# Appendix L

## Preliminary hazard analysis addendum

EMM
creating opportunities

# REPORT

# PHA ADDENDUM

# INCREASED BESS CAPACITY

# BIRRIWA SOLAR AND BATTERY PROJECT

# EMM CONSULTING PTY LTD

| | |
|---|---|
| **DOCUMENT NO:** | **22009-RP-001** |
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|---|---|
| **Title:**<br>**Report**<br>**PHA Addendum**<br>**Increased BESS Capacity**<br>**Birriwa Solar and Battery Project** | **QA verified:**<br>T. Malem<br><br>**Date:** 14-May-2025 |

# SUMMARY


ACEN Australia Pty Ltd (ACEN) have approval to develop the Birriwa Solar and Battery Project (SSD-29508870) (the approved project). ACEN is seeking approval to modify the development consent to increase the storage capacity and duration of the BESS from up to approximately 600 MW for a two-hour duration (600 MW/1200 MWh) up to approximately 900 MW for a four-hour duration (900 MW/3600 MWh). EMM Consulting Pty Ltd (EMM) are supporting ACEN with the modification application. Sherpa Consulting Pty Ltd (Sherpa) have been engaged to prepare this addendum to the approved project's 2022 Preliminary Hazard Analysis (PHA), Ref [1], to cover the proposed BESS modification.

The study scope is limited to the proposed modification associated with the project's BESS (i.e. increased battery storage). The 2022 PHA assessed a centralised BESS with capacity of up to 1000 MW/1000 MWh with 3 potential battery enclosure options (i.e. containerised, outdoor racks, indoor racks within building). For the PHA addendum the project has selected the containerised battery enclosure option with a storage capacity of up to 900 MW/3600 MWh.

The study objective was to assess and confirm that the risks associated with the proposed BESS modification would still comply with the NSW Department of Planning, Housing and Infrastructure (DPHI) Hazardous Industry Planning Advisory Paper (HIPAP) No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [2].

### Findings

The key study findings are as follows:

- Based on the consequence analysis for a battery unit on fire and the recommended setback to the development footprint boundary, the effects from a battery unit on fire are not expected to result in significant off-site impacts (i.e. serious injury due to heat radiation or irritation from toxic combustion products).
- The proposed BESS modification still complies with the HIPAP No.4 qualitative risk criteria.

### Recommendations

At the time of this study, the indicative layout of the operational infrastructure area and the location of the BESS compound within the area have not been finalised. This will be completed during detailed design stage. To minimise the potential for off-site impacts, based on the completed consequence analysis for a battery unit on fire Sherpa recommends providing a minimum setback of 24 m between the development footprint boundary and the closest battery unit.

Upon any significant modifications made to the project's design, the PHA should be reviewed and updated as required to ensure that the aspects considered (e.g. control measures, clearances between battery units, separation distance to off-site receptors) and assessments made in this report are still valid. Similarly, once the project's design is finalised and the battery OEM is selected, the PHA should be revisited and updated as required.

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## TABLES



## FIGURES

## ABBREVIATIONS

| | |
|---|---|
| AEGL | Acute Exposure Guideline Level |
| AS | Australian Standard |
| BESS | Battery Energy Storage System |
| CWO-REZ | Central West Orana Renewable Energy Zone |
| DG | Dangerous Goods |
| DPHI | Department of Planning, Housing and Infrastructure |
| EIS | Environmental Impact Statement |
| ha | Hectare |
| HAZID | Hazard Identification |
| HF | Hydrogen Fluoride |
| HIPAP | Hazardous Industry Planning Advisory Paper |
| HVAC | Heating Ventilation Air Conditioning |
| kV | Kilovolt |
| $kW/m^2$ | Kilowatts per metres squared |
| LGA | Local Government Area |
| MW | Megawatt |
| MWh | Megawatt hours |
| NSW | New South Wales |
| O&M | Operations and Maintenance |
| OEM | Original Equipment Manufacturer |
| PCU | Power Conversion Unit |
| PHA | Preliminary Hazard Analysis |
| PV | Photovoltaic |
| SSD | State Significant Development |
| UL | Underwriters' Laboratories |

## TERMINOLOGY

| Term | Definition |
|---|---|
| Consequence | Outcome or impact of a hazardous incident, including the potential for escalation. |
| Development footprint | The area to be developed within land where ACEN holds landholder agreements. All operational components of the project will be within the development footprint. |
| Non-associated residences | A dwelling that is not associated with the project, with no landholder agreement with ACEN. |
| Off-site | Areas extending beyond the development footprint boundary. |
| Project | Birriwa Solar and Battery Project |
| Proponent | ACEN Australia (ACEN) |
| Risk | The likelihood of a specified undesired event occurring within a specified period or in specified circumstances. It may be either a frequency (the number of specified events occurring in unit time) or a probability (the probability of a specified event following a prior event), depending on the circumstances. |

# 1. INTRODUCTION

## 1.1. Background

ACEN Australia Pty Ltd (ACEN) have approval to develop the Birriwa Solar and Battery Project, a large scale solar photovoltaic (PV) electricity generation facility along with battery storage and associated infrastructure, including the construction of a temporary accommodation facility (the approved project). The solar component of the approved project will have an indicative capacity of around 600 MW. The approved project includes a centralised Battery Energy Storage System (BESS) with capacity of up to 600 MW/1200 MWh. The project is a State Significant Development (SSD) and was approved on 16 August 2024 (SSD-29508870) by the NSW Independent Planning Commission, with development consent conditions.

The project site is approximately 15 km south-east of Dunedoo, in the Central West Orana region of New South Wales (NSW), in the localities of Birriwa and Merotherie. It is situated within the Mid-Western Regional Local Government Area (LGA). Part of the transport access route to the approved project site is via the Castlereagh Highway, which is situated within the Warrumbungle Shire LGA. The project is within the CWO Renewable Energy Zone (REZ).

