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# Appendix D.4

Addendum PHA

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# REPORT

## PHA ADDENDUM

### INCREASED BESS CAPACITY

## SANDY CREEK SOLAR FARM AMENDMENT REPORT

### EMM CONSULTING PTY LTD

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<b>Title:</b> <b>Report</b> <b>PHA Addendum</b> <b>Increased BESS capacity</b> <b>Sandy Creek Solar Farm Amendment Report</b>	<b>QA verified:</b> M. Amouzegar
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## SUMMARY

Lightsource Development Services Australia Pty Ltd (Lightsource bp) is proposing to develop the Sandy Creek Solar Farm (the project). The project site is approximately 25 km south-west of Dunedoo, NSW, within the Central West Orana Renewable Energy Zone (CWO REZ). The project is a State Significant Development (SSD-41287735), and an Environmental Impact Statement (EIS) was submitted for assessment to the Department of Planning, Housing and Infrastructure (DPHI) as part of the Development Application (DA). A Preliminary Hazard Analysis (PHA) was prepared by Sherpa to support the EIS in 2023, Ref [1]. The PHA assessed a Lithium Iron Phosphate (LFP) based Battery Energy Storage System (BESS) with a capacity of up to 700 MW/2800 MWh (4 hours storage).

Lightsource bp is seeking approval to increase the BESS capacity for a maximum export capacity of up to 1400 MW<sub>AC</sub> with storage capacity not exceeding 7,600 MWh, which would be achieved via one of the following options:

- Option A: Centralised BESS with a maximum capacity of up to approximately 700 MW/6,048 MWh. A single BESS compound would be established adjacent to the project's substation on the eastern side of the development footprint.
- Option B: Decentralised BESS with a maximum capacity of up to approximately 700 MW/6,832 MWh. Up to 128 decentralised BESS locations would be established across the development footprint located adjacent to the photovoltaic (PV) modules. Each location would include up to 8 battery units. Approximately 10 locations would be subject to reduced equipment numbers to ensure compliance with the noise criteria.
- Option C: A combination of centralised BESS (up to 700 MW/6,048 MWh) and decentralised BESS (up to 700 MW/5,894 MWh), with a maximum overall capacity of up to approximately 1,400 MW/7,600 MWh when run simultaneously. Approximately 32 decentralised BESS locations would be subject to reduced equipment numbers and limits on operation to ensure compliance with the noise criteria.

Separate areas are allocated for the centralised and decentralised BESS. For all options, the design is based on a modular design, non-walk-in containerised battery system with LFP batteries enclosed in a 20-ft container with a capacity of approximately 7 MWh per unit.

Lightsource bp has commissioned EMM Consulting Pty Ltd (EMM) to assist with the Amendment Report. EMM has retained Sherpa Consulting Pty Ltd (Sherpa) to prepare an addendum to the 2023 PHA to cover the proposed BESS amendment. The study objective was to assess and confirm that the risks associated with the proposed BESS amendment would continue to 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], and that the findings of the PHA remain valid.

The study concluded that:

- Based on the completed consequence analysis and separation distances to the nearest development footprint boundary and off-site receptors, 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 amendment still complies with the HIPAP No.4 qualitative risk criteria.
- The findings of the PHA remain valid for the proposed amendment.

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

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## ABBREVIATIONS

AEGL	Acute Exposure Guideline Level
AS	Australian Standard
BESS	Battery Energy Storage System
CWO	Central West Orana
DA	Development Application
DG	Dangerous Goods
DPHI	Department of Planning, Housing and Infrastructure
EIS	Environment Impact Statement
HAZID	Hazard Identification
HF	Hydrogen Fluoride
HIPAP	Hazardous Industry Planning Advisory Paper
km	Kilometres
kV	Kilovolt
kW	Kilowatt
LFP	Lithium Iron Phosphate
MW	Megawatt
MWh	Megawatt hours
NFPA	National Fire Protection Association
NSW	New South Wales
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
PCS	Power Conversion Station
PHA	Preliminary Hazard Analysis
Ppm	Parts per million
PV	Photovoltaic
REZ	Renewable Energy Zone
SSD	State Significant Development
UL	Underwriters' Laboratories

## TERMINOLOGY

<b>Term</b>	<b>Definition</b>
Consequence	Outcome or impact of a hazardous incident, including the potential for escalation.
Non-associated residences	A dwelling that is not associated with the project (i.e. no landholder agreement with the project).
Off-site	Areas extending beyond the development footprint boundary.
Project	Sandy Creek Solar Farm
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**

Lightsource Development Services Australia Pty Ltd (Lightsource bp) is proposing to develop the Sandy Creek Solar Farm, a large-scale solar photovoltaic (PV) electricity generation facility along with battery storage and associated infrastructure (the project). The project would be located approximately 25 km south-west of Dunedoo, NSW, within the Central West Orana Renewable Energy Zone (CWO REZ).

