road base or asphalt. Whilst most activity is anticipated to occur during business hours Monday to Friday, access to the Project Area will be required on a 24-hour basis, seven days a week.

The O&M facility will be constructed of low-combustibility or non-combustible materials in accordance with the National Construction Code (ABCB, 2022). The office within the O&M facility will be an insulated, free standing construction with steel frame affixed to a concrete base. The building will utilise Colorbond cladding in a colour shade designed to match the surrounding landscape. Internal walls will be wooden frame with insulation. The walls will be clad in plasterboard and painted a shade of white.

The O&M facility warehouse and workshop will be an insulated, free standing construction with steel frame affixed to a concrete base. The building will utilise Colorbond cladding that will be a colour shade designed to match the surrounding landscape. The building will include a large roller shutter door leading externally. The building will also include a climate controlled insulated room consisting of wooden frame clad in plasterboard within the outer shell for storage of smaller components. Additionally, there will be a double skinned/bunded container set on a concrete base for the storage of oils, greases, and other liquid substances with a safety shower on the outside of the building.

All buildings will have:

- Powered by single phase (240 V) electricity.
- Wi-Fi internet either by 4G or satellite connectivity.
- Water via tanks that are filled by rain water collected from the roofs or trucked in.
- Water tanks will be serviced by UV filtration.

All buildings will be installed to relevant state and federal safety and environmental regulations and signed off for occupancy.

3.7 Fire Protection System

3.7.1 Onsite Buildings

The following fire protection is proposed. As the design is not developed, details are unavailable for the PHA. The intent is provided below:

1. A HVAC system will actively cool the BESS. The BESS will be temperature monitored, and the automated control system will stop its operation if the temperature exceeds pre-set levels to prevent overheating (e.g., if all air conditioning units fail).
2. The BESS will include a gravel surface and a 35 m APZ to minimise the risk of fire escaping from the facility and the risk of external fire affecting the facility.
3. The onsite buildings (control room, workshop, switch rooms, storage shed) will have fire protection as required in the National Construction Code (fire extinguishers and hose reels).
4. Substations fire protection will be designed to the requirements of the following standards:
    - AS 2067-2008 (Substations and high voltage installations exceeding 1 kV). and
    - NFPA 15-2017 Standard for water spray fixed systems for fire protection.
5. The compound will include a static water supply for firefighting/bushfire management (may be part of above water supply) as well as a septic system. Guttering and a water tank will collect rainwater.
6. Fire protection and suppression system for the BESS will be designed to meet the requirements of NFPA 855-2023 [19] (or equivalent - See Appendix A for details), and the RFS guidelines [18], [17].

3.7.2 Bushfire Protection

A Bushfire Report has been prepared by ERM [20]. The report has considered bushfire impacts and found that:

- The risk of fire caused by the wind farm is minimal;
- A proposed upgrade to the internal road network would increase firefighting access and assist to reduce the likelihood of a widespread fire; and
- Due to the location of the Project Area within a bushfire prone landscape, a Bushfire Emergency Management and Operations Plan will be prepared in conjunction with relevant stakeholders.

A 35 m bushfire APZ will surround each substation.

4 Hazard Identification

4.1 Health

Electric and magnetic fields (EMFs) exist wherever electricity is generated, transmitted, distributed, or used and are strongest closest to their source [21]. Electric fields are produced by voltage, while magnetic fields are produced by current [22]. In Australia, EMFs associated with the use of electricity are generated at a frequency of 50 Hertz (Hz) [21]. This frequency falls within the extremely low frequency (ELF) range of 0–3,000 Hz, as defined by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) [21]. Subsequently, power lines, substations, transformers, and other electrical sources all emit ELF EMFs [21].

An assessment of EMF impact is required in the SEARs but is not covered in this PHA. A separate study is provided in the EIS.

4.2 Bushfire

Bushfires are a natural part of the Australian landscape and are the result of a combination of weather and vegetation (which acts as a fuel for the fire), together with a way for the fire to begin – most commonly due to a lightning strike and sometimes human-influences (mostly accidental such as the use of machinery which produces a spark). Depending on weather conditions, embers can be transported by wind from one location to another, causing new fires or spotting.

A separate bushfire impact assessment and management plan has been conducted and included in the EIS. The bushfire assessment is not repeated in this PHA.

4.3 Battery Storage

The Lithium-ion battery is classified as a Class 9 dangerous good (UN No. 3480) for transport purposes. The main hazards are [23]:

- Overheating with toxic gas generation and emission to atmosphere and potential exposure to toxic gases such as Carbon Monoxide (CO), Hydrogen Chloride (HCl), Hydrogen Fluoride (HF) and Hydrogen Cyanide (HCN) [23].
- Overheating with flammable gas generation within the container (CO, Hydrogen, hydrocarbons such as Benzene, Ethylene), ignition and explosion within the container, and potential for escalation to adjacent containers [23].
- Fire in Lithium-ion battery, escalating into the packs in the container, with potential for escalation to adjacent containers.

4.4 Wind Turbine Hazards

The hazards associated with the wind turbines include:

- Blade installation coming loose, and blade throw during operation causing damage to receptor infrastructure and serious harm to exposed people.
- Tower or nacelle collapse.
- Ice formation on the blades during winter months and subsequent melting of ice resulting in ice throw damage to receptors and serious harm to exposed people.
- Working at height hazards for maintenance and inspection work on the turbines.
- Turbine fires.

4.5 Electrical Hazards

- Power converter fire and explosion.
- High voltage transformer fire/ explosion, and potential for escalation.
- Electrical fire in sub-station (arcing etc.).
- Contact with electricity.

4.6 Other Hazards

Other hazards identified include:

- Vehicle interaction with infrastructure (collision hazards).
- Natural hazards (earth tremor, adverse weather).
- Dangerous goods storage and handling.

4.7 Hazard Register

A hazard identification register has been compiled, outlining the consequences of the identified hazards and the safeguards provided in the design towards prevention and mitigation. This register provided in Table 12.

Table 12: Hazard Identification and Safeguards Summary

No.	Hazard Scenario	Causes	Consequence	Identified / Recommended Safeguards
I	**Wind Turbine Hazards**			
1.	Blade throw – turbine blade detaches from the rotor and flung like a projectile	- Incorrect installation - Corrosion - Vibration - Environmental forces	- Damage to receptor structure - Fatality if strikes people - Impact can occur at distances ranging from 700m to 2 km, depending on tip speed [24].	• Installation QA • Corrosion resistant material • Vibration monitoring • Inspection and maintenance
2.	Ice throw	- Ice formation during still conditions at low ambient temperatures, thawing as temperature rises	- Fatality if strikes people - Impact can occur at distances up to c. 475 m [10]	• Separation distance to occupied buildings and people • Risk management plan for accessing potential ice throw area during icing conditions
3	Fire	- Overheating - Friction	- Serious harm if fire occurs during maintenance	• Regular lubrication • Inspection of electrical component integrity
3	Occupational hazards	- Fall from height during turbine inspection and maintenance - Confined space hazards	- Injury/ potential fatality	• Fall protection. • Confined space entry training • Competency training • Permit to work and isolation system • Job safety analysis
II	**BESS Hazards**			
4	Battery Fire	- Electrical failures – overcharging/ over discharging - Internal short-circuit - Damaged battery - Battery overheating - Frequent charging and discharging of the battery capacity and degradation of	- Thermal runaway from exothermic reaction - Escalation to other battery packs and modules - Thermal radiation and escalation to adjacent battery container - Toxic gas generation (CO, HF, benzene, and other flammable gases (H_2, hydrocarbons)	• Battery inspection and testing during installation • HVAC system to maintain temperatures within operating limits • Adequate spacing between battery packs for HVAC air circulation for heat dissipation • Regular inspection and maintenance regime for the battery assemblies • Installation as per AS/NZS 5139:2019

No.	Hazard Scenario	Causes	Consequence	Identified / Recommended Safeguards
		battery resulting in overheating [25]	- Part of the off gases may combust depending on generation rate and oxygen availability, but combustion gases are still toxic (HF, HCl)	• Fire detection and suppression system to prevent the outbreak of fires between battery modules and between containers • Ensuring that there are external fire protection systems for the BESS where relevant
5	Battery Explosion	- Battery overheating and off gases generation that are flammable. - Ignition of off gases within enclose resulting in confined explosion	- Significant damage to the container - Explosion may be followed by fire - Escalation to adjacent containers	• HVAC system for temperature control • ACH to prevent flammable gases reaching LFL • Battery Management System (Temperature monitoring and high temperature trip, levelizes charges across battery modules and cells, etc.) • Off gas monitoring and alarm through a CO detector at the ventilation exhaust recommended
III	**Vehicle Interaction**			
6	Vehicle collision with site infrastructure	- Vehicle movements in vicinity of personnel, - Vehicle impact to infrastructure	- Personal injury - Damage to equipment	• Construction management plan that includes standard traffic rules and signage. • Traffic management plan that includes implementation of site speed limits, ensuring driver competency, fencing / bollards and positioning of batteries to minimise vehicle interaction. • Transport of dangerous goods will comply with the requirements of the Australian Code for the Transport of Dangerous Goods by Road and Rail (the ADG Code). • Install bollards/protective barriers around key battery areas and infrastructure.
IV	**Electromagnetic Radiation**			
7	EMF	- EMF generated from BESS, High Voltage Power lines, Grid infrastructure)	- Exposure to EMF and personal injury	• All designs will be in accordance with the Guidelines for limiting exposure to Time varying Electric, Magnetic and Electromagnetic Fields (ICNIRP, 1998; ICNIRP, 2010b) and relevant codes and industry best practice standards in Australia.

No.	Hazard Scenario	Causes	Consequence	Identified / Recommended Safeguards
				• All relevant procedures in relation to a high voltage installation will be adhered to throughout the life of the Project. • The security system for the site, including safety fencing and closure of gates, will be maintained throughout the construction and operation, to provide safe exposure distances to the public. • Restricted access to site and access only to trained personnel. • Refer to Section 6.4 of the EIS for the EMF assessment.
V	**Natural hazards**			
8	Earthquake	- Earthquake	- Personal injury, Wind Farm shut down	• Project infrastructure will be built to relevant construction codes.
9	Lightning	- Lightning	- Personal injury, Wind Farm shut down	• Project infrastructure to be constructed in accordance with electrical standards.
10	Bushfires	- Bushfires	- Personal injury, Wind Farm shut down, - Possible fire	• A Bushfire Emergency Management and Operations Plan will be prepared in consultation with the RFS. This plan will include but is not limited to the following aspects: - Management of activities with a risk of fire ignition. - Management of fuel loads onsite. - Storage and maintenance of firefighting equipment, including siting and provision of adequate water supplies. • Respond to the requirements of the '*Planning for Bush Fire Projection 2018*' regulation, including: - Implementing APZ setbacks to mitigate external fire hazards, as well as mitigation of propagation of external fires to outside the Project boundary. - Implementing increased APZs for the BESS system, substations and switching station, and positioning
11	External fire (adjacent to site)	- Fire or explosion from adjacent land users	- Asset damage, Wind Farm shut down, Personal injury	

No.	Hazard Scenario	Causes	Consequence	Identified / Recommended Safeguards
				outside of the flame throw distance, as detailed in the bushfire assessment provided in the EIS. - Providing adequate egress/access to site, including multiple entrances and exits to site. - Emergency evacuation measures - ensuring that site staff and contractors are aware of evacuation measures and emergency procedures. • Operational procedures relating to mitigation and suppression of bush fire relevant to the operation of the Project. • Installation as per AS/NZS 5139:2019. • Ensuring that there are on site fire protection systems to protect exposures. • Design buildings and structures to appropriate codes and standards. • Manage fuel for vehicles and machinery on site to appropriate standards. • Refer to the EIS for the Bushfire Assessment.
VI	**Flammable and Combustible Materials Storage and Handling**			
12	Loss of containment of chemicals, including dangerous goods	- Damaged to chemical containers, spill during transport - Decanting of chemicals	- Environmental impairment - Personal injury	• Construction Environmental Management Plan and Operation Environmental Management Plan including spill containment and management • Store chemical in line with appropriate Australian standards • Implement a regular inspection and maintenance schedule for chemical storage areas • Develop Safe Work Method Statement detailing methods for handling chemicals • Provide spill kits to be used for accidental spill cleanup. • Safety Data Sheets (SDS's) available on site and referred to in handing processes

No.	Hazard Scenario	Causes	Consequence	Identified / Recommended Safeguards
				• Provide correct PPE to all staff (as per SDS).
VII	**Electrical Hazards**			
13	Power converter fire/ explosion	- internal failure of a power capacitor - Overvoltage and cables overheated - Overcurrent and cables overheated - Arc fault	- Localised fire damage. - Plant shutdown - Injury if personnel present in the vicinity	• Equipment certified and installed to relevant standards • Inverters tested for compliance with Australian Standard AS 4777.1-2015 • Voltage rating to match maximum open circuit voltage • Overcurrent trip if maximum current exceeded • Quality checks of installation before commissioning
14	Inverter failure	- Reverse polarity of cables, human error	- Electric shock and serious injury/ fatality	• Certified electrician • Quality checks of installation before commissioning
15	Power Transformer Fire	- Coolant leak and ignition - Overheating - Earth leakage	- Localised fire - Injury to personnel in the vicinity - Potential for escalation	• Designed to AS 2374.8:2000 – Power Transformers – Application Guide • Fire protection provided • Separation distance/ fire isolation of transformers
16	Transformer explosion	- Gases generation inside transformer enclosure (hydrogen)	- Overheating of transformer and explosion from overpressure	• Dissolved gas testing (DGA) and nitrogen detection • Relief valve on transformer to vent off gases • High temperature trip
17	Contact with electricity	- Contact with live electrical sources; - Cranes impacting overhead lines; - Hitting underground services; - Overhead services damaged during natural hazards; and - Security issues with trespassers in contact with electrical lines.	- Personal injury / fatality	• Implement Isolation procedures • Install fit for purpose electrical systems • Ensure that installation is carried out by suitably qualified electrical personnel • Adherence to AS 3000 • Follow underground utility identification protocols, including Dial Before You Dig • Contractor management, including: - Sign on/off registers - Ensuring familiarity with site WHS procedures

No.	Hazard Scenario	Causes	Consequence	Identified / Recommended Safeguards
				- Appropriate permit to work procedures - Crane height limitations where works are undertaken in the vicinity of overhead power lines – overhead work height limits
VIII	**Site Security**			
18	Security breach	- Persons seeking theft of property/battery components	- Theft of equipment Personal injury	• Installation of fencing around facility and battery facility separately • CCTV where practical on critical infrastructure/battery units • Alarms/locks on battery doors • Inspections to monitor for potential security concerns
IX	**Construction Related Hazards**			
19	Construction risks	- General miscellaneous construction risks	- Personal injury / fatality	• Implement a Workplace Health and Safety (WHS) plan • Conduct a detailed Safety in Design processes during project execution
20	Transport and delivery (manual handling)	- Personnel injury though manual handling of equipment during operations	- Personal injury	• Adhere to requirement of a WHS plan and the ADG Code • Ensure batteries have specific equipment handling advice where appropriate for staff

Only the hazards that could result in an offsite impact, and those hazards that may impact on emergency service providers are analysed in detail in Section 5.