ACEN is seeking approval to modify the development consent to:

1. Increase the project area and development footprint to include three additional lots (Lot 11/DP 750755, Lot 40/DP 750755, Lot 60/DP 750755) and the remaining part of Lot 34/DP 750755, allowing for additional land to be used for solar generation, BESS, and associated ancillary infrastructure, as needed.
2. Increase the storage capacity and duration of the BESS from up to approximately 600 MW for a two-hour duration up to approximately 900 MW for a four-hour duration. Modifying the project area and development footprint across additional neighbouring lots will enable flexibility in design and construction, optimisation of the solar array layout, and will allow sufficient space for maintenance. The additional capacity will allow the project to increase its energy storage potential, providing additional firming support and greater network system strength.
3. Increase the project area and development footprint to allow for an upgrade to part of the existing Birriwa Bus Route South Road from the Golden Highway via Merotherie Road as secondary access route including a public road crossing. This upgrade will enable access to the project for the purpose of constructing and operating the approved temporary accommodation facility, construction, operation and maintenance of the BESS and EnergyCo's infrastructure associated with the project. Note, oversize over-mass vehicles will continue to access the project area, via the primary access point.

4. Increase the approved project's accommodation facility capacity from 500 workers to 650 workers, within the approved accommodation footprint (up to an additional 150 workers will reside at the accommodation facility in peak construction periods).
5. Amend the schedule of land to include three additional neighbouring lots.

EMM Consulting Pty Ltd (EMM) are supporting ACEN with the modification application. Sherpa Consulting Pty Ltd (Sherpa) on behalf of EMM and ACEN have been engaged to prepare an addendum to the approved project's Preliminary Hazard Analysis (PHA), Ref [1], to cover the proposed BESS modification.

This document is prepared as an addendum to the PHA. For context, methodology on the PHA and detailed information on the BESS, refer to the 2022 PHA, Ref [1].

## 1.2. Scope

The study scope is limited to the proposed modification associated with the project's BESS (i.e. increased battery storage).

The 2022 PHA was prepared for input to the project's Environmental Impact Statement (EIS) and assessed a centralised BESS with capacity of up to 1000 MW/1000 MWh with 3 potential battery enclosure options (i.e. containerised, outdoor racks, indoor racks within building). For the modification, only the containerised battery enclosure option was considered and assessed.

## 1.3. Objectives

The overall study objective was to assess and confirm that the risks associated with the proposed BESS modification would still comply with the NSW Department of Planning, Housing and Infrastructure (DPHI) Hazardous Industry Planning Advisory Paper (HIPAP) No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [2].

Specifically, the following activities were completed:

- Review of potential impact to onsite and off-site receptors.
- Verify that the proposed increase in BESS capacity would be able to fit within the land area designated accounting for separation distances between the:
  - BESS sub-units (e.g. battery units, inverters, transformers) ensuring that a fire from a sub-unit do not propagate to neighbouring sub-units; and
  - The overall BESS and other onsite or off-site receptors.
- Assess the risk against HIPAP No. 4 criteria.

## 1.4. Exclusions, assumptions and limitations

The exclusions and limitations that apply to this report are summarised in Table 1.1.

**Table 1.1: Exclusions and limitations**

| Item | Scope area | Exclusions and limitations |
|---|---|---|
| 1 | Study basis | The number of battery units and Power Conversion Unit (PCU) skids, and area required for the proposed BESS capacity was estimated from the Birriwa Energy Storage System Design Considerations Report, Ref [3]. |
| 2 | Design elements for the BESS | Design elements for the BESS may be subject to change prior to construction. Sherpa notes that the selection of the battery Original Equipment Manufacturer (OEM) and layout of the battery units and associated equipment within the BESS area will be finalised during detailed design. Detailed design will be conducted upon project approval. |
| 3 | Knock-on effects and cumulative risk impacts | This study excludes assessment of:<br>• Knock-on effects from existing and/or proposed developments in the area.<br>• Cumulative risk impacts to off-site receptors from the project operating in conjunction with existing and/or proposed developments in the area. |
| 4 | Fire Safety Study | The PHA does not constitute a Fire Safety Study. Requirement for a Fire Safety Study will be subject to the conditions of consent of the modification application approval. For more information, refer to HIPAP No. 2 *Fire Safety Study*. |

# 2. PROPOSED MODIFICATION

## 2.1. Overview

A detailed description of the proposed modification is provided in the Birriwa Solar and Battery Project - Modification Report (EMM Consulting, 2025). Description of the proposed modification included in the following sections relates to the proposed modification associated with the BESS only (i.e. item 2 listed in Section 1.1).

An overview of the approved project and modification area is shown in Figure 2.1.

## 2.2. BESS

Two location options were previously considered for the operational infrastructure area (i.e. locations A and B) within the approved project (Figure 2.1). For the modification, the BESS is proposed to be constructed within operational infrastructure area B. To accommodate the increased BESS capacity, the operational infrastructure area B has been extended to include the adjacent Lot 34, as shown in Figure 2.2.

Dwelling A4 (part of Lot 34) is associated with the project, allowing the overall available area to be developed for the project. It is uninhabited and currently used as a temporary office for the CWO-REZ construction site.

The Birriwa Energy Storage System Design Considerations Report, Ref [3], which was used to inform the PHA for the approved project, Ref [1], included sizing and configuration for a containerised battery enclosure option with 1000 MW power with up to 4-hour energy storage (i.e. 1000 MW/4000 MWh[1]). The report was also used as input to the assessment made in this study.