The project is a State Significant Development (SSD-41287735), and an Environmental Impact Statement (EIS) was prepared and submitted for assessment to the Department of Planning, Housing and Infrastructure (DPHI) as part of the Development Application (DA). A Preliminary Hazard Analysis (PHA) was prepared by Sherpa to support the EIS in 2023, Ref [1]. The PHA assessed a Lithium Iron Phosphate (LFP) based Battery Energy Storage System (BESS) with a capacity of up to 700 MW/2800 MWh (4 hours storage).

Lightsource bp is seeking approval to increase the BESS capacity for a maximum export capacity of up to 1400 MW<sub>AC</sub> with storage capacity not exceeding 7,600 MWh. Lightsource bp has commissioned EMM Consulting Pty Ltd (EMM) to assist with the Amendment Report. EMM has retained Sherpa Consulting Pty Ltd (Sherpa) to prepare an addendum to the 2023 PHA to cover the proposed BESS amendment.

This report is prepared as an addendum to the project's PHA. For context and methodology on the PHA, refer to the 2023 PHA, Ref [1].

### **1.2. Objectives**

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

### **1.3. Scope**

The study scope is limited to the proposed amendment associated with the project's BESS (i.e. increased capacity with maximum overall capacity of up to approximately 1,400 MW/7,600 MWh). The study is based on the operating phase of the BESS and assesses events with potential for off-site impacts (i.e. consequences extending outside of the development footprint boundary).

### **1.4. Exclusions and limitations**

The study exclusions and limitations are summarised in Table 1.1.

**Table 1.1: Exclusions and limitations**

Item	Scope area	Exclusions and limitations
1	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 following the project's DA approval. This report is based on the proposed BESS layouts and design at this stage of the project.
2	Knock-on effects and cumulative risk impacts	<p>This study excludes assessment of:</p> <ul style="list-style-type: none"> <li>• Knock-on effects from existing and/or proposed developments in the area.</li> <li>• Cumulative risk impacts to off-site receptors from the project operating in conjunction with existing and/or proposed developments in the area.</li> </ul>