5 RISK ANALYSIS

5.1 Battery Energy Storage Systems

5.1.1 Battery Fires

The causes of battery fires are outlined in Table 12. This section describes fire modelling of a BESS fire and its consequences.

There is no established methodology for quantitatively assessing fire hazards. Earlier studies were based on the total quantity of electrolyte in the container and treated the fire like other batteries. This had led to unrealistic separation distances [26].

Experiments on a Tesla Battery Pack conducted by Exponent Inc. [26] found the following:

- The propagation of fire within the container is slow when the source of fire was inside the container.
- The smoke is associated with thick white fumes vented through the container vent, with flames of up to 4m in height.
- At the centre of fire, temperatures up to 1100˚C were experienced, but outside temperature of container was not significantly higher than the ambient.
- The walls of the container did not fail for a fire that lasted 90 minutes. Many panels were unaffected and could be reused.

The study concluded that separation distances between containers was not required except for access to the end door(s). The National Fire Protection Association (NFPA) has included mitigation controls for these findings in NFPA 855 [19].

Some of the earlier studies on BESS fire assessment [27] have postulated a fire temperature of the panel as 500˚C and calculated thermal radiation from a planar surface (battery panel dimensions) to a receiving plane. The distances were quite short, 3m to 4.7 kW/m^2, and 1m to 23 kW/m^2. This approach does not reflect the nature of the battery fires described in the experiment [26].

A battery container fire behaves quite differently whether the container is naturally ventilated or forced ventilated. In more detailed study sponsored by the NFPA in the USA, Hutchison [15] described a battery container fire development with forced ventilation as follows:

(a) Local heating and generation of off gases containing significant flammables.

(b) Ignition of flammables resulting in jet fire of high intensity but does not last long.

(c) The fire further heats the battery racks and generates more off gases and jet fire.

(d) Thus, the fire is a cyclical phenomenon, alternating between a jet fire and developing fire in target racks.

(e) Not only the decomposing electrolyte, but the battery materials, cables and insulation materials containing plastics also get involved in the fire, as the fire spreads.

(f) Without fire protection, the fire spreads to the whole of the container, whose wall may collapse due to excessive pressure inside, if the ventilation system cannot remove the smoke layer effectively.

(g) In a fully developed fire, the radiating rectangular surface of the container wall can radiate heat to the surrounds by heating an adjacent container and generating off gases from the battery rack on the heat receiving container.

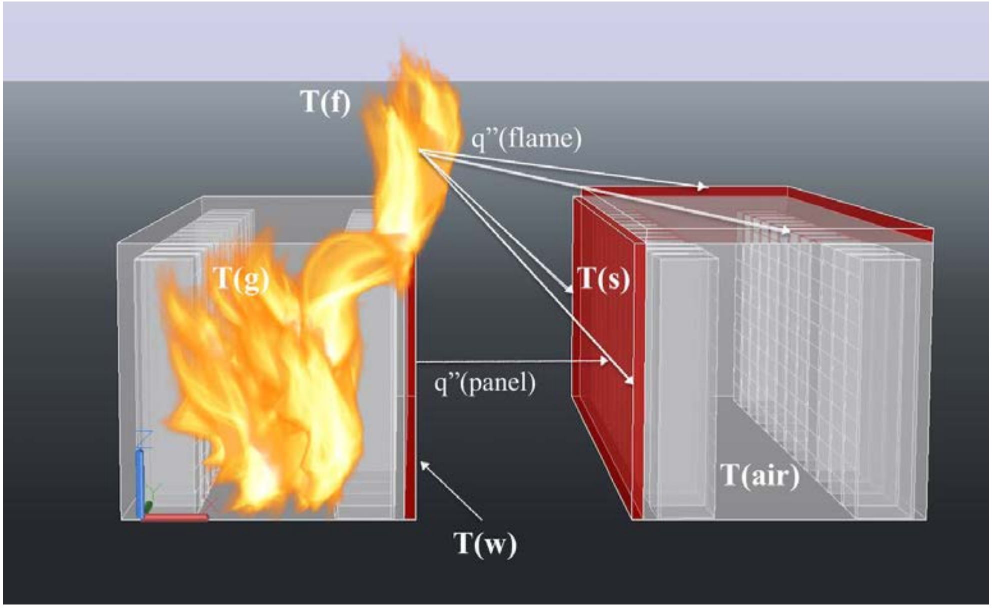
(h) The fully developed fire may be modelled as a surface fire of the whole side wall of the container, radiating with a surface temperature of 500^{O}C, and high emissivity, similar to a plastic material fire.

(i) With fire protection, the container would remain intact and while the fire gradually abates, the generated gases and combustion products are vented through the ventilation exhaust duct on the roof.

(j) The vent itself can catch fire and the torch fire of ignited flammable gases can radiate high intensity thermal radiation to the surroundings, an additional source of thermal radiation that helps to heat up adjacent container and impact on personnel in the vicinity.

The fire growth is schematically shown in Figure 13, reproduced from [15].

Figure 13: BESS Container Fire Radiation Modelling Schematic



While Figure 13 shows the fully developed fire, it is necessary to take into account the fire protection aspects into account as an integral part of fire modelling, which makes the modelling more complex, but more representative of the fire.

Since the BESS fire modelling is still in the developmental stages, with limited field data and some planned experimental data [26], this study has not quantitatively modelled BESS fires. Instead, based on the available data, it can be concluded that, provided adequate fire protection is provided, including cooling adjacent containers, fire escalation to adjacent containers can be prevented with the separation distance already provided for explosion escalation prevention, described in the next section.

It may be concluded that the thermal radiation effects of BESS fires would be confined within the site and there would be no offsite thermal radiation effect. The separation distance between containers also enables approach of the fire by firefighting personnel.

In the case study shown, the fire brigade decided to let the unit burn out and protect surrounding units from exposure.

5.1.2 Toxic Gas Exposure

When a battery pack gets overheated, it produces off gases that are flammable and toxic. Typical composition of off gas for Lithium Iron Phosphate battery is listed in Table 13 [23].

Table 13: Off Gas Composition from Overheating of Lithium Phosphate BESS

Chemical	Name	% in offgas
CO_2	Carbon Dioxide	36.9
CO	Carbon Monoxide	11.9
CH_4	Methane	5.9
C_2H_6	Ethane	21.1
C_2H_4	Ethylene	6.1
C_3H_8	Propane	4.7
HCl	Hydrogen Chloride	1.1
HF	Hydrogen Fluoride	3.8
HCN	Hydrogen Cyanide	0.6
C_6H_6	Benzene	0.3
C_7H_8	Toluene	0.7
C_2H_5OH	Ethanol	4.2
CH_3OH	Methanol	2.6
	Total	100.0
Average Molecular weight		35.41

The total flammable gas content is 54.7%. Toxic gas concentration is 17.4% (CO, HCl, HF and HCN).

The off gas generation rate is calculated as follows (normalised to 25^{O}C), and using the molecular weight in Table 13:

- It is assumed that one string (8 modules) can be overheated over a period of 240 sec, based on the data in Ref. [28].
- The rating of a cell is taken as 1.5 Ah, and offgas generation rate = 4 L/Ah [23].
- Off gas generated = [8x52 x 1.5/240] x4 L/Ah x (1/1000) m^3/s] / [24.44 m^3/kg mol] x 35.41 kg/ kmol] = 0.015 kg/s.
- Emission temperature = 75^{O}C.

Gas dispersion calculation were conducted for a generation rate of 0.015 kg/s emitted through the roof vent, at a height of 5m above ground level, using the gas composition in [23].

The DNV software package PHAST was used for dispersion.

Toxic exposures were tracked at the following concentrations for HCl, HF, HCN, CO and CO_2. The definitions of ERPG are reproduced from Ref. [29].

- ERPG 2: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.

  Evacuation required as soon as possible. Emergency services to approach with breathing apparatus, as the fire could escalate.
- ERPG 3: The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

  Immediate evacuation required. Emergency services to approach with breathing apparatus.

The ERPG concentrations are listed in Table 14 [30].

Table 14: ERPG Concentrations for Toxic Components

No.	Component	Symbol	ERPG 2, ppm	ERPG 3, ppm
1	Hydrogen Chloride	HCl	20	150
2	Hydrogen Fluoride	HF	20	50
3	Carbon Monoxide	CO	350	500
4	Hydrogen Cyanide	HCN	10	25

5.1.2.1 Injury Concentrations

The dispersion modelling results are shown in Figure 14, Figure 15, Figure 16 and Figure 17 for HCl, HF, HCN and CO, respectively. The injury concentration is taken as the ERPG-3 level at which a person may experience life-threatening effects if exposed for more than 1 hour.

At ERPG-2 level, a person may experience acute irritation and discomfort on exposure.