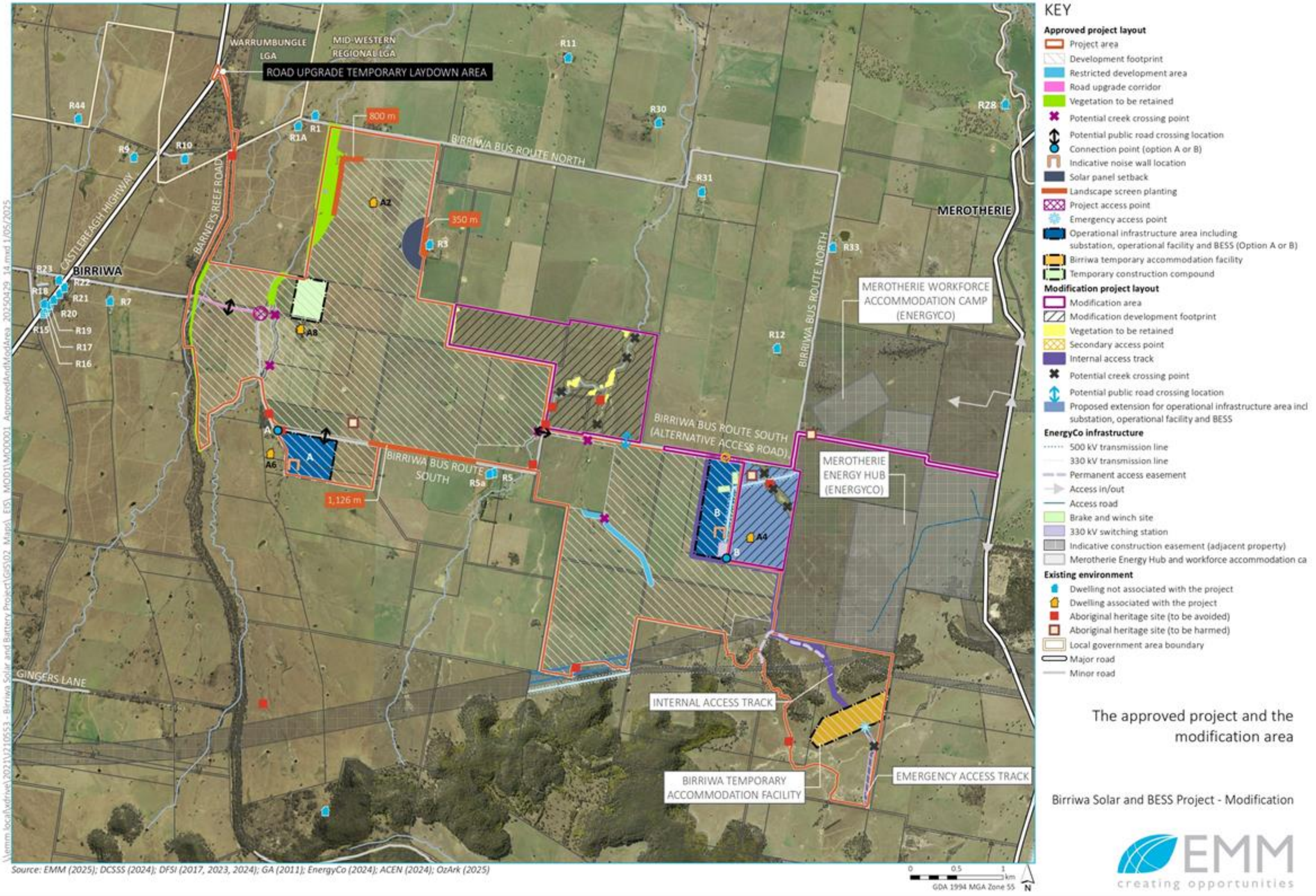
An overview of the containerised battery enclosure option including the dimension and capacity for each unit, the number of units required is provided in Table 2.1.

**Table 2.1: Overview – Containerised BESS**

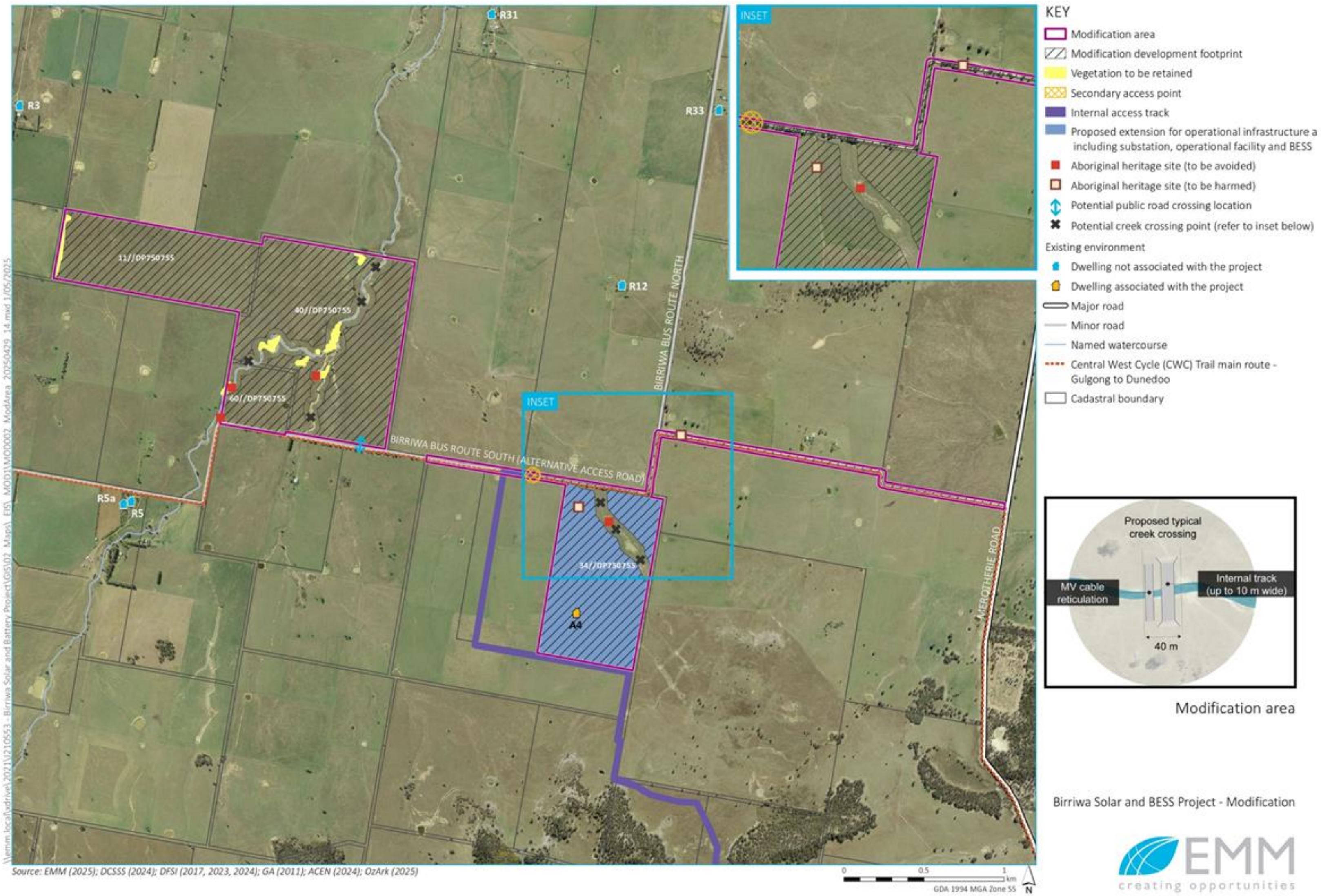
| | Description |
|---|---|
| Overview | Battery racks assembled in 40-foot ISO High Cube Container, with externally mounted Heating Ventilation Air Conditioning (HVAC) system. |
| Dimension | L12,190 mm x W2,440 mm x H2,990 mm (plus HVAC units on both ends). |
| Capacity | Each container is rated for 4.6 MW/4.6 MWh. |
| No of units required for the capacity | For the proposed 900 MW/3600 MWh BESS, it is estimated that the following number of units will be required:<br>• Battery containers: 966<br>• Power Conversion Unit (PCU) skids: 268. |