## 2. PROPOSED BESS AMENDMENT

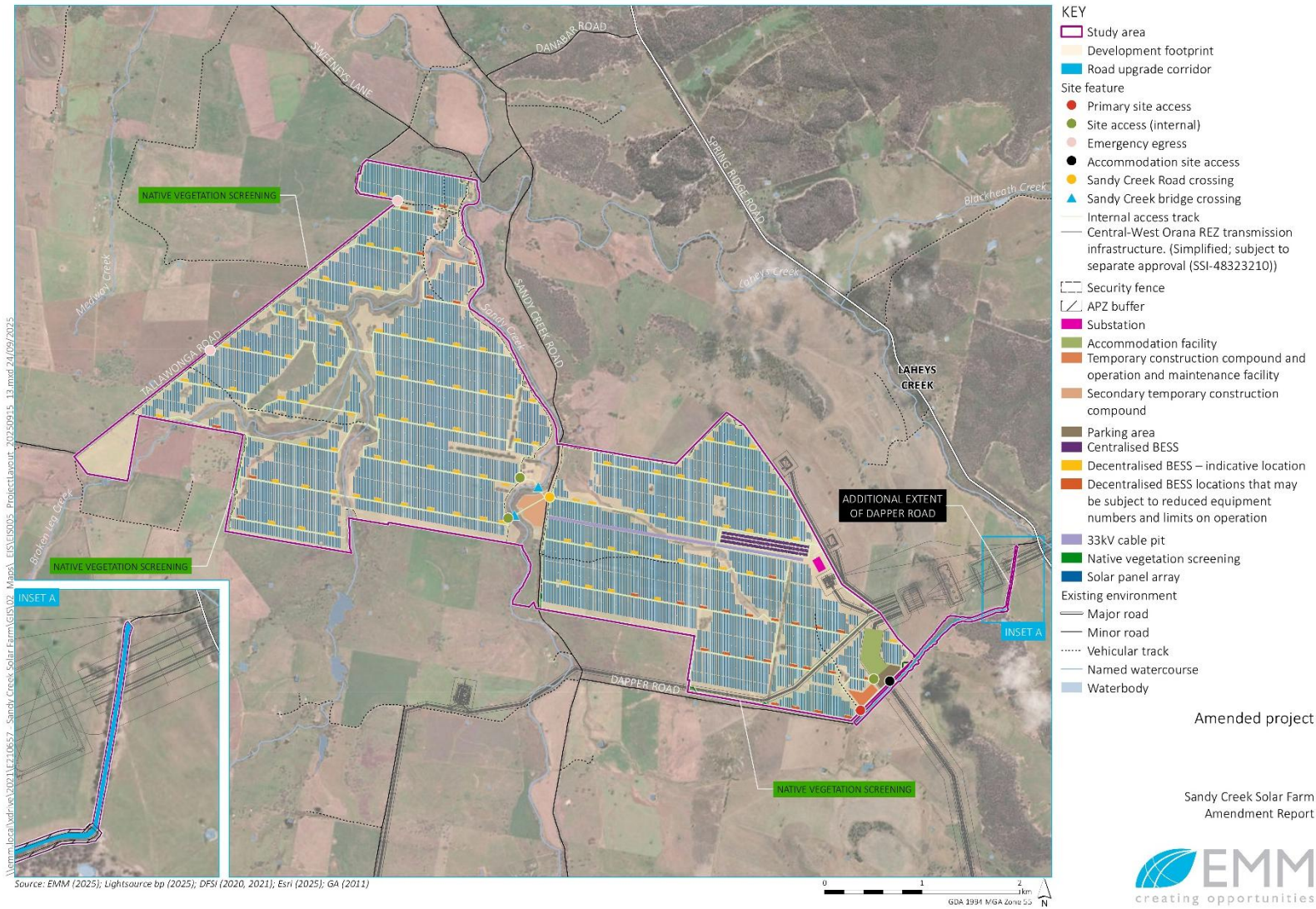
### 2.1. Overview

The proposed BESS with capacity of up to approximately 1,400 MW/7,600 MWh would be achieved via one of the following options:

- Option A: Centralised BESS with a maximum capacity of up to approximately 700 MW/6,048 MWh. A single BESS compound would be established adjacent to the project's substation on the eastern side of the development footprint.
- Option B: Decentralised BESS with a maximum cumulative capacity of up to approximately 700 MW/6,832 MWh. Up to 128 decentralised BESS locations would be established across the development footprint located adjacent to the PV modules. Each location would include up to 8 battery units. Approximately 10 locations would be subject to reduced equipment numbers to ensure compliance with the noise criteria.
- Option C: A combination of centralised BESS (up to 700 MW/6,048 MWh) and decentralised BESS (up to 700 MW/5,894 MWh), with a maximum overall capacity of up to approximately 1,400 MW/7,600 MWh when run simultaneously. Approximately 32 decentralised BESS locations would be subject to reduced equipment numbers and limits on operation to ensure compliance with the noise criteria.

Separate areas with sufficient space are allocated for the centralised and decentralised BESS as shown in Figure 2.1. For all options, the capacity is determined based on the use of a 7 MWh battery system. More details on the battery system are provided in Section 2.2.

Figure 2.1: Revised concept layout



## 2.2. Battery system

At the time of this study, Lightsource bp has not made a final decision on the battery OEM. Consistent with the PHA, the assessment made in this study was based on the use of a modular design, non-walk in containerised battery system with LFP batteries enclosed in a 20-ft container (L 6,058 mm x W 2,438 mm x H 2,896 mm) with capacity of approximately 7 MWh per unit, which was used for the concept design.

Selection of the battery OEM and layout of the battery units and associated equipment will be finalised during detailed design, which will be conducted following the project's DA approval.

The following was assumed:

1. The battery units will be installed in accordance with the OEM's instructions, industry standards and codes, safety in design principles, and best practice for mitigation of fire propagation, including clearance requirements.
2. The specific battery system (make and model) will be tested to Underwriters' Laboratories (UL) 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*, to evaluate the thermal runaway and fire propagation characteristics, informing the required protection for installation and operation of the respective battery system. A UL 9540A test is considered successful if a thermal runaway does not propagate to a battery unit on fire and/or explosion during the test.

### 3. METHODOLOGY

#### 3.1. Overview

The following activities were completed for the study:

1. Determine if the amendment introduces new hazards and risks with the potential for off-site impact that were not covered in the Hazard Identification (HAZID) completed for the 2023 PHA.
2. Undertake consequence analysis for a battery unit fire event to determine potential impacts due to heat radiation and toxic products of combustion.

Note: In the 2023 PHA, potential impacts were determined qualitatively based on the separation distance to nearest off-site receptors. The consequences are quantified in this study to support the assessment of off-site impact.