Figure 14: Dispersion Profile (Side View) for HCl to ERPG-3

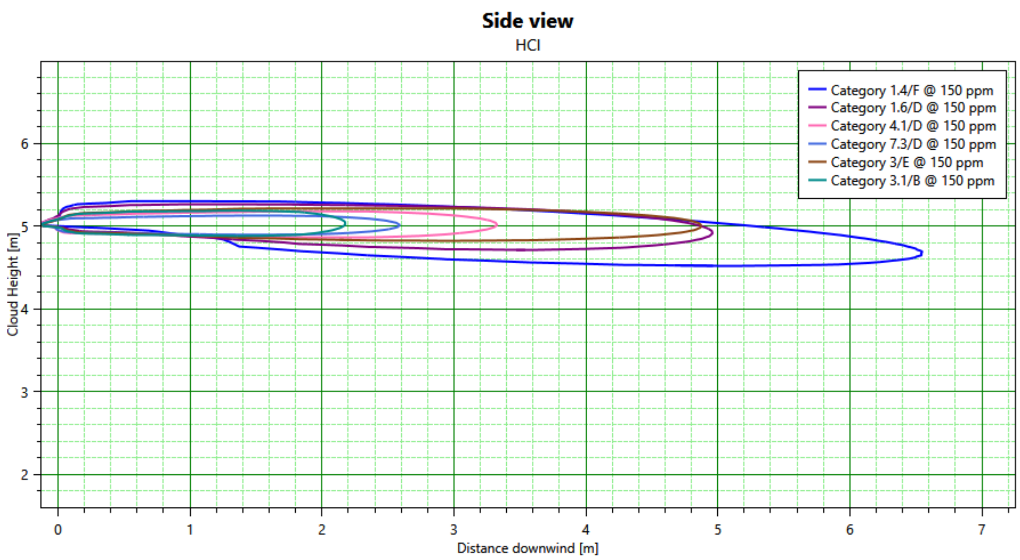


Figure 15: Dispersion Profile (Side View) for HF to ERPG-3

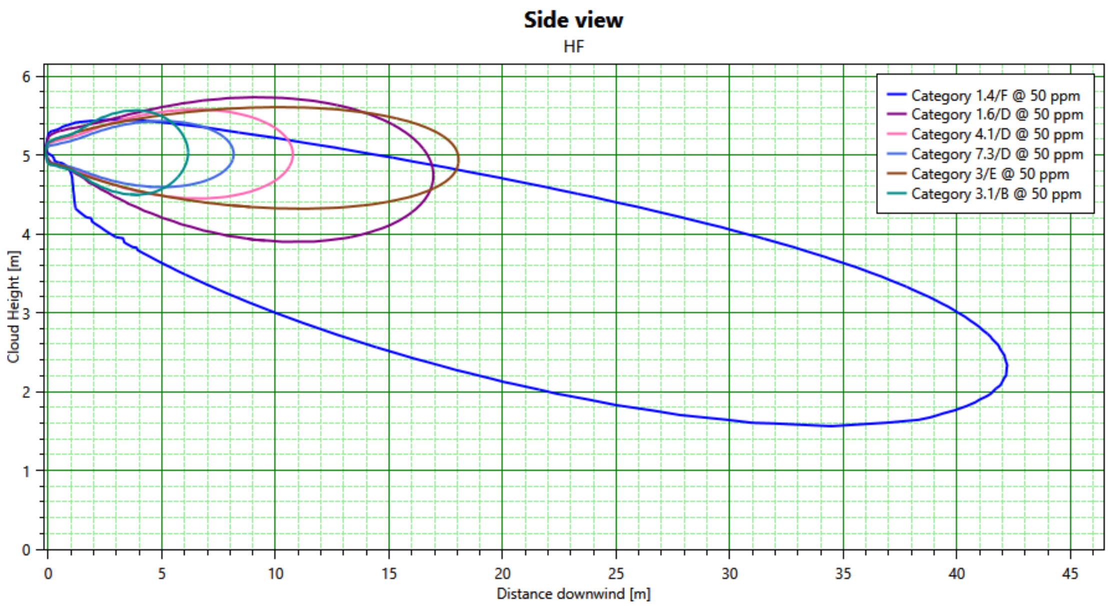


Figure 16: Dispersion Profile (Side View) for HCN to ERPG-3

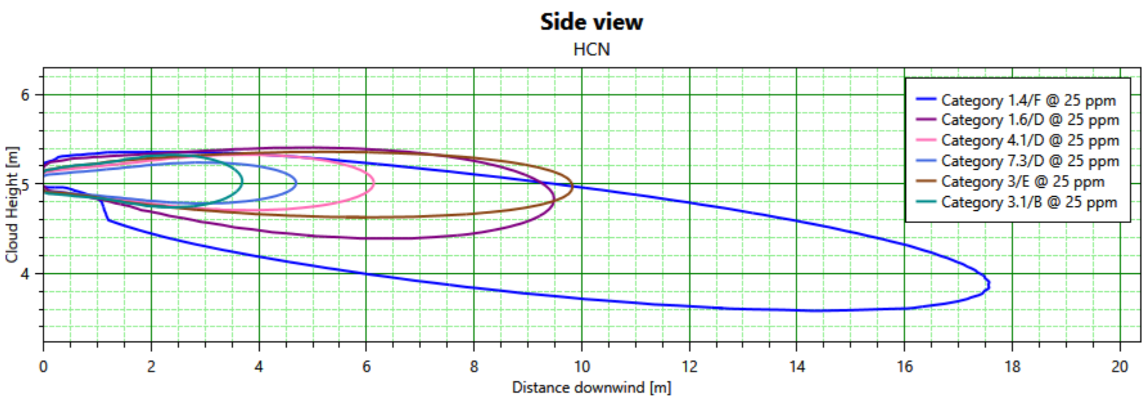
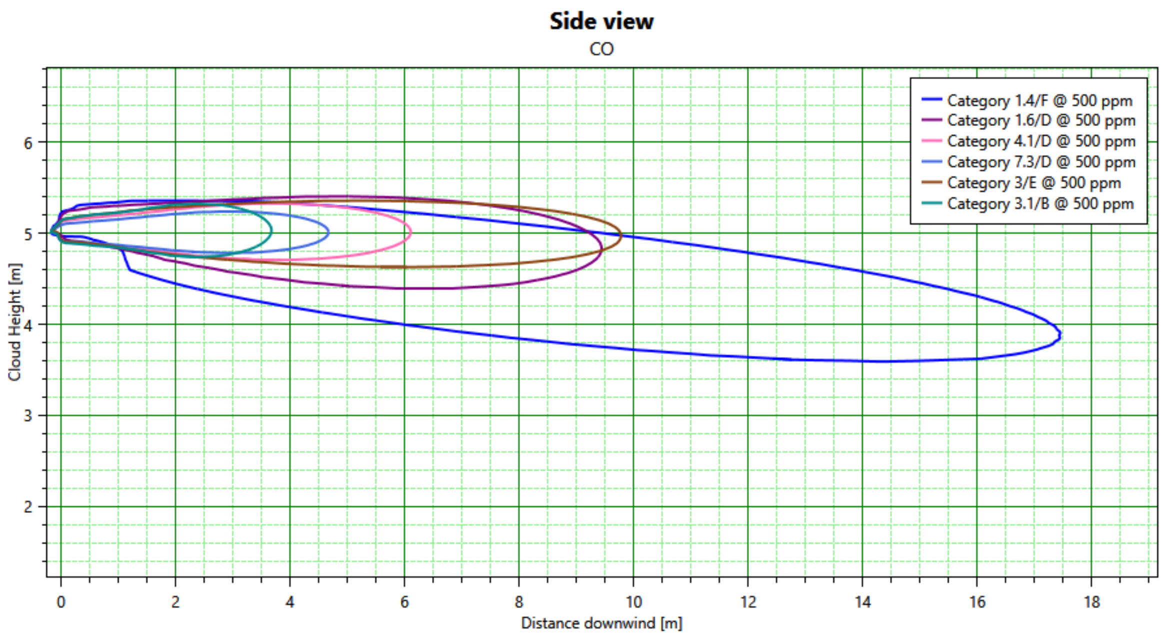


Figure 17: Dispersion Profile (Side View) for CO to ERPG-3



Findings from the dispersion modelling are summarised below:

- For HCl, HF, HCN and CO dispersions, the toxic substance stays in the dispersing plume, released 5m above ground level and does not result in injury or irritation producing concentrations at ground level.
- For HF dispersion, the distance to ERPG-3 concentration ranges from 6m to 42m from the container, the longest distance being for vent for wind conditions F1.4 (1.4m/s, Pasquil stability F). The HF ERPG-3 for F1.4 may reach outside the site boundary, but not at ground level.
- For HCN dispersion, the distance to ERPG-3 concentration ranges from 4m to 18m from the container, the longest distance being for vent for wind conditions F1.4 (1.4m/s, Pasquil stability F). The HCN ERPG-3 for F1.4 would not reach outside the site boundary, and does not reach ground level.
- For CO dispersion, the distance to ERPG-3 concentration ranges from 3.5m to 17.5m from the container, the longest distance being for vent for wind conditions F1.4 (1.4m/s, Pasquil stability F). The ERPG-3 for F1.4 would not reach outside the site boundary, and does not reach ground level.
- There is no toxic injury impact to personnel or public from CO, HCl, HF and HCN in the emission of off gases as the toxic concentrations do not reach ground level.
- Entry into the container for firefighting will require self-contained breathing apparatus to be worn by the fire fighters.

5.1.2.2 Irritation/ Discomfort Concentrations

The toxic concentrations at which a person exposed may experience irritation and discomfort, but not injury effects, are taken as the ERPG-2 levels.

The dispersion modelling results for ERPG-2 levels are shown in Figure 18, Figure 19, Figure 20 and Figure 21 for HCl, HF, HCN and CO, respectively.

Figure 18: Dispersion Profile (Side View) for HCl to ERPG-2

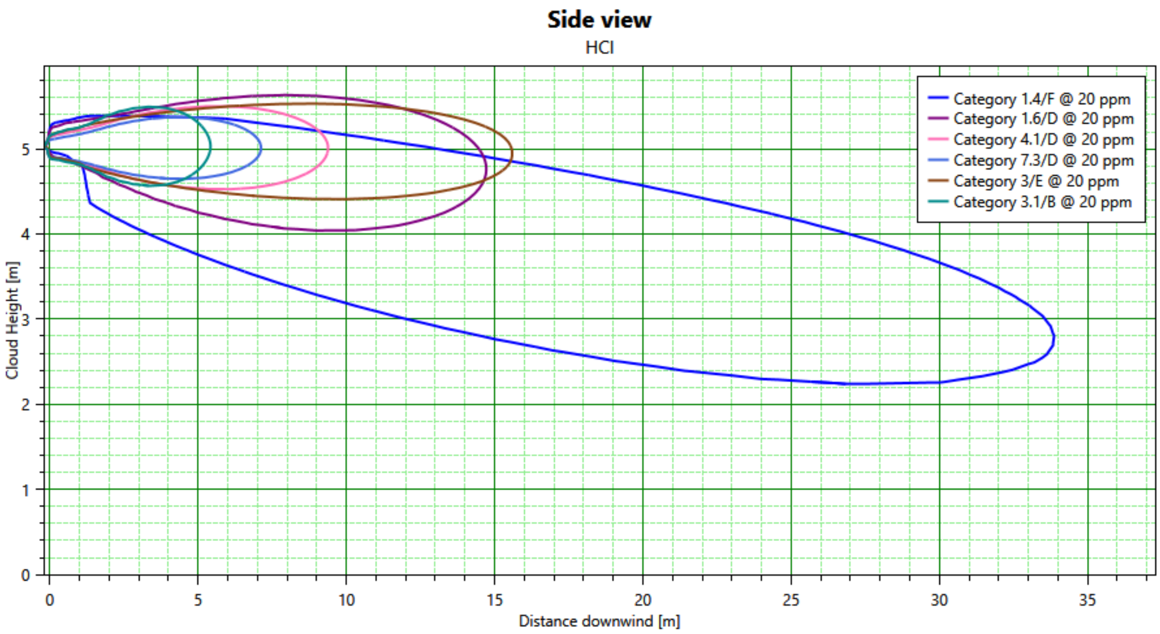


Figure 19: Dispersion Profile (Side View) for HF to ERPG-2

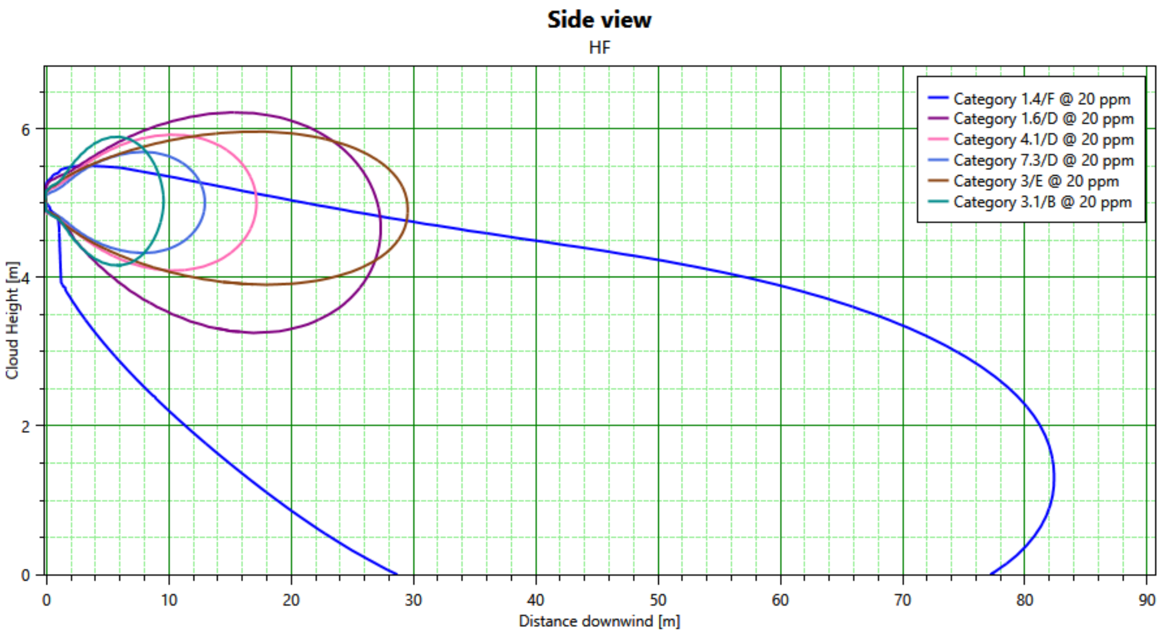


Figure 20: Dispersion Profile (Side View) for HCN to ERPG-2

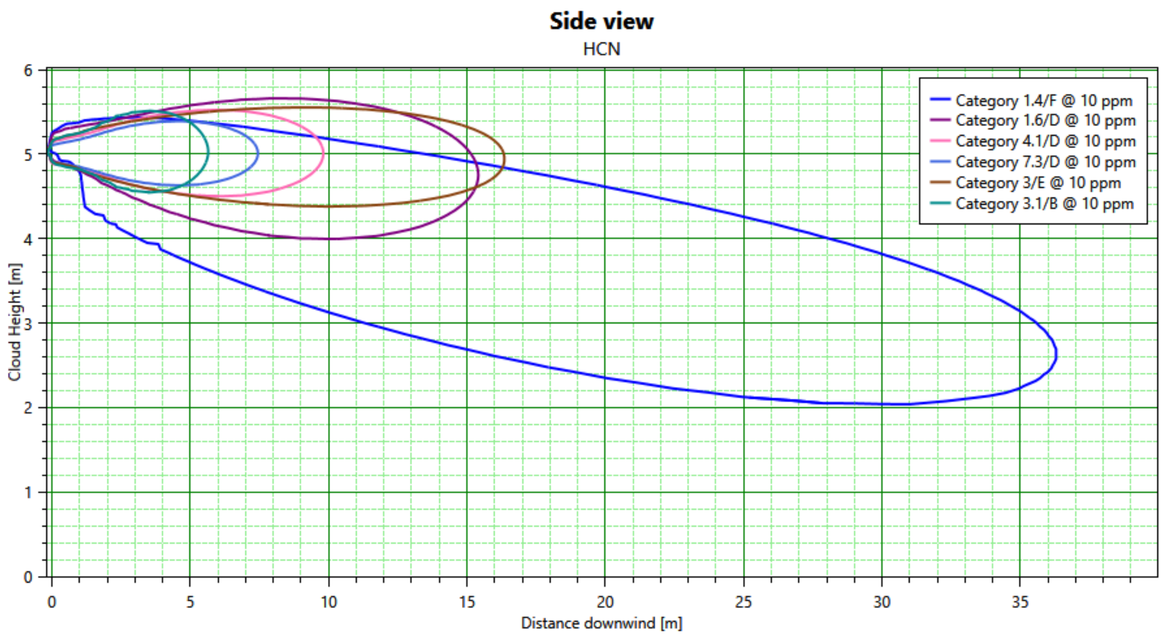
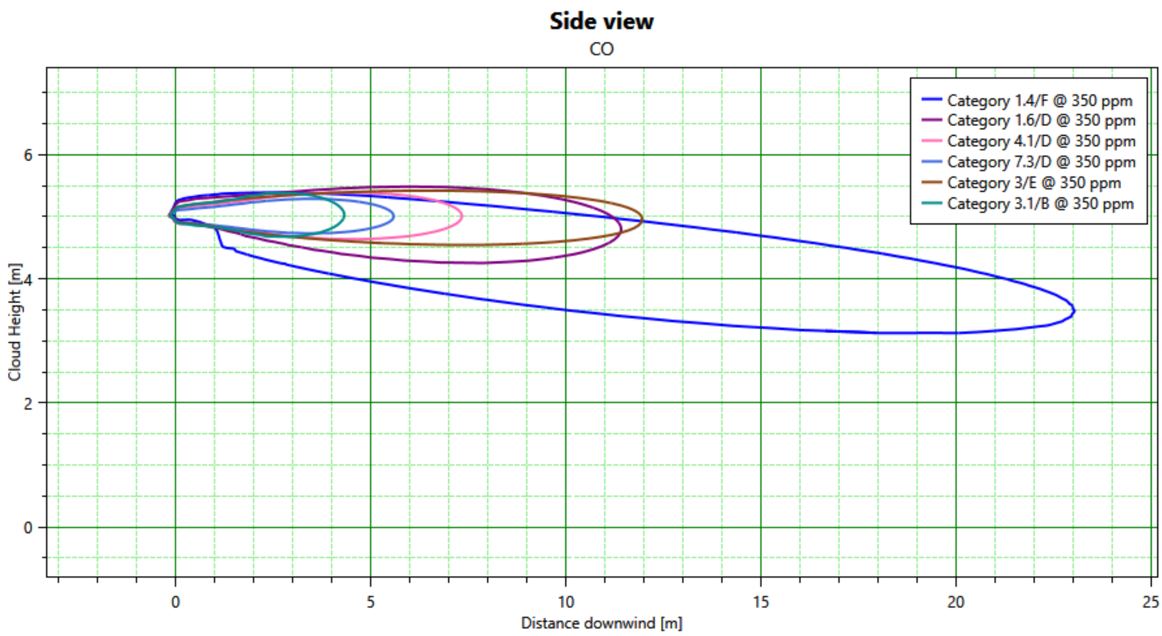


Figure 21: Dispersion Profile (Side View) for CO to ERPG-2



Findings from the dispersion modelling are summarised below:

- Toxic concentrations to ERPG-2 level do not reach ground level, except for HF at low wind speeds.
- Toxic concentrations to ERPG-2 level for HCl, HF, HCN and CO cover a range of 4-82m and may reach the southern Operations and Maintenance facility plot but are confined entirely within the site boundary.

- F stability occurs for only 2% of time during day time but can occur for up to 30% of the time at night.
- A frequency assessment was not carried out because injury / irritation risk criteria are only relevant for residential & sensitive uses, and the consequence distances do not reach these areas.

5.1.3 Battery Storage Container Explosion

When a battery pack gets overheated, it produces off gases that are flammable and toxic.