[1] This exceeds the proposed modification capacity of 900 MW/3600 MWh.

# Figure 2.1: Approved project and modification area



# Figure 2.2: Modified operational infrastructure area B



# 3. METHODOLOGY

## 3.1. Overview

The following steps were completed for this study:

- Identify events with the potential for off-site impact.
- Undertake consequence modelling to understand the potential impact. In the 2022 PHA, potential impacts were determined qualitatively based on the separation distance to nearest off-site receptors, the consequence have been quantified in 2025 to reflect an increased understanding of battery fires.
- Review of potential impact to onsite and off-site receptors.
- Verify that the proposed BESS capacity would be able to fit within the land area designated accounting for separation distances between the:
  - BESS sub-units (battery units, inverters, transformers) ensuring that a fire from a sub-unit does not propagate to neighbouring sub-units; and
  - The overall BESS and other onsite or off-site receptors.
- Assess the risk against HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*.

The project's development footprint boundary was used to define and determine off-site impact (i.e. impact extending outside of this boundary).

## 3.2. Study basis and assumptions

The study basis and assumptions are presented in Table 3.1.

**Table 3.1: Study basis and assumptions**

| Item | Description |
|---|---|
| Basis | • There is no change to the containerised battery enclosure option assessed in the 2022 PHA (i.e. the same containerised battery was assessed for the proposed modification).<br>• There is no change to the Hazard Identification (HAZID) completed as part of the 2022 PHA. The HAZID for lithium-ion batteries remains valid.<br>• Aside from the increased lithium-ion batteries, there is no change to the Dangerous Goods (DG) stored/ used on site.<br>• The location considered for the BESS compound is within operational infrastructure area B (extending into the remaining Lot 34) shown in Figure 5.1. |
| Assumptions | As the indicative layout for the proposed 900 MW/3600 MWh capacity showing the configuration and clearances between the BESS sub-units was not available, the required area to accommodate all BESS sub-units was conservatively assumed to be the same as that required for a 1000 MW/ 4000 MWh capacity, which was considered in the Birriwa Energy Storage System Design Considerations Report, Ref [3].<br>Note: The Birriwa Energy Storage System Design Considerations Report which was used to inform the PHA for the approved project, Ref [1], was also used as input to the assessment made in this study. |

# 4. CONSEQUENCE ANALYSIS

## 4.1. Overview

To inform the risk assessment, consequence analysis was undertaken for events with the potential to result in propagation and/or off-site impact. The scope of the consequence analysis is shown in Table 4.1. The analysis results were used to determine the potential impacts to off-site receptors.

Fire involving the BESS transformer (part of the PCU skid) was not modelled. Per the Birriwa Energy Storage System Design Considerations Report, Ref [3], the minimum clearances for outdoor transformers to other transformers/equipment and buildings will be in accordance with OEM recommendation and/or AS 2067:2016 *Substations and high voltage installations exceeding 1 kV*, Ref [4].

**Table 4.1: Consequence analysis scenarios**

| BESS infrastructure | Scenario | Consequence | Analysis method |
|---|---|---|---|
| Battery unit | Single battery unit – thermal runaway (pre-ignition) | Toxic gas generated from decomposition of battery electrolyte | Qualitative (Section 4.2) |
| | | Accumulation and ignition of flammable vapours inside a battery unit | |
| | Single battery unit – fully developed fire | Heat radiation | Quantitative (Section 4.3) |
| | | Toxic products of combustion | |

## 4.2. Battery thermal runaway (pre-ignition)

In a thermal runaway event, decomposition of the battery electrolyte may result in generation of flammable and toxic gases. The conditions under which flammable and toxic gases may be generated are typically informed by testing in accordance with UL 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*, or an equivalent test standard (i.e. large-scale fire test).

At the time of this study:

- ACEN has not made a final decision on the battery OEM. Selection of the battery OEM will be finalised during detailed design, which will be conducted upon project approval.
- The UL 9540A test reports for the selected containerised battery enclosure option were not available and the composition of vented gas from battery thermal runaway is not known. As such, dispersion of toxic gas generated from decomposition of battery electrolyte was not modelled.

Per the 2022 PHA, it is assumed that the battery system meets the safety performance requirements of the UL 9540A unit-level test, which typically include the following observations:

- Module to module propagation was not observed.
- No flying debris or explosive discharge of gases observed during test.
- No sparks, electrical arcs, or other electrical events observed during test.
- No external flaming was observed during test.

## 4.3. Battery unit on fire

Consequence analysis of a battery unit on fire (i.e. propagated battery thermal runaway resulting in a fully developed fire) was completed to determine the potential impacts to off-site receptors. The following consequences were modelled:

1. Heat radiation impact from the fire.
2. Toxic gas generation from decomposition of battery electrolyte due to fire. For lithium-ion batteries, there is a potential for hydrogen fluoride (HF) to be formed following electrolyte decomposition from a battery fire event. In this study, dispersion of HF was modelled to determine the impact to receptors. The following Pasquill weather stability and wind conditions were used for the dispersion modelling:
   a. Typical day condition: Neutral (Class D) and wind speed of 5 m/s (D5).
   b. Typical night condition: Very stable (Class F) and wind speed of 2 m/s (F2).

### 4.3.1. Heat radiation criteria

Consequences of various heat radiation levels in accordance with HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [2]. Table 4.2 presents the heat radiation levels and their effects and notes the criteria adopted in this study.

**Table 4.2: Heat radiation criteria**

| Heat radiation ($kW/m^2$) | Effect | Study criteria |
|---|---|---|
| 1.2 | Received from the sun at noon in summer | Not used |
| 2.1 | Minimum to cause pain after 1 minute | Not used |
| 4.7 | Will cause pain in 15-20 seconds and injury after 30 seconds' exposure (at least second-degree burns will occur) | Injury |
| 12.6 | • Significant chance of fatality for extended exposure. High chance of injury.<br>• Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure.<br>• Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure. | Fatality |

| Heat radiation ($kW/m^2$) | Effect | Study criteria |
|---|---|---|
| 23 | • Likely fatality for extended exposure and chance of fatality for instantaneous exposure.<br>• Spontaneous ignition of wood after long exposure.<br>• Unprotected steel will reach thermal stress temperature which can cause failure.<br>• Pressure vessels need to be relieved, or failure would occur. | Escalation to adjacent equipment |
| 35 | • Cellulosic material will ignite within one minute's exposure.<br>• Significant chance of fatality for people exposed instantaneously. | Not used |

### 4.3.2. Toxic gas dispersion criteria

The Acute-Exposure Guideline Level (AEGL) concentration levels (60-minute exposure) for HF are presented in Table 4.3. These concentrations were used to inform harm levels following exposure (irritation, injury and fatality).

**Table 4.3: AEGL levels for HF (60-minute)**

| AEGL level | Health effects | Concentration (ppm) |
|---|---|---|
| AEGL-1 | Irritation threshold | 1 |
| AEGL-2 | Injury threshold | 24 |
| AEGL-3 | Life-threatening health effects threshold (fatality) | 44 |

### 4.3.3. Results

The modelling results for heat radiation and toxic gas dispersion impacts are presented in Table 4.4 and Table 4.5, respectively. The modelling approach, input parameters and assumptions are detailed in APPENDIX A.

A summary of the analysis results is as follows:

- Heat radiation impact: the distance to the injury level (4.7 $kW/m^2$) was used to determine potential for off-site impact, which is approximately 18 m.
- Dispersion of toxic products of combustion (HF): the distances to Acute Exposure Guideline Level (AEGL) thresholds for injury (AEGL-2) and irritation (AEGL-1) at D5 condition are 12 m and 24 m, respectively. For the plume rise from fire model, further downwind distance was observed at the D5 condition compared to F2 condition. As a conservative approach, the distance to the irritation level (AEGL-1) at D5 condition was used to determine potential for off-site impact, i.e. 24 m.

For a battery unit on fire scenario, the impact distance is approximately 24 m accounting for both heat radiation and dispersion of toxic product of combustion. This was used to determine potential for off-site impact based on separation distance to the nearest development footprint boundary. A review of the separation distances from the BESS compound to the development footprint boundary and nearest off-site receptors is provided in Section 5.

**Table 4.4: Battery unit on fire – heat radiation impact**

| Battery enclosure | Size – largest face of battery compartment (L x H, mm) | Distance (m) at receptor height (1.5 m) to heat radiation levels | | |
|---|---|---|---|---|
| | | 23 $kW/m^2$ (structural failure) | 12.6 $kW/m^2$ (fatality) | 4.7 $kW/m^2$ (injury) |
| Containerised (40-ft container) | 12,190 x 2,990 | 7 | 10 | 18 |

**Table 4.5: Battery unit on fire – toxic dispersion impact (HF)**

| Battery enclosure | Capacity per unit (MWh) | HF generation rate (kg/s) | Wind weather stability | Distance (m) at receptor height (1.5 m) to AEGL levels | | |
|---|---|---|---|---|---|---|
| | | | | AEGL-1 (irritation) | AEGL-2 (injury) | AEGL-3 (fatality) |
| Containerised (40-ft container) | 4.6 | 0.26 | D5 | 24 | 12 | 9 |
| | | | F2 | 4 | 3 | 3 |

# 5. BESS SEPARATION DISTANCES

## 5.1. Overview

In addition to demonstrating that the fire risks from the BESS can comply with the DPHI HIPAP No. 4 land use safety planning risk criteria, PHAs for renewable energy projects with a BESS facility with capacity exceeding 30 MW include an additional requirement to 'consider all recent standards and codes and verify the separation distances to onsite or off-site receptors to prevent fire propagation'. This requirement is intended to ensure that fire risks from the BESS have been considered in the design. Specifically, the Applicant must demonstrate that the proposed BESS capacity would be able to fit within the designated land area accounting for separation distances between:

- The BESS sub-units (e.g. battery units, PCUs, transformers), to ensure that a fire from a sub-unit does not propagate to neighbouring sub-units.
- The BESS and other onsite or off-site receptors.

This section covers the following:

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

## 5.2. Clearances between BESS sub-units

Per the Birriwa Energy Storage System Design Considerations Report, Ref [3]:

- The OEM-specified minimum clearances between the battery enclosure and other equipment are defined based on the outcome of the UL 9540A test. The additional clearances for battery enclosures are included based on the OEM recommendations for operability, or using AS 3000 and AS 2067 as a guide to operability requirements.
- For other equipment including the inverter and transformers, AS 3000 and AS 2067 are applied directly to determine minimum clearances. Where these minimum installation standards are met, clearances will be based on the recommended distances as described by the OEM.

The clearances for the BESS sub-units are shown in Table 5.1.