The off-gas composition in Table 13 does not show hydrogen. According to Ref. [23], hydrogen evolves as part of the off gases, and gets consumed in the process by the time the gas reaches the sensors and hence H_2 was not reported. A maximum of 30% hydrogen could be present. The DNV study [23] assumed 30% in the off gas and normalised the composition of the measured gas to arrive at the gas composition as it is evolved from the battery pack.

The gas composition adjusted for hydrogen is shown in Table 15.

Table 15: Calculated Off Gas Contents Incorporating Assumed Hydrogen Content of 30%

Chemical	Name	% in offgas
CO_2	Carbon Dioxide	31.3
CO	Carbon Monoxide	10.1
CH_4	Methane	5.1
C_2H_6	Ethane	18.2
C_2H_4	Ethylene	5.1
H_2	Hydrogen	30.3
	Total	100.0
	Molecular weight	24.91

The off gas generation rate is calculated as follows (normalised to 25^{O}C):

- Overheating is assumed to evolve off gases until ignition occurs, after which the gas themselves would be combusted in the flame [31]. The duration to spread through a module is estimated to be 240-280 seconds [28]. The lower value was used for conservatism.
- One string (8 modules) assumed to be involved in the overheating, with 52 cells to a module.
- The capacity of a cell is 1.5 Ah (Ampere-hours) [23]. Total capacity overheating = 8x52x1.5 = 624 Ah.
- Thus, the capacity emitting off gases = [624 Ah] /240 s] = 2.6 Ah/s. The emission, however, would be continuous as the runaway escalated to other modules.
- Volume of off gases = 4 L/Ah [23].
- Thus, flammable off gas generation rate = [4 L/Ah x 2.6 Ah/s x (1/1000) m^3/s] / [24.44 m^3/kg mol] x 24.91 kg/ kmol]= 6.89E-03 kg/s.

5.1.3.1 Flammable Concentration in Container

The lower flammability limit (LFL) of the gas mixture in the container is calculated using the Le Chatelier principle as follows:

Table 16: Calculation of Lower Flammability Limit of Off Gas Mixture

Gas	LFL, %	UFL, %	% in off gas
CO_2	-	-	31.3
CO	12	75	10.1
CH_4	4.4	16.4	5.1
C_2H_6	3	12.4	18.2
C_2H_4	2.75	28.6	5.1
H2	4	75	30.3
Molecular weight			24.91
Molecular weight (flammables alone)			16.2

$$LFL_{mixture} = \frac{\sum y_i}{\sum \frac{y_i}{LFL_i}}$$

Where y_i = mole fraction of component 'I' and $LFL_{i\ i}$s the lower flammability limit (volume fraction) of component 'I'.

Therefore, LFL = (1-0.313)/ [(0.101/0.12+0.051/0.044+0.182/0.03+0.051/0.0275+0.303/0.04)] = 0.0393 (v/v), or (flammables alone)

On mass basis, LFL mixture = 0.0223 kg/m^3

Container volume = 12.2m x 2.62m x 2.44m = 77.93 m^3.

Free volume in container (i.e., volume not occupied by battery modules) = 25% (19.48 m^3).

Flammables concentration in container is calculated as follows:

$$V\ dc/dt = v.\ c_0 - v.\ c + w$$

Where V = free volume in container; c = concentration in container kg/m^3; v = HVAC flow rate m^3/s; w = flammable off gas generation rate; and t = time; c_0 = flammable gas concentration in incoming air = 0.

v can also be expressed as an air change rate per hour (ACH) = v/V x 3600

Solving, c =(w/v) [1- exp(-v.t/V)].

Steady state concentration in the container = w/v.

A sensitivity analysis for various ACH values gave the results shown in Table 17.

Table 17: Flammable Gas Concentrations in Container for Various ACH

No.	ACH	v, m^3/s	C (steady state) = w/v kg/m^3	LFL mixure kg/m^3	Flammable mixture in container?	Time to reach LFL, min
V_{free} = 19.48 m^3;	w =	0.01 kg/s (total); w = 6.89E-03 kg/s (Flammable)				
1	6	0.032	2.12E-01	2.23E-02	Yes	0.99
2	12	0.065	1.06E-01	2.23E-02	Yes	1.05
3	20	0.108	6.37E-02	2.23E-02	Yes	1.15
4	30	0.162	4.25E-02	2.23E-02	Yes	1.32
5	40	0.216	3.18E-02	2.23E-02	Yes	1.60
6	50	0.271	2.55E-02	2.23E-02	Yes	2.22
7	57	0.308	2.23E-02	2.23E-02	No	Not reached

If the ACH is < 57, the off-gas mixture in the container can be still flammable and an ignition may result in an explosion.

For ACH >57 or higher, an explosion can be averted.

If HVAC fails, any off gas will quickly accumulate and result in an explosion if ignited.

It is desirable to have a CO detector on the ventilation exhaust duct (CO is present whether the gas is ignited or not), and shutdown the BESS charging / discharging if CO is detected. HVAC should be kept on, and alarm if HVAC flow stops. These aspects are covered in the recommendations.

5.1.3.2 Explosion Consequence

If ignition if off gases occurs, at the time of ignition, the total amount of flammable gas present in the container is taken as the stoichiometric mixture (worst case explosion scenario).

The flammable gas concentration in the container at the time of ignition is taken as 0.0591 kg/m^3 (the geometric mean of LFL and UFL), and the flammable gas content is 1.15 kg.

The flammable gas compositions are in Table 16, except for the CO_2.

The explosion overpressures generated by ignition of the gas cloud are calculated using the TNT explosion model in PHAST.

The explosion overpressures generated are summarised in Table 18.

Table 18: BESS Explosion Results

Explosion overpressure, kPa	Distance from Container, m	Consequences	Offsite Impact?
7	10.4	Damage to battery pack Injury to personnel on site	No
14	6.6	Damage to battery pack Injury to personnel on site	No
21	5.1	Major damage to storage Potential for damage to adjacent container	No

Explosion overpressure, kPa	Distance from Container, m	Consequences	Offsite Impact?
35	3.4	Escalation to adjacent BESS container and damage to battery package in adjacent container, propagating to other containers	No

It was found that there would be no offsite impact from a battery storage container explosion.

If two containers are within 3m of one another, an explosion in one container may result in incident escalation and domino effect.

It is recommended that to protect adjacent containers, they be located with a minimum distance of 3 m from one another. This is consistent with the requirements of NFPA 855.

If a high CO alarm is raised, then personnel entry into a BESS container is not advisable due to the potential for an explosion. The ventilation system should be maintained, and the unit shut down until the alarm is cleared.

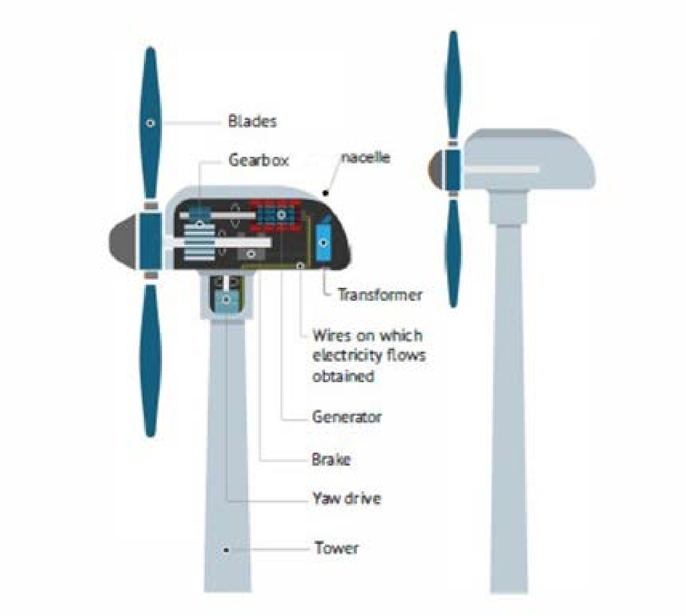
5.2 Wind Turbine Hazards

5.2.1 Blade Throw, Tower Collapse or Nacelle Collapse

The main wind turbine subassemblies and components are shown in Figure 22. There are three main points of failure that can result in an impact hazard:

- Detachment of a blade.
- Collapse of the supporting tower.
- Collapse of the nacelle (i.e. detachment from the tower).

Figure 22 Wind Turbine Components



Key Assumptions:

- The dimensions and operating parameters for the WTGs are as reported in Table 11.
- The direction of rotation for the blades on the WTGs is clockwise.
- The effects of the wind and air resistance (drag) are not included in the blade throw analysis. This is conservative as drag significantly reduces the maximum potential range of a projectile.
- Blade failure results in a full blade fragment rather than a smaller partial blade fragment.

Additional assumptions are included in the following sections.

5.2.2 Estimation of Hazard Range and Impact Area

Blade Throw

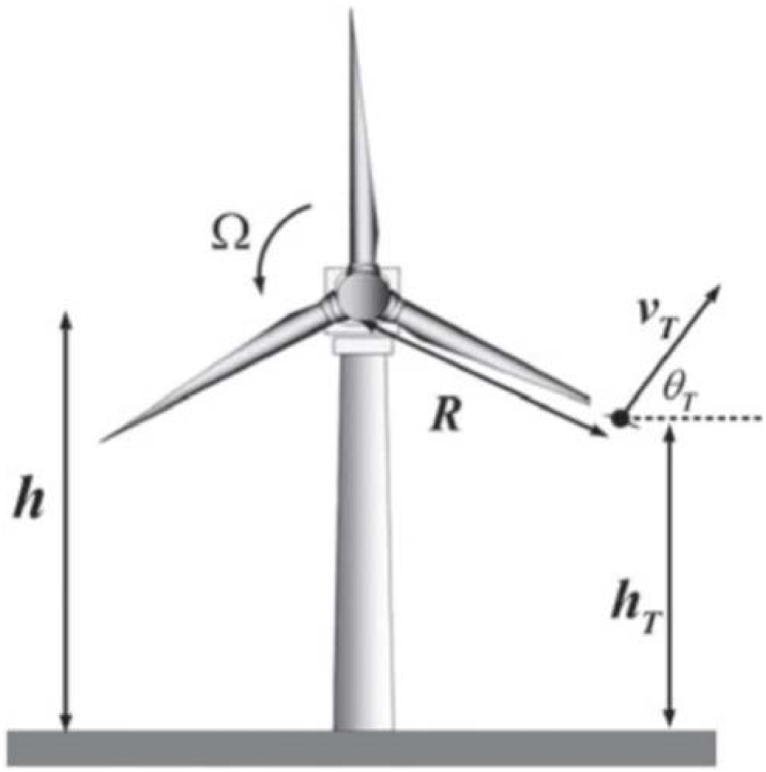
The lateral throw distance is the driving factor for the maximum extent of the potential risk contours. Neglecting aerodynamics, the maximum range of a projectile may be estimated using following formula [32]:

$$D = \frac{v_T^2 s_{\theta_T} c_{\theta_T} \pm v_T^2 \sqrt{s_{\theta_T}^2 c_{\theta_T}^2 + 2\frac{g}{v_T^2}\left(h - Rc_{\theta_T}\right) c_{\theta_T}^2}}{g}$$

Where:

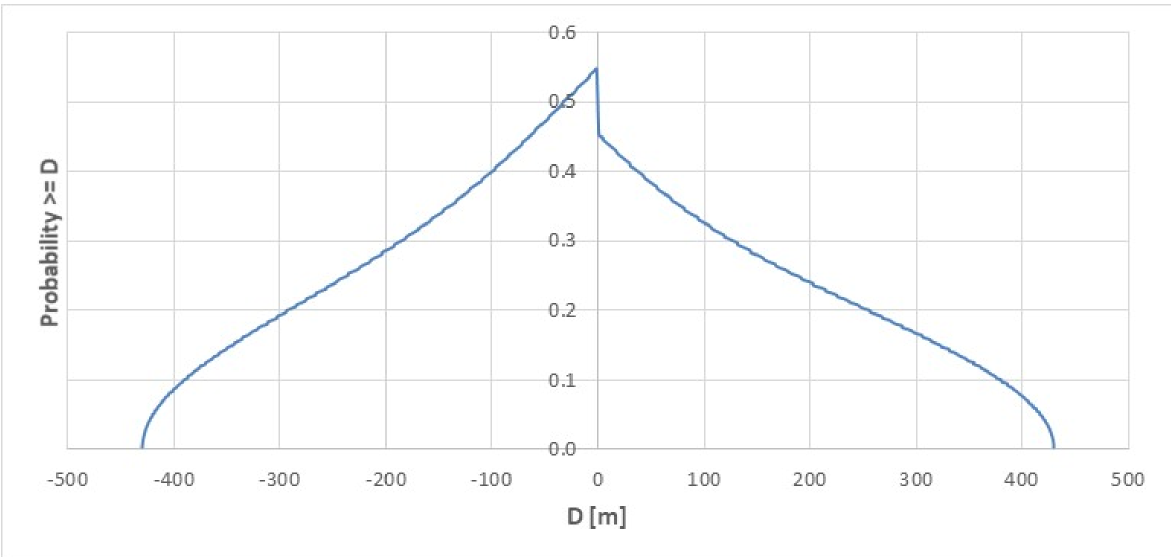
Where:	D	=	Lateral distance (m)
	v_T	=	Initial velocity (m/s)
	Θ_T	=	Initial angle (refer to Figure 23)
	$c_{\Theta T}$	=	$\sin\Theta_T$
	$c_{\Theta T}$	=	$\cos\Theta$
	g	=	acceleration due to gravity (m/s^2)
	h	=	Hub height (m)
	R	=	Radial distance (m)

Figure 23 Blade Throw Diagram [32]



Using the formula above, and assuming an equal probability of failure at any angle of rotation (i.e. omega divided into one-degree increments), the probability vs. distance distribution for an entire blade fragment (at nominal rpm speed) is shown in Figure 24. A fragment is slightly more likely to impact on one side of turbine than the other and there is a < 20% chance of a blade throw at greater than approximately 195 to 229 m (Note: This increases to approximately 1306 to 4045 m at the higher 'emergency' rpm speed). With inclusion of drag, these maximum distances would be lower.

Figure 24 Example Distance Distribution for Blade Throw at Nominal RPM



The length and width of the potential impact area is assumed to be equivalent to twice the fragment length (i.e. up to 2 x 91.5 m for a full blade – refer to Table 11).

The direction of blade throw is assumed to be perpendicular to the wind direction with the probability of each wind direction factored into the risk calculations (see Section 5.2.4).

Tower Collapse

In the event of a collapse at the base of the tower, a person or object may be impacted if located within a distance equal to the tip height of the WTG (i.e. up to 291.5 m – refer to Table 11). A break in the lower or upper half is assumed to occur at the centre of the corresponding half, which reduces the maximum impact distance.

The width of the potential impact area is assumed to be equivalent to the rotor diameter (i.e. up to 183 m – refer to Table 11).

The direction of collapse is assumed to be in the same direction as the wind with the probability of each wind direction factored into the risk calculations.

Nacelle Collapse

In the event of a nacelle collapse, a person or object may be impacted if located within a distance equal to half the rotor diameter (i.e. up to 91.5 m – refer to Table 11). This assumes the nacelle collapses at the base of the tower.

The width of the potential impact area is assumed to be equivalent to half the rotor diameter (i.e. up to 91.5 m for the proposed WTGs – refer to Table 11).

5.2.3 Likelihood of Blade Throw, Tower Collapse or Nacelle Collapse

The frequency (per turbine per year) of blade throw, tower collapse or nacelle collapse reported in various sources is summarised in Table 19. The frequency data from the *Handbook Wind Turbines* (2019) [33] was assumed to apply for the risk analysis as it is the most recent complete data set.

Table 19 Frequency (per turbine per year) of Blade Throw, Tower Collapse or Nacelle Collapse

Failure Case	Braam & Rademakers (2002) [34]	Handbook Risicozonering Wind turbines (2002) [35]	Data cited in UK HSE RR968 (2013) [36]							Handbook Risicozonering Wind turbines (2014) [37]	Handleiding Omgevingsveiligheid (2019) [38]	Handbook Wind turbines (2019) [33]
			Data cited by Larwood (2005)						UK HSE			
			Solar Energy Research Institute (1979)	Alameda County (2000-2003)	Denmark (1993 to 2004) and Germany (1996 to 2004)	Manufacturers (1989)						
						Netherlands	Denmark	USA				
Tower collapse												
- Break at base	3.2E-04	3.2E-04	-	6.9E-04	-	-	-	-	1.3E-04	1.3E-04	-	1.5E-05
- Break in lower half	-	-	-	-	-	-	-	-	-	-	-	3.5E-05
- Break in upper half	-	-	-	-	-	-	-	-	-	-	-	8.0E-06
Loss of an entire blade	8.4E-04	8.4E-04	-	5.4E-03	3.4E-03	-	-	-	8.4E-04	8.4E-04	8.4E-04	6.2E-04
- Nominal operating rpm	4.2E-04	4.2E-04	-	-	-	-	-	-	-	8.4E-04	8.4E-04	6.2E-04
- Mechanical braking (1.25 x nominal rpm)	4.2E-04	4.2E-04	-	-	-	-	-	-	-	-	-	-
- Emergency (2.0 x nom. rpm)	5.0E-06	5.0E-06	-	-	-	-	-	-	-	5.0E-06	5.0E-06	5.0E-06
Loss of a blade tip	2.6E-04	-	-	-	-	-	-	-	-	-	-	-
Nacelle collapse	1.3E-04	1.3E-04	1.2E-02	-	1.5E-02	2.0E-02	5.0E-03	3.0E-03	3.2E-04	4.0E-05	-	1.8E-05

Notes: Nominal operating rpm is regular operation during power production, from the lowest wind speed that the turbine turns on (typically c. 3 m/s) to the highest wind speed that the turbine turns off (typically c. 23 m/s). Braking refers to the condition when the turbine is shutting down, for any reason except an overspeed condition, and emergency refers to a rotor overspeed condition.

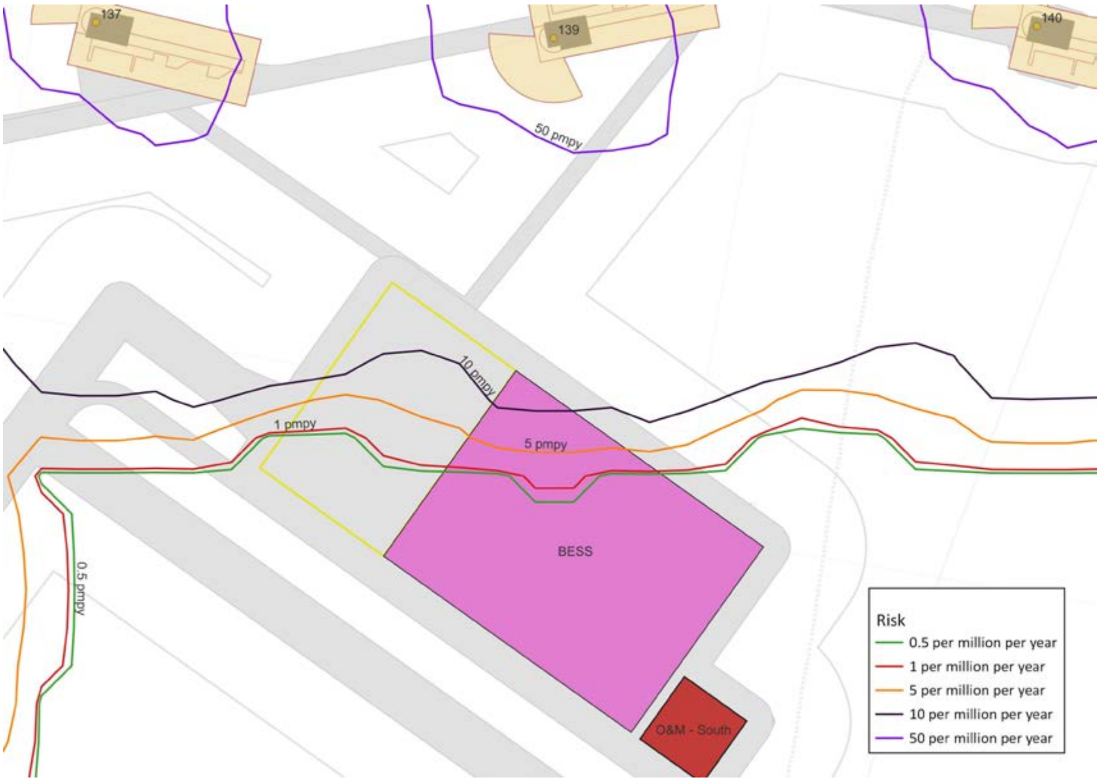
Mechanical braking no longer occurs in modern wind turbines. This type of braking used a separate segment of the blade near the tip which could be independently rotated to slow the blade. Modern turbines do not have a separate blade tip and are assembled as a single piece. Therefore, the blade tip scenario is excluded from more recently reported failure rate data and blade breakage during mechanical braking is excluded from the risk analysis.

5.2.4 Location-Specific Impact Risk due to Blade Throw, Tower Collapse or Nacelle Collapse

The location-specific risk results presented in Figure 25 to Figure 30 for the various locations on the site. The figures indicate the cumulative risk of potential impact by a thrown blade or a tower or nacelle collapse. Any impact by a blade, tower or nacelle would be fatal; therefore, the risk results presented in Figure 25 to Figure 30 also show the cumulative location-specific individual fatality risk contours. The locations selected are:

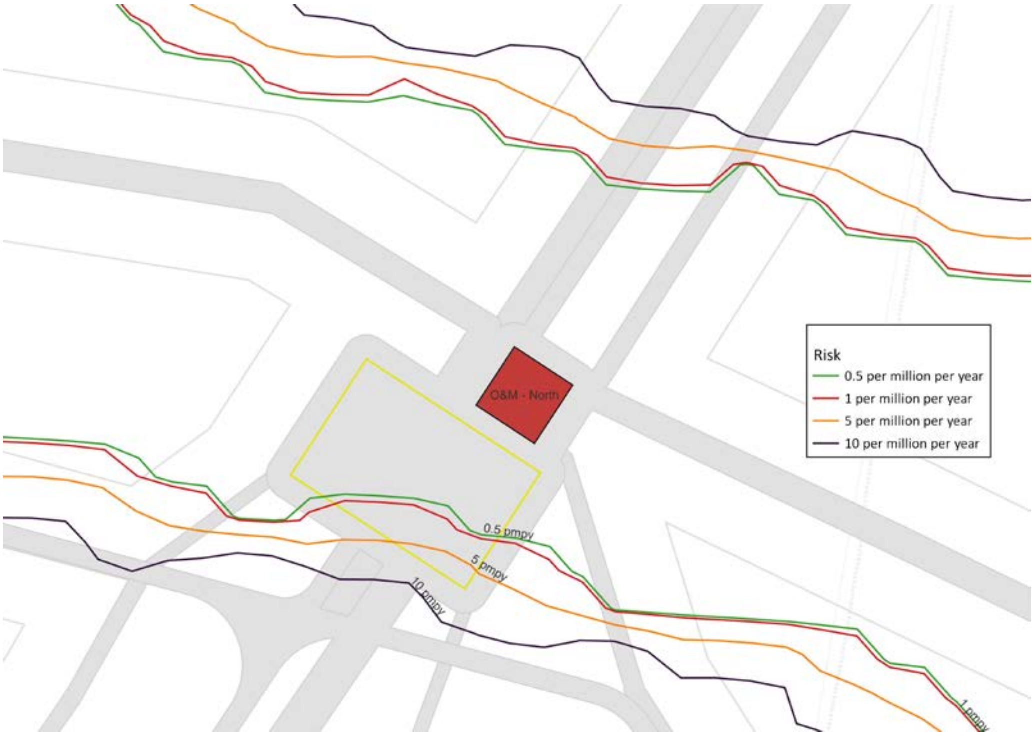
- BESS
- O&M North, Central and South as shown in Figure 26 to Figure 28.
- Rest area
- Non-associated dwellings

Figure 25 Cumulative Risk from Structural Failure of WTGs



- The maximum risk from blade throw at the wind farm is $10x10^{-6}$ per annum, at the NW corner of the BESS site.
- The contributors to risk on BESS are T37, T39 and T40.
- The $50x10^{-6}$ p.a. risk from individual WTGs is localised and does not reach the BESS.
- There is no offsite impact from T37, T39 and T40.

Figure 26 Cumulative Risk from Structural Failure of WTGs for O&M North



None of the WTGs pose a significant risk to the northern O&M building.

Figure 27 Cumulative Risk from Structural Failure of WTGs for O&M Central

None of WTGs pose a significant risk to the central O&M building.

Figure 28 Cumulative Risk from structural failure of WTGs for O&M South

None of WTGs pose a significant risk to the southern O&M building.

Figure 29 Cumulative Risk from Structural Failure of WTGs for Rest Area

The Rest Area is subject to risk levels of approximately 10 in a million per year.

The criteria for individual risk of fatality in open spaces in HIPAP No.4 [5] states:

Sporting complexes and active open space areas should not be exposed to individual fatality risk levels in excess of ten in a million per year (10 x 10^{-6}).

The question is whether to consider the Rest Area on the roadside of Sturt Highway as an "active open space". It is to be noted that the Rest Area may be occupied only for short periods at any one time by a few passing cars on Sturt Highway. The population density and occupancy of the Rest Area is not known, but expected to be very low. On that basis, it may be considered that a marginal exceedance of 10x10^{-6} p.a. risk at the Rest Area is tolerable.

The risk to the closest associated dwellings is shown in Figure 30.

Figure 30 Cumulative Risk from Structural Failure of WTGs for non-associated Dwellings

The risk contour for 0.5x10^{-6} per annum does not reach the non-associated dwellings, indicating that the risk would satisfy the risk criteria for dwellings.

The BESS (and substation) are not normally occupied areas and normal working hours for the O&M are 7am to 6pm, 6 days per week (i.e. not normally 24 hours). Therefore, the risk to individual personnel is very low.

The DPE risk criteria for land use safety planning in HIPAP No. 4 [5] do not apply to the O&M building and the BESS (or substation) since these facilities are within the boundary of the proposed development (Note: The DPE risk criteria also do not apply public roads). However, to comply with Section 2.4.2.1 of HIPAP No. 4, "Individual fatality risk levels for industrial sites at levels of 50 in a million per year (50 x 10^{-6} per year) should, as a target, be contained within the boundaries of the site where applicable".

It was found that the 50 in a million per year (pmpy) contours did not encroach on occupied buildings on site.

The maximum cumulative risk of impact due to blade throw, tower collapse or nacelle collapse is less than 0.5 pmpy at the closest dwelling. This is lower than the DPE risk criterion of 1 pmpy, which applies for residential uses.

5.2.5 Turbine Fire

A fire in the nacelle may occur due to a lightning strike, electrical malfunction, mechanical malfunction, or maintenance. These fires are relatively infrequent, with reported fire frequencies of approximately 1.7×10^{-4} fires per turbine per year [39] to 5.8×10^{-4} fires per turbine per year [40]. Some example fires are described in the European Confederation of Fire Protection Associations (CFPA) *Wind Turbines Fire Protection Guidelines* [41].

A fire in the nacelle may be difficult to extinguish due to its height AGL and can lead to a secondary fire on the ground (due to falling burning components, such as parts of the blade). Bush fire risks due to a turbine fire are addressed separately in the *Bushfire Risk Assessment* in the EIS.

The falling burning components pose a potential hazard to people and a potential escalation hazard (e.g. if this burning debris were to fall into the BESS area).

5.2.6 Ice Throw

The maximum distance for ice throw for an operating wind turbine can be estimated with the following empirical formula [42]:

$$dt = 1.5 * (D + H)$$

Where: dt = Maximum throwing distance (m)

D = Rotor diameter (m)

H = Hub height (m)

This formula is widely accepted as being conservative (i.e. Ice throw will remain within this zone) [10] and is typically used as the maximum ice throw distance for screening purposes. Measurements of collected ice particles confirm the conservatism of this formula, for example:

- Bredesen reports that ice pieces have been found at 68% of the maximum throw distance [43].
- An analysis of 1000 collected ice particles for wind farms located in the Jura Mountains (Switzerland) indicated that all landed within 1.4 x tip height, with only 3% located further than the tip height [44].
- An analysis of 530 collected ice particles from three wind farms in Sweden indicated that 75% landed at 20 to 90 m, with almost all particles located within 1 x tip height [45].

The maximum falling distance for a non-operating (i.e. stationary) wind turbine can be established with the following empirical formula [42]:

$$df = (H+D/2) * V/15$$

Where: df = Maximum falling distance (m)

D = Rotor diameter (m)

H = Hub height (m)

V = Wind speeds at the hub height (m/s). Average wind speed at the hub height is derived from site meteorological data and is 8.1 m/s.

Table 20 Estimation of Ice Throw Hazard Range

Combined Height of Blade and Tower [m AGL]	Rotor Diameter, D [m]	Hub Height, H [m]	Max. Ice Throw Distance, dt [m]	68% of Max. Ice Throw Distance [m]	1.4 x Tip Height [m]	Ice Drop from Stopped Turbine, df [m] @8.1 m/s WS
291.5	183	200	574.5	390.7	408.1	157.4

The maximum ice throw hazard range (574.5 m) is significantly less than the distance to the closest residence (viz. c. 1085m). However, ice throw may pose a hazard for personnel at:

- The northern substation;
- Central substation;
- Central O&M building;
- Southern substation; and
- BESS.