**Table 5.1: Summary of clearances for BESS[2]**

| Source | Target | Clearance (Safety) | Clearance (Recommended operability) | Comment | Reference |
|---|---|---|---|---|---|
| Battery container | Other battery racks<br>Non-combustible surfaces | 0.1-0.15 m | 1.9 m | Operability clearance includes door (1,300 mm) and access (600 mm). Access may be shared with adjacent containers. | • OEM specifications from two surveyed manufacturers.<br>• AS 3000:2018 accessibility requirement. |
| Integrated Power Conversion Unit | Any other equipment | 2 m | 2-4 m | - | • OEM specifications from three surveyed manufacturers. |
| Inverter or switchgear | Any other equipment | 2 m | 2-4 m | - | • OEM specifications from three surveyed manufacturers. |
| Transformer | Non-combustible equipment, including other transformers or fire-resistant building materials | 1 m | - | Applicable for:<br>• Oil insulated transformers with oil volume between 100-1000 L.<br>• Less-combustible liquid-insulated transformers with volume between 100-1000 L. | • AS 2067:2016 |
| Transformer | Combustible surfaces | 6 m | - | Applicable for:<br>• Oil insulated transformers with oil volume between 100-1000 L.<br>• Less-combustible liquid-insulated transformers with volume between 100-1000 L. | • AS 2067:2016 |
| All equipment | Perimeter fence | 10 m | 10 m | APZ (perimeter)<br>Allows semi-trailer turning with minimal clearance.<br>May include clearance required for adjacent equipment. | • Victorian Rural Fire Service (2022) Design Guidelines and Model Requirements for Renewable Energy Facilities.<br>• Austroads turning templates. |
| Internal roads | All other equipment | N/A | 10-16m | May include clearance required for adjacent equipment. | • Entura experience.<br>• Austroads turning templates. |

[2] Reproduced from Table 3.2 of the Birriwa BESS Design Considerations report, Ref [3].

## 5.3. Land area designated for the BESS

The BESS is proposed to be located within the operational infrastructure area B. At the time of this study, the indicative layout of the operational infrastructure area and the location of the BESS compound within the area have not been finalised. This will be completed during detailed design stage. As such, verification of whether the required area for the BESS would fit within the designated land area was performed by comparing the required area against the available area within operational infrastructure area B (expressed in % coverage).

The verification is summarised in Table 5.2. It was determined that the available area within operational infrastructure area B would be adequate to accommodate the proposed BESS capacity.

**Figure 5.1: Available area within operational infrastructure area B**

**Table 5.2: Land area required for the BESS**

| | Value | Remarks |
|---|---|---|
| Required land area, Ref [3] | 22.4 ha<br>(640 m x 350 m) | The land area required for the proposed BESS capacity (900 MW/3600 MWh) was conservatively assumed to be the same as that required for a 1000 MW/4000 MWh BESS, which is approximately 22.4 ha. ACEN confirmed that this land area includes the required clearances between the BESS sub-units<br>At the time of this study, the indicative layout showing the configuration and clearances between the BESS sub-units was not available and verification of the clearances was not carried out. |
| Available area within operational infrastructure area B | 56.2 ha | Refer to Figure 5.1. |
| % of operational infrastructure area B | 40% | There is remaining area available for other supporting infrastructure to be developed (e.g. Operations and Maintenance (O&M) building, warehouse, etc). |
| Fits the designated land area for the BESS (Y/N)? | Yes | - |

## 5.4. Impact to onsite receptors

The BESS will be located within the operational infrastructure area. The closest onsite receptors will be other project infrastructure located within the operational infrastructure area, which may include:

- an onsite substation
- staff office, amenities and meeting facilities
- O&M building
- workshop and spare parts storage facility.

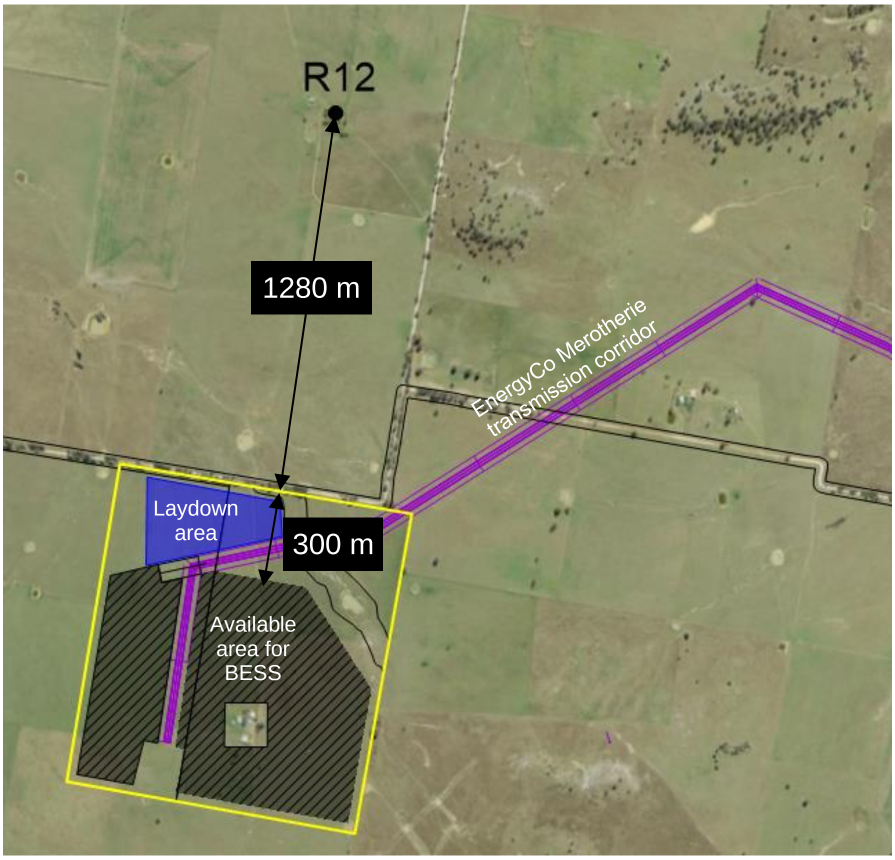
At the time of this study, the indicative layout of the operational infrastructure area (i.e. siting of the project infrastructure within this area is not known) and the location of the BESS compound within the area have not been finalised. This will be completed during detailed design stage. A minimum of 10 m APZ will be provided for all structures and associated buildings/ infrastructure, Ref [5].