Figure 31: Example Maximum Ice Throw Hazard Ranges for WTG No. 139

Ice throw may also pose a potential hazard when driving along roads or accessing the WTGs during icing conditions.

There are 18 WTGs located near the edge of the Keri Keri site where the maximum ice throw hazard range of 574.5 m extends outside the site (WTG's 1, 3, 4, 5, 6, 13, 25, 49, 50, 75, 76, 98, 105, 127, 128, 151, 170, 178).

Of those WTGs, some have maximum ice throw hazards that impact on public roads:

- Keri Keri Road is impacted by 3 WTGs: 76, 105 & 128.
- Sturt Highway is impacted by 10 WTGs: 1, 6, 14, 26, 27, 28, 29, 30, 31, 177.

In Table 4 to Table 7, the icing conditions analysis showed that the likelihood of ice formation is very low. This analysis is based on an approach that has been very conservative and expected to an over-estimation of the icing duration. It was concluded that the potential for ice formation is not credible for the wind turbines in the Project Area. Therefore the marginal excursion of the risk contours on public roads based on a conservative estimate should be considered tolerable.

Figure 32: Maximum Ice Throw Hazard Ranges adjacent Sturt Highway

5.3 Electrical Hazards

5.3.1 Transformer Fire

The BESS produces 600V DC. This needs to be converted into ultimate grid voltage of 330 kV AC through a series of power transformers.

There are several configurations possible and the optimum configuration will be finalised during detailed design. For sake of the PHA, the following configuration is selected:

BESS (600 V DC) → Inverter (480 V AC) → Booster Transformer (0.69/35 kV)

→ Power transformer (35 kV to 220 kV to grid)

The power transformer has a capacity of 415kVA - 35/220 kV. The transformer oil volume in circulation is assumed to be 800 Litres [46]. The oil tank of capacity 12,000 L is located on top of the transformer. The transformer is in a bund.

5.3.2 Impairment Criteria

The levels of heat radiation selected to examine the heat effects were 4.7, 12.5, 23, 30, and 37.5 kW/m^2, as given in HIPAP No.4 [47].

The general effects of these levels of heat radiation are summarised in Table 21. These heat flux radiation effects are widely accepted by industry and is appropriate for this analysis.

Table 21: Heat Radiation Effects

Heat Radiation (kW/m^2)	Effect
4.7	Maximum heat radiation level to which fire-fighting personnel may be exposed.
12.5	Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure. 30% chance of fatality for long exposure. High chance of injury.
23	Unprotected steel will reach thermal stress temperatures to cause failure. Pressure vessels need to be relieved, or failure will occur. 100% chance of fatality for long exposure and 10% chance of fatality for instantaneous exposure.
37.5	100% chance of fatality for instantaneous exposure.

5.3.3 Material Modelled

The transformer oil is a mineral oil, comprising of hydro-treated light naphthenic and paraffinic distillates. On this basis, dodecane (C12) was selected as a representative single component material for the consequence modelling.

PHAST models both the luminous and smoky part of the flame for calculating thermal radiation impact distances.

5.3.4 Pool Fire Results

The results in the following table represent the maximum ground level impact distance measured from the centre of the bund in a downwind orientation. The flame height represents the length of the flame from the pool surface to the tip of the flame.

Substation layout design details are not available at the stage of the EIS. Two sets of transformers in parallel are assumed.

The heat radiation hazard zones are determined using PHAST. The bund fire was modelled as a circular pool with an equivalent area to that of the area of the rectangular bund (equivalent 8m diameter).

Table 22: Transformer Bund Pool Fire Heat Radiation Impact Distances

Stability Class /Wind Speed	Maximum Surface Emissive Power (kW/m^2)	Pool Diameter (m)	Flame Height (m)	Wind Tilt (deg)	Distance to heat radiation kW/m^2 (m)			
					4.7	12.6	23	35
D 1.6	86.4	8	11.8	30.6	22.5	15.3	11.1	7.8
D 4.1	86.4	8	11.8	34.9	23.4	16.6	13.0	8.8
D 7.3	86.4.	8	11.8	58.9	23.5	17.8	14.5	9.4

*Pool fire diameter based on the equivalent diameter of the bund.

The thermal radiation impacts from transformer fires are confined within the site boundary with no potentially injurious offsite effects. The separation distances between transformers and to protected works on site is specified in AS-2067 (2016).

From fire hydrants available, the fire can be fought with fire water and foam. Based on a recent fire in Victoria [48], the fire brigade approach appears to be to let a container burn itself out, evacuate non-essential personnel and protect exposures – i.e., other containers exposed to the original fire.

It is necessary that that all bund penetrations, including conduits, are sealed with a suitable fire-resistant packing or sealant.

6 STANDARDS APPLICABLE TO BESS

Several Australian and International standards exist or are in development for battery energy storage systems. The relevance of each standard to the Keri Keri Wind Farm BESS is discussed below.

6.1 NFPA 855-2023: Standard for the Installation of Stationary Energy Storage Systems

The purpose of this standard [19] is to provide the minimum requirements for mitigating the hazards associated with stationary energy storage systems.

6.2 AS/NZS 5139: Electrical Installations - Safety of Battery Systems for use with Power Conversion Equipment

This standard [49] only applies if "each individual BESS is no more than 200 kWh". Current advice is that each individual BESS unit will be 2.5 MWh. Therefore AS/NZS 5139 is not applicable.

6.3 IEC 62897: ED1 Stationary Energy Storage Systems with Lithium Batteries - Safety Requirements

This standard is still under development, and therefore not applicable.

6.4 IEC 62933 Series

This standard [50] is currently under development, with the following sections published:

- IEC 62933-1:2018, Electrical energy storage (EES) systems – Part 1: Vocabulary [51]

  Defines terms applicable to EES systems including terms necessary for the definition of unit parameters, test methods, planning, installation, safety, and environmental issues.

  This terminology document is applicable to grid-connected systems able to extract electrical energy from an electric power system, store it internally, and inject electrical power to an electric power system. The step for charging and discharging an EES system may comprise an energy conversion.

- IEC 62933-2-1:2017, Electrical energy storage (EES) systems – Part 2-1: Unit parameters and testing methods – General specification [52]

  Focuses on unit parameters and testing methods of EES systems. The energy storage devices and technologies are outside the scope of this document. This document deals with EES system performance defining:

  - unit parameters,
  - testing methods.

- IEC TS 62933-2-2:2022, Electrical energy storage (EES) systems – Part 2-2: Unit parameters and testing methods – Application and performance testing [53]

  Defines testing methods and duty cycles to validate the EES system's technical specification for the manufacturers, designers, operators, utilities, and owners of the EES systems which evaluate the performance of the EES systems for various applications.

- IEC TR 62933-2-200:2021, Electrical energy storage (EES) systems – Part 2-200: Unit parameters and testing methods – Case study of electrical energy storage (EES) systems located in EV charging station with PV [54].

- IEC TS 62933-3-1:2018, Electrical energy storage (EES) systems – Part 3-1: Planning and performance assessment of electrical energy storage systems - General specification [55].

  Is applicable to EES systems designed for grid-connected indoor or outdoor installation and operation. This document considers:

  - Necessary functions and capabilities of EES systems
  - Test items and performance assessment methods for EES systems
  - Requirements for monitoring and acquisition of EES system operating parameters
  - Exchange of system information and control capabilities required

- IEC TS 62933-3-2:2018, Electrical energy storage (EES) systems – Part 3-2: Planning and performance assessment of electrical energy storage systems - Additional requirements for power intensive and renewable energy sources integration related applications [56].

  Provides the requirements for power intensive and renewable energy sources integration related applications of EES systems, including grid integration, performance indicators, sizing and planning, operation, and control, monitoring and maintenance. The power intensive applications of EES systems are usually used to improve the dynamic performance of the grid by discharging or charging based on corresponding control strategies. The renewable energy sources integration related applications of EES systems are usually used to mitigate short-term fluctuation and/or to keep long-term stability. This document includes the following applications of EES systems:

  - frequency regulation/support;
  - grid voltage support (Q(U)) (“volt/var support”);
  - voltage sag mitigation;
  - renewable energy sources integration related applications;
  - power oscillation damping (POD).

- IEC TS 62933-3-3:2022, Electrical energy storage (EES) systems – Part 3-3: Planning and performance assessment of electrical energy storage systems - General specification [57].

  Is applicable to EES systems designed for grid-connected indoor or outdoor installation and operation. This document considers:

  - necessary functions and capabilities of EES systems
  - test items and performance assessment methods for EES systems
  - requirements for monitoring and acquisition of EES system operating parameters
  - exchange of system information and control capabilities required.

- IEC TS 62933-4-1:2017, Electrical energy storage (EES) systems – Part 4-1: Guidance on environmental issues – General specification [58].

  Describes environmental issues associated with electrical energy storage systems (EES systems) and presents guidelines to address the environmental impacts to and from EES systems including the impacts to humans due to chronic exposure associated with the mentioned environmental impacts.

- IEC TS 62933-5-1:2017, Electrical energy storage (EES) systems – Part 5-1: Safety requirements for grid integrated ESS systems – General specification [59].

  Specifies safety considerations (e.g., hazards identification, risk assessment, risk mitigation) applicable to EES systems integrated with the electrical grid.

  This document provides criteria to foster the safe application and use of electric energy storage systems of any type or size intended for grid-integrated applications.

- IEC 62933-5-2:2020, Electrical energy storage (EES) systems – Part 5-2: Safety requirements for grid integrated ESS systems – electrochemical based systems [60].

  Primarily describes safety aspects for people and, where appropriate, safety matters related to the surroundings and living beings for grid-connected energy storage systems where an electrochemical storage subsystem is used.

6.5 UL 9540: Energy Storage System (ESS) Requirements

These requirements [61] cover ESS that are intended to receive and store energy in some form so that the energy storage system 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. This standard is covered/referred to by NFPA 855.

6.6 UL 9540A: Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

This standard [62] is a test method for BESS fires and is covered/referred to by NFPA 855. This test method was updated in 2022.

6.7 FM Global Property Loss Prevention Data Sheet 5-33: Electrical Energy Storage Systems

This data sheet [63] describes loss prevention recommendations for the design, operation, protection, inspection, maintenance, and testing of ESS that use lithium-ion batteries.

6.8 FM Global Development of Sprinkler Protection Guidance for Lithium Ion Based Energy Storage Systems

This guidance document [64] is only relevant for commercial occupancies and is not applicable for Keri Keri Wind Farm BESS.

6.9 IEEE Std 2030.2.1-2019: Guide for Design, Operation, and Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems

IEEE Std 2030.2.1 [65] provides guidance in understanding and defining the general structure of a battery energy storage system, its basic technical characteristics, and general applications in an electric system, and how to design the battery system, power conversion system, monitoring, information exchange, and control (MIC) system. Furthermore, the standard also fills the need for guidance key to operating and maintaining a battery energy storage system in its application, including functional performance, optimization especially for batteries, and countermeasures for different emergencies.

6.10 EI Battery Storage Guidance Note 1: Battery Storage Planning

This Energy Institute (EI) publication [66] provides guidance covering various aspects of planning a battery storage facility. It provides an overview of battery storage types, planning regulations in the UK, and information on safety issues that should be considered during planning and risk assessments.

The UK planning regulations are not relevant here. The safety issues that should be considered for planning provides useful guidance.

6.11 EI Battery Storage Guidance Note 2: Battery Energy Storage System Fire Planning and Response

This EI publication [67] provides guidance on how to respond to BESS fires. It represents the 'current state' of knowledge (in 2019), but also identifies gaps in knowledge. The guidance covers primarily non-domestic battery installations, although the guidance may also generally be applicable to smaller, domestic-scale incidents. It provides an overview of the fire risk of common battery chemistries, briefly describes how battery fires behave, and provides guidance on personnel response, managing combustion products, risks to firefighters, pre-fire planning, and fire-aftermath.

Although much of this guidance is generally applicable to other battery chemistry types, this guidance is of relevance to fires involving Lithium-ion (Li-ion) chemistries, except where otherwise noted.

This publication provides useful guidance that would be input to an emergency response plan.

6.12 EI Battery Storage Guidance Note 3: Design, Construction and Maintenance

This EI publication [68] aims to capture learning and experience from battery storage construction projects, with special emphasis on ensuring the safety of such projects to people and environment. Based on industry interviews and available literature, this publication covers a large range of issues that have caused, or can potentially cause, issues during battery storage projects during design, construction, commissioning, or maintenance, including site selection, using containerised solutions, construction, maintenance, and decommissioning. Its purpose is not to provide a 'how to' document on constructing a battery storage system, but rather to share experience and help others to avoid some of the pitfalls that have affected previous projects, helping to avoid safety issues and project delays.

6.13 EI battery storage research report: Using second-life electric vehicle batteries for stationary storage

The EI research report [69] aims to set out the issues related to the use of 'second life' batteries for stationary BESS. The predicted growth of the EV industry is anticipated to result in large numbers of batteries becoming available whose energy storage capacity has degraded to the point where it is no longer adequate for use in EVs, but which may well still have enough capacity for use in BESS. Potential benefits include:

- avoiding or delaying the costs of recycling and disposal;
- reducing environmental impacts of disposal;
- reducing environmental impacts of mining and processing of materials for batteries, and
- potential cost savings over new batteries.

6.14 Summary

All the publications offer useful information on the safety requirements for battery energy storage systems. For the purposes of land use planning safety, NFPA 855 and FM Global DS 5-33 are most applicable.

As an example, an assessment of the Keri Keri Wind Farm BESS against NFPA 855 has been conducted and the results shown in Appendix A.

A safety management system will be developed by Accione and implemented for safe operations, inspection and maintenance.

7 Risk Assessment

7.1 Risk Criteria Comparison

The following table details a comparison of the risk analysis with the NSW DPIE Hazardous Industry Planning Advisory Paper No. 4, 'Risk Criteria for Land Use Safety Planning' [47]. The criteria implicitly assumes that an effective safety management system is in place to manage the risks.