## 5.5. Impact to off-site receptors

The BESS compound location within operational infrastructure area B has not been finalised. To minimise the potential for off-site impacts, based on the consequence analysis for a battery unit on fire Sherpa recommends providing a minimum setback of 24 m between the development footprint boundary and the closest battery unit.

A review of the separation distance from the potential BESS compound location to the nearest dwelling is shown in Figure 5.2. The nearest residence (R12) is at least 1.2 km away from the development footprint boundary. Off-site impact to the nearest residential dwelling is not expected based on the separation distance from the nearest battery unit.

**Figure 5.2: Separation distances to nearest offsite receptors**



# 6. RISK ASSESSMENT

Assessment against the HIPAP No. 4 qualitative land use planning risk criteria is provided in Table 6.1.

**Table 6.1: Assessment against HIPAP No. 4 qualitative risk criteria**

| HIPAP 4 qualitative criteria | Remarks | Complies? |
|---|---|---|
| *All 'avoidable' risks should be avoided. This necessitates the investigation of alternative locations and alternative technologies, wherever applicable, to ensure that risks are not introduced in an area where feasible alternatives are possible and justified.* | The separation distance from the closest battery unit to the development footprint boundary was used to determine off-site impact. Based on the completed consequence analysis for a battery unit on fire and the recommended setback to the development footprint boundary, the effects from a battery unit on fire are not expected to result in significant off-site impacts (i.e. serious injury due to heat radiation or irritation from toxic combustion products).<br>It is not possible to eliminate batteries from a BESS development. Selection of the battery technology is a balance of cost and availability with the most commonly used versions being lithium ion. | Yes |
| *The risk from a major hazard should be reduced wherever practicable, irrespective of the numerical value of the cumulative risk level from the whole installation. In all cases, if the consequences (effects) of an identified hazardous incident are significant to people and the environment, then all feasible measures (including alternative locations) should be adopted so that the likelihood of such an incident occurring is made very low. This necessitates the identification of all contributors to the resultant risk and the consequences of each potentially hazardous incident. The assessment process should address the adequacy and relevancy of safeguards (both technical and locational) as they relate to each risk contributor.* | Based on the completed consequence analysis for a battery unit on fire and the recommended setback to the development footprint boundary, the effects from a battery unit on fire are not expected to result in significant off-site impacts (i.e. serious injury due to heat radiation or irritation from toxic combustion products). | Yes |
| *The consequences (effects) of the more likely hazardous events (i.e. those of high probability of occurrence) should, wherever possible, be contained within the boundaries of the installation.* | Events with high probability of occurrence are expected to be contained within the boundaries of the project site.<br>Based on the completed consequence analysis for a battery unit on fire and the recommended setback to the development footprint boundary, the effects from a battery unit on fire are not expected to result in significant off-site impacts (i.e. serious injury due to heat radiation or irritation from toxic combustion products). | Yes |
| *Where there is an existing high risk from a hazardous installation, additional hazardous developments should not be allowed if they add significantly to that existing risk.* | There are no hazardous developments in the vicinity of the project site. | Yes |

# 7. CONCLUSION AND RECOMMENDATIONS

The study concludes that:

- Based on the completed consequence analysis and the recommended setback to the development footprint boundary, the effects from a battery unit on fire are not expected to result in significant off-site impacts (i.e. serious injury due to heat radiation or irritation from toxic combustion products).
- The proposed BESS modification still complies with the HIPAP No.4 qualitative risk criteria.

At the time of this study, the indicative layout of the operational infrastructure area and the location of the BESS compound within the area have not been finalised. This will be completed during detailed design stage. To minimise the potential for off-site impacts, based on the completed consequence analysis for a battery unit on fire Sherpa recommends providing a minimum setback of 24 m between the development footprint boundary and the closest battery unit.

Upon any significant modifications made to the project's design, the PHA should be reviewed and updated as required to ensure that the aspects considered (e.g. control measures, clearances between battery units, separation distance to off-site receptors) and assessments made in this report are still valid. Similarly, once the project's design is finalised and the battery OEM is selected, the PHA should be revisited and updated as required.

# APPENDIX A. BATTERY UNIT FIRE IMPACT ESTIMATION

## A1. Overview

Consequence analysis of a battery unit on fire was completed to determine the potential for off-site impacts. The following scenarios were analysed:

- A battery unit on fire (e.g. propagated thermal runaway resulting in a fully developed fire).
- Toxic gas generation from decomposition of battery electrolyte due to fire.

Impact distances associated with heat radiation due to fire and dispersion of toxic gas were estimated to determine potential for off-site impacts to off-site receptors.

This appendix summarises the consequence modelling approach, input, assumptions, and results.

## A2. Battery unit fire

### A2.1. Modelling approach

Consequence modelling was undertaken based on the Stefan-Boltzmann correlation to analyse the heat transfer effect between two parallel planes, simulating a battery enclosure on fire and the heat radiation exposure to a receptor, as shown in Figure B.1. Distances to heat radiation levels in accordance with HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*, Ref [2], were calculated.

To estimate the heat radiation generated from a battery enclosure on fire, the emitted heat flux was calculated using the Stefan-Boltzmann Law:

$$E_{emitted} = e\sigma T^4$$

where E is the radiant emittance, $e$ is the emissivity, $\sigma$ is the Stefan-Boltzmann constant and T is the surface temperature.