Table 23: Risk Criteria Comparison

Criterion Description	Criterion Value, per year	Comment
Individual Fatality Risk Criteria		
Hospitals, schools, child-care facilities, old age housing.	0.5×10^{-6}	Distances to fatal consequences from fires and explosions are not reached at these land uses for hazards associated with the wind farm. There is also significant uncertainty in frequency assessment of this evolving technology. Frequency assessment was carried out for blade throw hazard and found to satisfy the risk criteria. Consequences resulting in potential fatality do not reach industrial areas.
Residential, hotels, motels, tourist resorts.	1×10^{-6}	
Commercial developments including retail centres, offices, and entertainment centres.	5×10^{-6}	
Sporting complexes and active open space.	10×10^{-6}	
Industrial	50×10^{-6}	
Injury Risk		
Incident heat flux radiation at residential and sensitive use areas should not exceed 4.7 kW/m^2.	50×10^{-6}	Potentially hazardous consequences (viz. >4.7 kW/m^2 or >7 kPa) are not reached at these land uses for fire / explosion hazards associated with the BESS.
Incident explosion overpressure at residential and sensitive use areas should not exceed 7 kPa.	50×10^{-6}	
Toxic concentrations in residential and sensitive use areas should not exceed a level which would be seriously injurious to sensitive members of the community following a relatively short period of exposure.	10×10^{-6}	Potentially hazardous consequences are not reached at these land uses for fire hazards associated with the BESS.
Toxic concentrations in residential and sensitive use areas should not cause irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community.	50×10^{-6}	

Criterion Description	Criterion Value, per year	Comment
Risk of Property Damage and Accident Propagation		
Incident heat flux radiation at neighbouring potentially hazardous installations or at land zoned to accommodate such installations should not exceed the 23 kW/m^2 heat flux level.	50 x 10^{-6} / year	Potentially hazardous consequences (viz. >23 kW/m^2 or >14 kPa) are not reached at these land uses for fire / explosion hazards associated with the BESS and WTG systems.
Incident explosion overpressure at neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings should not exceed the 14 kPa explosion overpressure level.	50 x 10^{-6} / year	
Societal Fatality Risk	Refer to HIPAP No. 4, Figure 3: 'Indicative Societal Risk Criteria'	There is negligible offsite risk of fatality and hence there are no societal risk implications.

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

The following conclusions were made from the current assessment of the proposal:

- The thermal radiation, explosion and toxic gas effects of BESS fires would be confined within the site and there would be no potentially injurious offsite effects. The separation distance between containers should enable approach of the fire by firefighting personnel; however, if entry into a container is required for firefighting this will require self-contained breathing apparatus due to the potentially toxic fumes.
- A separation distance of 3m between adjacent containers should be considered to prevent escalation from an explosion of off gases generated in one container from battery overheating.
- Toxic gas concentrations that produce injury or irritation level are confined entirely within the site boundary, and do not reach ground level.
- If a high CO alarm is raised, then personnel entry into a BESS container is not advisable due to the potential for an explosion. The ventilation system should be maintained, and the unit shut down until the alarm is cleared.
- The thermal radiation impacts from transformer fires are localised with no potentially injurious offsite effects.
- The DPE risk criteria for land use safety planning in HIPAP No. 4 do not apply to the O&M buildings and the BESS since these facilities are within the boundary of the proposed development. To comply with Section 2.4.2.1 of HIPAP No. 4, "Individual fatality risk levels for industrial sites at levels of 50 in a million per year (50 x 10^{-6} per year) should, as a target, be contained within the boundaries of the site where applicable". This criterion is satisfied.
- The proposed development complies with the relevant DPE criteria for land use safety planning.
- A set of recommendations have been made that would further improve the safety of the proposed installation.

8.2 Recommendations

Recommendations based on the key findings of the assessment include:

1. A separation distance of 3m between adjacent containers should be considered to prevent escalation from an explosion of off gases generated in one container from battery overheating.
2. The transformers in separate bunds should be protected by firewalls if a separation distance of 10m from each other cannot be achieved.
3. Forced ventilation should be installed in the BESS containers (minimum 30 air changes per hour).
4. An alarm should be installed to indicate loss of ventilation flow through the containers.

5. Installing a CO detector on the ventilation exhaust duct (CO is present whether the gas is ignited or not) should be considered, with shutdown of the BESS charging/ discharging if CO is detected. The HVAC should be kept on, and alarm if HVAC flow stops.
6. Firefighting in a BESS container will require breathing apparatus protection to prevent exposure to potentially lethal toxic fumes.
7. Bollards/protective barriers around be provided around key battery areas and infrastructure.
8. The Emergency Response Plan for the proposed development should address the specific hazards identified in the PHA (e.g. battery overheating, fires, explosions etc.) and ensure emergency response personnel take appropriate precautions to protect themselves from the hazards and escalating events. Additional recommendations based on a gap analysis against the recommendations of NFPA 855 are also included in Appendix A.
9. Measures to mitigate ice formation on the turbines (e.g. anti-icing or de-icing technologies) and/or control access (e.g. ice risk management plan) should be considered to reduce the risk of ice impact 'so far as reasonably practicable'. This is applicable for the turbines within 550m of Sturt Highway.

NFPA 855 Compliance Requirements

10. Confirm BESS listed with UL 9450.
11. Confirm BESS HVAC monitoring, alarming and thermal or other trip systems for individual BESS containers. See also NFPA 855:2023 Section 9.2.3.2 which says: The ESMS or BMS shall electrically isolate the ESS or affected components of the ESS or place the system in a safe condition if potentially hazardous conditions are detected.
12. Confirm BESS charge controllers are UL 1741 listed or are provided as part of a listed ESS.
13. Confirm BESS inverters and converters are UL 1741 listed.
14. Confirm BESS safety, automation and energy management systems meet the requirements of NFPA 855:2023 Section 4.6.10.
15. Confirm BESS enclosures meet the requirements of NFPA 855:2023 Section 4.6.12.
16. Confirm that fire department access to BESS layout complies with the requirements of FRNSW.
17. Complete a Hazardous Area Zoning Study for the BESS plot.
18. Confirm BESS smoke and fire detection systems meet the requirements of NFPA 855:2023 Section 4.8.
19. Confirm BESS fire control and suppression systems meet the requirements of NFPA 855:2023 Section 4.9.
20. Confirm BESS disconnecting means meet the requirements of NFPA 855:2023 Section 5.2.
21. Confirm BESS compliant with UL 9450A.

22. Confirm BESS compliant with UL 9450 or perform a Hazard Mitigation Analysis in accordance with NFPA 855:2023 Section 4.4.
23. Confirm BESS will consist of new batteries or will meet the requirements of NFPA 855:2023 Section 9.2.4.
24. Ensure BESS container layout achieves a more than 30.5 m separation from any exposure hazards.
25. To achieve a Location Classification of *Outdoor Installations - Remote locations*, ensure nearest BESS container to southern O&M building will be separated by a minimum 30.5 m. See also Recommendation 23.
26. Confirm BESS layout complies with the requirements of NFPA 855 Section 9.5.2.6.1.6.
27. Confirm that the means of egress from the BESS layout comply with NFPA 855 Section 9.5.2.6.1.7 or other relevant Australian Standards if they exceed the requirements of NFPA 855.
28. Confirm that BESS fire control and suppression comply with NFPA 855 Section 9.6.2.1 or other relevant Australian Standards if they exceed the requirements of NFPA 855.
29. Confirm that BESS Mechanical Exhaust Ventilation complies with NFPA 855 Section 9.6.5.1.5 and its subsections.
30. Include appropriate spill control to Australian Standards where required.
31. Confirm that BESS Thermal Runaway Protection complies with NFPA 855 Section 9.6.5.5 and its subsections.
32. Confirm that BESS Explosion Control complies with NFPA 855 Section 9.6.5.6 and its subsections.
33. Ensure the relevant requirements of NFPA 855 Section 9.6.6 are included in the Emergency Response Plan.
34. Confirm allowed storage of Lithium Metal or Lithium-ion Batteries at the site. Confirm the storage meets the recommendations of NFPA 855 Section 14.

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APPENDICES

Appendix A Review of Compliance with NFPA 855

An assessment of the Keri Keri Wind Farm preferred BESS against the relevant sections of NFPA 855 [19] and has been conducted and the results are shown below. This highlights any gaps against this standard, and where further information is required. Only the specific and relevant sections of NFPA 855 [19] are included.

Note that the effective date of NFPA 855:2023 was September 1, 2022, and that is labelled the 2023 Edition. The pace of developments in battery energy storage systems and the development of their standards has been proceeding in parallel. Thus, some of the parts of NFPA 855:2023 would not have been known during the development of the Keri Keri Wind Farm and BESS Project.

It is also acknowledged that items such as UL listing of components or systems can take time to complete.

NFPA 855 Reference	Potential Gap/s	Comment
4.2.1.1 The plans and specifications associated with an ESS and its intended installation, replacement or renewal, commissioning, and use shall be submitted to the AHJ for approval and include the following: (1) Location and layout diagram of the room or area in which the ESS is to be installed (2) Details on hourly fire-resistant-rated assemblies provided or relied upon in relation to the ESS (3) The quantities and types of ESS units (4) Manufacturer's specifications, ratings, and listings of ESS (5) Description of energy storage management systems and their operation (6) Location and content of required signage (7) Details on fire suppression, smoke or fire detection, gas detection, thermal management, ventilation, exhaust, and deflagration venting systems, if provided (8) Support arrangement associated with the installation, including any required seismic support	Not currently applicable	Detailed engineering for the project has not commenced. This section does provide a useful check of the requirements.

NFPA 855 Reference	Potential Gap/s	Comment
4.2.1.3 The following test data, evaluation information, and calculations shall be provided in addition to the plans and specifications in 4.2.1.1 where required elsewhere in this standard: (1) Fire and explosion testing data in accordance with 9.1.5 (2) Hazard mitigation analysis (HMA) in accordance with Section 4.4 (3) Calculations or modelling data to determine compliance with NFPA 68 and NFPA 69 in accordance with 9.6.5.6.3 (4) Other test data, evaluation information, or calculations as required elsewhere in this standard	Not currently applicable	Detailed engineering for the project has not commenced. This section does provide a useful check of the requirements.
4.2.1.4 If modelling data is provided, validation of the modelling results shall also be included.	Not currently applicable	Detailed engineering for the project has not commenced. This section does provide a useful check of the requirements.
4.2.2 Building Owner The construction documents described in this section shall be provided to the building owner or the owner's authorized agent prior to the system being put in service.	Not currently applicable	Detailed engineering for the project has not commenced. This section does provide a useful check of the requirements.

NFPA 855 Reference	Potential Gap/s	Comment
4.2.3 Manuals. An operations and maintenance manual shall be provided to both the ESS owner or their authorized agent and system operator before the system is put into operation and includes the following: (1) Submittal data stating the ESS size and selected options for each component of the system. (2) Manufacturer's operation manuals and maintenance manuals for the entire ESS or for each component of the system requiring maintenance that clearly identify the required routine maintenance actions. (3) Contact information for a contracted service agency or responsible in-house personnel. (4) A narrative of how the ESS and its components and controls are intended to operate, including recommended operational set points. (5) A service record log that lists the schedule for all required service and maintenance actions with space for logging such actions that can be completed over time	Not currently applicable	Detailed engineering for the project has not commenced. This section does provide a useful check of the requirements.
4.2.3.1 The operations and maintenance manual shall be prepared prior to final approval of the ESS and be readily accessible to personnel responsible for the ESS.	Not currently applicable	Detailed engineering for the project has not commenced. This section does provide a useful check of the requirements.

NFPA 855 Reference	Potential Gap/s	Comment
4.2.3.2 A copy of the operations and maintenance manual shall be placed in an approved location to be accessible to AHJs and emergency responders.	Not currently applicable	Detailed engineering for the project has not commenced. This section does provide a useful check of the requirements.
4.3 Emergency Planning and Training	Not currently applicable	Detailed engineering for the project has not commenced. This section does provide a useful check of the requirements.
4.4 Hazard Mitigation Analysis	No Gap Identified	This PHA study meets this requirement.
4.5 Combustible Storage	Not currently applicable	Detailed engineering for the project has not commenced. This section does provide a useful check of the requirements.
4.6.1 Listings ESS shall be listed in accordance with UL 9450, unless specifically exempted in other sections of this standard.	Unknown	**Recommendation A1: Confirm BESS listed with UL 9450.**
4.6.2 Repairs	Not currently applicable	Detailed engineering for the project has not commenced. This section does provide a useful check of the requirements.
4.6.3 Retrofits	Not currently applicable	Detailed engineering for the project has not commenced. This section does provide a useful check of the requirements.
4.6.4 Replacements	Unknown	Detailed engineering for the project has not commenced. Any replacements should be evaluated as new ESS's as per NFPA 855:2023 Section 4.6.4.
4.6.5 Reused Equipment	Unknown	Detailed engineering for the project has not commenced. Any reused equipment should be evaluated as new ESS's as per NFPA 855:2023 Section 4.6.5.
4.2.6 Increase in Power Rating or Maximum Stored Energy	Not currently applicable	It is envisaged that the planning approval would set a maximum stored energy value for the BESS. Any increase would thereby be subject of an amendment or new planning approval.

NFPA 855 Reference	Potential Gap/s	Comment
4.6.7 Environment The temperature, humidity, and other environmental conditions in which an ESS is located shall be maintained in accordance with the listing and the manufacturer's specifications.	Unknown	**See Recommendation A1.** **Recommendation A2: Confirm BESS HVAC monitoring, alarming and thermal or other trip systems for individual BESS containers. See also NFPA 855:2023 Section 9.2.3.2 which says: The ESMS or BMS shall electrically isolate the ESS or affected components of the ESS or place the system in a safe condition if potentially hazardous conditions are detected.**
4.6.8 Charge Controllers	Unknown	**Recommendation A3: Confirm BESS charge controllers are UL 1741 listed or are provided as part of a listed ESS.**
4.6.9 Inverters and Converters	Unknown	**Recommendation A4: Confirm BESS inverters and converters are UL 1741 listed.**
4.6.10 Energy Storage Management System (ESMS)	Unknown	**Recommendation A5: Confirm BESS safety, automation and energy management systems meet the requirements of NFPA 855:2023 Section 4.6.10.**
4.6.11 ESS Toxic and Highly Toxic Gas Release During Normal Use ESS shall not release toxic or highly toxic gases during normal charging, discharging, and use.	No Gap Identified	BESS containers have air conditioning for operational reasons. See Recommendation A2.
4.6.12 Enclosures	Unknown	**Recommendation A6: Confirm BESS enclosures meet the requirements of NFPA 855:2023 Section 4.6.12.**
4.7 Installation	Unknown	Detailed engineering for the project has not commenced. This section does provide a useful check of the requirements. Installation to relevant standards is assumed in the EIS. Commentary about seismic risk is included in this PHA Report.
4.7.11 Access Roads	Unknown	Compliance to relevant industry standards Identified as mitigation in the EIS, however, fire department access to and inside the BESS plot is unclear. **Recommendation A7: Confirm that fire department access to BESS layout complies with the requirements of FRNSW.**

NFPA 855 Reference	Potential Gap/s	Comment
4.7.12 Hazardous Atmospheres The ESS shall not be located in a classified area as defined in *NFPA 70* or IEEE C2 unless listed and approved for the specific installation	Unknown	Detailed engineering for the project has not commenced, so a Hazardous Area Zoning study has not been conducted. **Recommendation A8: Complete a Hazardous Area Zoning Study for the substations, switchyards, BESS plot, O&M plots, and battery storage area plot.**
4.8 Smoke and Fire Detection	Unknown	**Recommendation A9: Confirm BESS smoke and fire detection systems meet the requirements of NFPA 855:2023 Section 4.8.**
4.9 Fire Control and Suppression	Unknown	**Recommendation A10: Confirm BESS fire control and suppression systems meet the requirements of NFPA 855:2023 Section 4.9.**
5.2 Disconnecting Means. A readily accessible disconnecting means for the ESS shall be provided.	No Gap Identified	Detailed engineering for the project has not commenced. This section does provide a useful check of the requirements. Installation to relevant standards is assumed in the EIS. **Recommendation A11: Confirm BESS disconnecting means meet the requirements of NFPA 855:2023 Section 5.2.**
5.3 Nonelectrical Systems.	No Gap Identified	Detailed engineering for the project has not commenced. This section does provide a useful check of the requirements. Installation to relevant standards is assumed in the EIS.
5.4 Support Systems.	No Gap Identified	Detailed engineering for the project has not commenced. This section does provide a useful check of the requirements. Installation to relevant standards is assumed in the EIS.
Chapter 6 – Commissioning	Not currently applicable	Project is not at construction phase, and the battery supplier for the BESS has not been selected. There will be some iterative detailed design. This section does provide a useful check of the requirements.

NFPA 855 Reference	Potential Gap/s	Comment
Chapter 7 – Operation and Maintenance	Not currently applicable	Detailed engineering for the project has not commenced, and the battery supplier for the BESS has not been selected. There will be some iterative detailed design. This section does provide a useful check of the requirements.
Chapter 8 – Decommissioning	No Gap Identified	Requirement for a decommissioning plan is identified in the EIS.
9.1.5 Fire and Explosion Testing	Unknown	**Recommendation A12: Confirm BESS compliant with UL 9450A.**
9.2 Equipment	Unknown	**Recommendation A13: Confirm BESS compliant with UL 9450 or perform a Hazard Mitigation Analysis in accordance with NFPA 855:2023 Section 4.4.**
9.2.4 Repurposed and Refurbished Batteries.	Unknown	**Recommendation A14: Confirm BESS will consist of new batteries or will meet the requirements of NFPA 855:2023 Section 9.2.4.**

NFPA 855 Reference	Potential Gap/s	Comment
9.3.2 Outdoor Installations. Outdoor ESS installations shall be classified as follows: (1) Remote locations: ESS located more than 100 ft (30.5 m) from buildings, lot lines that can be built upon, public ways, stored combustible materials, hazardous materials, high-piled stock, and other exposure hazards not associated with electrical grid infrastructure (2) Locations near exposures: all outdoor ESS locations that do not comply with remote outdoor location requirements (3) Specific outdoor locations, as follows: (1) Rooftop installations: ESS installations located on the roofs of buildings (2) Open parking garage installations: ESS installations located in a structure or portion of a structure as defined in 3.3.19 (3) Mobile ESS installations	Unknown	It would be desirable to minimise the infrastructure costs to have the Location Classification set as *Outdoor Installations - Remote locations*. **Recommendation A15: Ensure BESS container layout achieves a more than 30.5 m separation from any exposure hazards.**
9.4.1 Maximum Stored Energy	No Gap Identified	Outdoor location, not near any exposure.
9.4.2 Size and Separation	Unknown	**See Recommendation A12.**
9.5.1.2.1 Occupied Work Centres	No Gap Identified	BESS containers are not occupied work centres.
9.5.2 Outdoor Installations	Unknown	Detailed engineering for the project has not commenced, and the battery supplier for the BESS has not been selected. There will be some iterative detailed design. This section does provide a useful check of the requirements.

NFPA 855 Reference	Potential Gap/s	Comment
9.5.2.2 Vegetation Control	No Gap Identified	Asset Protection Zones as identified as bushfire mitigation measures in the EIS meet this requirement.
9.5.2.3 Walk-in Units	No Gap Identified	BESS containers are not occupied work centres.
9.5.2.4 Maximum Size 9.5.2.4.1 Outdoor walk-in containers or enclosures housing ESS shall not exceed 53 ft x 8.5 ft x 9.5 ft (16.2 m x 2.6 m x 2.9 m), not including HVAC and other equipment.	No Gap Identified	BESS containers are 5.960 m x 2.358 m x 2.9 m. (Standard 20' container)
9.5.2.5 Remote Locations. When agreeable with the ESS owner and approved by the AHJ, fire suppression systems and water supply shall not be required.	Unknown	A permanent source of water for fire protection may not be required if a Location Classification of Outdoor Installations - Remote locations is achieved. **See Recommendation A15.**
9.5.2.6.1 Clearances to Exposures ESS located outdoors shall be separated by a minimum of 10 ft (3 m) from the following exposures: (1) Lot lines (2) Public ways (3) Buildings (4) Stored combustible materials (5) Hazardous materials (6) High-piled stock (7) Other exposure hazards not associated with electrical grid infrastructure	Unknown	Detailed engineering for the project has not commenced, and the battery supplier for the BESS has not been selected. There will be some iterative detailed design. This section does provide a useful check of the requirements. Compliance to relevant industry standards Identified as mitigation in the EIS, including a Bushfire Management Plan. BESS plot and Southern O&M plot are adjacent. **Recommendation A16: To achieve a Location Classification of *Outdoor Installations - Remote locations*, ensure nearest BESS container to southern O&M building will be separated by a minimum 30.5 m. See also Recommendation A15.**

NFPA 855 Reference	Potential Gap/s	Comment
9.5.2.6.1.6 ESS exhaust outlets shall comply with the following: (1) Exhaust outlets from an ESS that exhaust other than ventilation air shall be located at least 15 ft (4.57 m) from heating, ventilating, and air conditioning (HVAC) air intakes, windows, doors, loading docks, ignition sources, and other openings into buildings and facilities. (2) Exhaust outlet(s) from an ESS shall not be directed onto means of egress, walkways, or pedestrian or vehicular travel paths.	Unknown	Detailed engineering for the project has not commenced, and the battery supplier for the BESS has not been selected. There will be some iterative detailed design. This section does provide a useful check of the requirements. Unclear whether containers have or need fire/explosion venting. See 9.6.5.6 Explosion Control. **Recommendation A17: Confirm BESS layout complies with the requirements of NFPA 855 Section 9.5.2.6.1.6.**
9.5.2.6.1.7 Means of Egress Separation. (A) ESS located outdoors shall be separated from any accessible means of egress as required by the AHJ to ensure safe egress under fire conditions but in no case less than 10 ft (3 m). (B) Where approved by the AHJ, clearances to accessible means of egress shall be permitted to be reduced to 3 ft (0.9 m) where fire and explosion testing in accordance with 9.1.5 demonstrates that a fire within the ESS will not adversely impact the means of egress.	Unknown	Detailed engineering for the project has not commenced, and the battery supplier for the BESS has not been selected. There will be some iterative detailed design. This section does provide a useful check of the requirements. **Recommendation A18: Confirm that the means of egress from the BESS layout comply with NFPA 855 Section 9.5.2.6.1.7 or other relevant Australian Standards if they exceed the requirements of NFPA 855.**
9.6.2.1 Fire control and suppression for rooms or areas within buildings and outdoor walk-in units containing ESS shall be provided in accordance with Section 4.9, unless modified by this chapter.	Unknown	Detailed engineering for the project has not commenced, and the battery supplier for the BESS has not been selected. There will be some iterative detailed design. This section does provide a useful check of the requirements. **Recommendation A19: Confirm that BESS fire control and suppression comply with NFPA 855 Section 9.6.2.1 or other relevant Australian Standards if they exceed the requirements of NFPA 855.**

NFPA 855 Reference	Potential Gap/s	Comment
9.6.3.1 Sites where nonmechanical ESS are installed shall be provided with a permanent source of water for fire protection in accordance with 4.9.4, unless modified by this chapter.	Unknown	A permanent source of water for fire protection may not be required if a Location Classification of Outdoor Installations - Remote locations is achieved. **See 9.5.2.5, Recommendations A15 and A16.**
9.6.5.1 Exhaust Ventilation During Normal Operation. Where required by Table 9.6.5 or elsewhere in this standard, exhaust ventilation during normal operation shall be provided for rooms, enclosures, walk-in units, and cabinets as follows: (1) ESS rooms and walk-in units shall use mechanical exhaust ventilation in accordance with 9.6.5.1.5. (2) Outdoor ESS cabinets shall use either mechanical or natural exhaust ventilation in accordance with 9.6.5.1.4 or 9.6.5.1.5.	Unknown	Detailed engineering for the project has not commenced, and the battery supplier for the BESS has not been selected. There will be some iterative detailed design. This section does provide a useful check of the requirements.
9.6.5.1.4 Natural Exhaust Ventilation. Exhaust ventilation shall be designed to limit the maximum concentration of flammable gas to 25 percent of the lower flammable limit (LFL) of the total volume of the outdoor cabinet during the worst-case event of simultaneous “boost” charging of all the batteries, in accordance with nationally recognized standards.	No Gap Identified	Detailed engineering for the project has not commenced, and the battery supplier for the BESS has not been selected, however Mechanical Exhaust Ventilation is expected.

NFPA 855 Reference	Potential Gap/s	Comment
9.6.5.1.5 Mechanical Exhaust Ventilation. Exhaust ventilation shall be provided in accordance with the applicable mechanical code and one of the following: (1) Where hydrogen is the gas generated, an exhaust ventilation rate based on hydrogen generation estimates sufficient to limit the maximum concentration of hydrogen to 1.0 percent of the total volume of the room, walk-in unit, or cabinet during the worst-case event of simultaneous "boost" charging of all the batteries, in accordance with nationally recognized standards (2) An exhaust ventilation rate based on the area of not less than 1 ft3/min/ft2 (5.1 L/sec/m2) of floor area of the room, walk-in unit, enclosure, container, or cabinet	Unknown	Detailed engineering for the project has not commenced, and the battery supplier for the BESS has not been selected. There will be some iterative detailed design. This section does provide a useful check of the requirements. **Recommendation A20: Confirm that BESS Mechanical Exhaust Ventilation complies with NFPA 855 Section 9.6.5.1.5 and its subsections.**
9.6.5.1.5.1 Mechanical exhaust ventilation shall be either continuous or activated by a gas detection system in accordance with 9.6.5.1.5.4.	Unknown	Detailed engineering for the project has not commenced, and the battery supplier for the BESS has not been selected. There will be some iterative detailed design. This section does provide a useful check of the requirements. **See Recommendation A20.**
9.6.5.1.5.2 Required mechanical exhaust ventilation systems shall be installed in accordance with the manufacturer's installation instructions and local building, mechanical, and fire codes.	Unknown	Detailed engineering for the project has not commenced, and the battery supplier for the BESS has not been selected. There will be some iterative detailed design. This section does provide a useful check of the requirements. **See Recommendation A20.**

NFPA 855 Reference	Potential Gap/s	Comment
9.6.5.1.5.3 Required mechanical exhaust ventilation systems shall either be supervised by an approved central, proprietary, or remote station service in accordance with NFPA 72 or initiate an audible and visual signal at an approved, constantly attended location.	Unknown	Detailed engineering for the project has not commenced, and the battery supplier for the BESS has not been selected. There will be some iterative detailed design. This section does provide a useful check of the requirements. **See Recommendation A20.**
9.6.5.1.5.4 Where gas detection is used to activate exhaust ventilation in accordance with 9.6.5.1.5.1, rooms, walk-in units, enclosures, walk-in containers, and cabinets containing ESS shall be protected by an approved continuous gas detection system that complies with the following: (1) The gas detection system shall be designed to activate the mechanical exhaust ventilation system when the level of flammable gas detected in the room, walk-in unit, enclosure, container, and cabinet exceeds 25 percent of the LFL of the flammable gas mixture. (2) The mechanical exhaust ventilation system shall remain on until the flammable gas detected is less than 25 percent of the LFL of the flammable gas mixture. (3) The gas detection system shall be provided with a minimum of 2 hours of standby power. (4) Failure of the gas detection system shall annunciate a trouble signal at an approved central, proprietary, or remote station in accordance with NFPA 72 or at an approved, constantly attended location.	Unknown	Detailed engineering for the project has not commenced, and the battery supplier for the BESS has not been selected. There will be some iterative detailed design. This section does provide a useful check of the requirements. **See Recommendation A20.**

NFPA 855 Reference	Potential Gap/s	Comment
9.6.5.2.6 Rooms, buildings, or areas containing other hazardous materials shall include spill control as required in NFPA 1.	Unknown	Detailed engineering for the project has not commenced. **Recommendation A21: Include appropriate spill control to Australian Standards where required.**
9.6.5.5 Thermal Runaway Protection. Where required by Table 9.6.5, a listed device evaluated as part of the ESS or other approved method shall be provided to manage charging and discharging during normal operation of the ESS to maintain batteries and capacitors within their safe operating parameters and preclude thermal runaway. 9.6.5.5.2 Thermal runaway protection shall be permitted to be provided by the battery management system or a capacitor ESS management system that has been evaluated as part of the UL 1973 or UL 9540 listing.	Unknown	Detailed engineering for the project has not commenced, and the battery supplier for the BESS has not been selected. There will be some iterative detailed design. This section does provide a useful check of the requirements. **Recommendation A22: Confirm that BESS Thermal Runaway Protection complies with NFPA 855 Section 9.6.5.5 and its subsections.**
9.6.5.6 Explosion Control 9.6.5.6.1 Where required elsewhere in this standard, explosion prevention or deflagration venting shall be provided in accordance with this section.	Unknown	Detailed engineering for the project has not commenced, and the battery supplier for the BESS has not been selected. There will be some iterative detailed design. This section does provide a useful check of the requirements. **Recommendation A23: Confirm that BESS Explosion Control complies with NFPA 855 Section 9.6.5.6 and its subsections.**
9.6.6 Remediation Measures	Not currently applicable	Detailed engineering for the project has not commenced, and the battery supplier for the BESS has not been selected. There will be some iterative detailed design. This section does provide a useful check of the requirements. **Recommendation A24. Ensure the relevant requirements of NFPA 855 Section 9.6.6 are included in the Emergency Response Plan.**

NFPA 855 Reference	Potential Gap/s	Comment
14 Storage of Lithium Metal or Lithium-ion Batteries	Unknown	Detailed engineering for the project has not commenced. **Recommendation A25: Confirm allowed storage of Lithium Metal or Lithium-ion Batteries at the site. Confirm the storage meets the recommendations of NFPA 855 Section 14.**