The heat flux received was estimated using the view factor method, where *d* is receiver distance to the battery enclosure on fire:

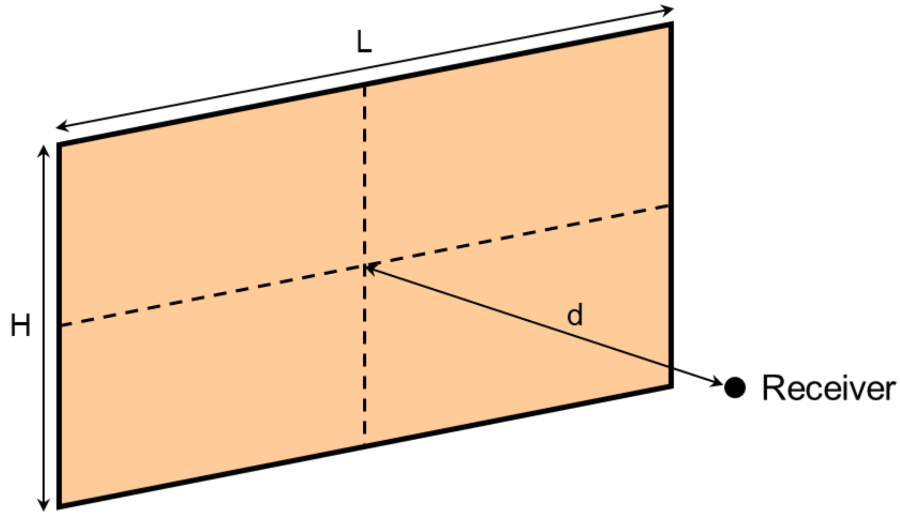
$$\emptyset = \frac{1}{2\pi}\left[\frac{a}{(1+a^2)^{1/2}}tan^{-1}\frac{b}{(1+a^2)^{1/2}} + \frac{b}{(1+b^2)^{1/2}}tan^{-1}\frac{a}{(1+b^2)^{1/2}}\right]$$

$$a = \frac{0.5\,H}{d}\,, a = \frac{0.5\,L}{d}$$

To calculate the heat radiation experienced by the receptor at height 1.5 m (approximately half of the battery enclosure height), the surface area of the battery enclosure (front aspect) is divided into 4 equal sections. Figure B.1 provides a graphical depiction of the parameters used in the calculation.

$$E_{received} = 4\,\emptyset\,E_{emitted}$$

Figure B.1: The graphical depiction of parameters (L, H, d)




## A2.2. Inputs and assumptions

The modelling input and assumptions used were as follows:

- The flame temperature of the emitting surface was set at 1000°C, which is a typical value for lithium metallic fires, Ref [6].
- An emissivity value of 0.9 was assumed (noting that a black body has an emissivity value of 1).
- Receptor height was set at 1.5 m.
- The heat radiation calculation was performed for the front aspect of the battery enclosure and assumed a full planar fire. This is conservative, as the front aspect has the largest surface area and, consequently, the highest heat radiation impact. This approach is deemed appropriate to determine off-site impacts.

## A2.3. Results

The distances to the specified heat radiation levels are presented in Table B.1. The distance to the injury level (4.7 kW/m$^2$) was found to be approximately 18 m. This distance was used to determine potential for off-site impact.

Table B.1: Battery unit on fire – Heat radiation impact

| Battery enclosure | Size – largest face of battery compartment (L x H, mm) | Distance (m) at receptor height (1.5 m) to heat radiation levels | | |
|---|---|---|---|---|
| | | 23 kW/m$^2$ (structural failure) | 12.6 kW/m$^2$ (fatality) | 4.7 kW/m$^2$ (injury) |
| Containerised (40-ft container) | 12,190 x 2,990 | 7 | 10 | 18 |

## A3. Dispersion of toxic gas

### A3.1. Modelling approach

In the event of a battery enclosure fire, there is a potential for toxic gas to be generated from (1) decomposition of the battery electrolyte, and/or (2) combustion products. For lithium-ion batteries, there is a potential for HF to be formed following electrolyte decomposition from a battery fire event. In this study, dispersion of HF was modelled to better understand its impact on receptors.

Consequence modelling was performed using the Gexcon EFFECTS v12.4.0 software (Plume Rise from Fire model) to simulate HF dispersion during a battery enclosure fire. The HF generation rate was based upon published experimental literature for lithium-ion batteries. The downwind distances to the AEGL concentrations for HF were determined.

### A3.2. Inputs and assumptions

The modelling input and assumptions used were as follows:

- Hydrogen fluoride is considered the most toxic decomposition products from the batteries fire, Ref [7].
- A lithium-ion battery cell experiment, Ref [7], indicates that the HF quantity released from a 1 Wh battery varies between 20 mg and 200 mg, depending on the battery type and state of charge. As a conservative approach, a generation rate of 200 kg per 1 MWh was adopted for the analysis. The HF generation rate was calculated based on the capacity a single battery enclosure and fire duration of 1 hour. The resulting HF generation rate used for analysis is conservative as typically the fire duration is longer than 1 hour.
- Release is continuous, with concentration averaging time of 60 minutes used for reporting.
- Surface roughness factor of 0.1 m was used (representing low crops and occasional large obstacles).
- The heat release rate from the battery (with 100% state of charge) is estimated to be 882 kW/m2, Ref [8].
- The plume was assumed to be released from the top of the battery enclosure. This is viewed as a reasonable approach, based on observation from recent BESS fire incidents (e.g. Victoria Big Battery fire).
- Receptor height was set at 1.5 m.
- Wind and weather stability conditions of D 5 m/s (D5) and F 2 m/s (F2) were used to represent typical day and night conditions, respectively.

### A3.3. Results

The distances to AEGL concentrations at receptor height of 1.5 m are presented in Table B.2. As a conservative approach, the maximum distance to the irritation level (AEGL-1) was used to determine potential for off-site impact. This was found to be 24 m at D5 conditions.

**Table B.2: Battery unit on fire – Toxic dispersion impact (HF)**

| Battery enclosure | Capacity per unit (MWh) | HF generation rate (kg/s) | Wind weather stability | Distance (m) at receptor height (1.5 m) to AEGL levels | | |
|---|---|---|---|---|---|---|
| | | | | AEGL-1 (irritation) | AEGL-2 (injury) | AEGL-3 (fatality) |
| Containerised (40-ft container) | 4.6 | 0.26 | D5 | 24 | 12 | 9 |
| | | | F2 | 4 | 3 | 3 |

# APPENDIX B. REFERENCES

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