3. Review the separation distances from the battery units to the nearest onsite receptors, site boundary, and off-site receptors to determine potential impacts from a battery unit fire. The development footprint boundary was used to define and determine off-site impact (i.e. impact extending outside of this boundary).
4. Verify that the proposed BESS capacity would be able to fit within the designated land area 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.
5. Assess the risk against HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*.
6. Determine if the findings of the 2023 PHA remain valid.

At the time of this study, Lightsource bp has not made a final decision on the configuration option for the proposed BESS (refer to Section 2.1). All 3 options were assessed to demonstrate compliance with the HIPAP No. 4 risk criteria and allow flexibility when progressing into detailed design. As separate areas are allocated for the centralised and decentralised BESS, assessment requirements for Option C (combined centralised and decentralised BESS) are met when assessment requirements for Options A (max centralised BESS) and B (max decentralised BESS) are met.

#### 3.2. Study assumptions

The study assumptions are as follows:

- Aside from the increased number of LFP batteries, there is no change to the Dangerous Goods (DG) to be stored or used on site to that previously assessed in the PHA.
- There are no new off-site receptors for the project (i.e. non-associated residences, surrounding land uses) to that previously assessed in the PHA.

#### 4. HAZARD IDENTIFICATION

The following were reviewed to identify additional hazards and risks associated with the proposed BESS amendment with respect to the HAZID completed for the 2023 PHA, Ref [1]:

- Battery type.
- Equipment associated with the proposed BESS.
- DG stored on site.

The review found that the HAZID completed as part of the 2023 PHA is still applicable and that there are no additional hazards with the potential to result in significant off-site impacts, based on the following considerations:

- The proposed BESS utilises LFP batteries which were also used as the basis of assessment for the 2023 PHA.
- The 2023 PHA assessed both centralised and decentralised BESS configurations, with similar equipment to that of the proposed BESS.
- It was assumed that aside from the increased number of batteries, there is no change to the DG to be stored or used on site.

The following scenarios were carried forward to consequence analysis to determine the potential impact to off-site receptors:

1. Battery unit on fire.
2. Transformer fire.

## 5. CONSEQUENCE ASSESSMENT

### 5.1. Overview

To inform the risk assessment, consequence analysis was undertaken for events identified in the HAZID as having the potential to result in off-site impact. The scope of the consequence analysis is shown in Table 5.1. The analysis results were used to determine the potential impacts to off-site receptors.

**Table 5.1: Consequence assessment 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 5.2)
		Accumulation and ignition of flammable vapours inside a battery unit	
	Single battery unit – fully developed fire	Heat radiation	Quantitative (Section 5.3)
		Toxic products of combustion	
Transformer	Transformer fire	Heat radiation	Qualitative (Section 5.4)

### 5.2. 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, Lightsource bp has not made a final decision on the battery OEM. Selection of the battery OEM will be finalised during detailed design. As the UL 9540A test reports for the battery system were not available and the composition of vented gas from battery thermal runaway is not known, dispersion of toxic gas generated from decomposition of battery electrolyte was not modelled.

Sherpa assumed that the battery system would meet 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.

### 5.3. 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 LFP 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:
  - Typical day condition: Neutral (Class D) and wind speed of 5 m/s (D5).
  - Typical night condition: Very stable (Class F) and wind speed of 2 m/s (F2).

#### 5.3.1. Heat radiation criteria

The heat radiation levels, their effects and the criteria adopted for the consequence assessment are presented in Table 5.2, Ref [2].

**Table 5.2: Heat radiation criteria**

Heat radiation (kW/m <sup>2</sup> )	Effect	Study criteria
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	<ul style="list-style-type: none"> <li>• Significant chance of fatality for extended exposure. High chance of injury.</li> <li>• Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure.</li> <li>• Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure.</li> </ul>	Fatality

#### 5.3.2. Toxic gas dispersion criteria

The Acute-Exposure Guideline Level (AEGL) concentration levels (60-minute exposure) for HF are presented in Table 5.3. These concentrations were used to inform harm levels following exposure (irritation, injury and fatality).

**Table 5.3: 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

### 5.3.3. Results

The modelling results for heat radiation and toxic gas dispersion impacts are presented in Table 5.4 and Table 5.5, 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<sup>2</sup>) was used to determine potential for off-site impact, which is approximately 12 m.
- Dispersion of toxic products of combustion (HF): The distances to AEGL thresholds for injury (AEGL-2) and irritation (AEGL-1) at D5 condition are 11 m and 25 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. 25 m.

For a battery unit on fire scenario, the impact distance is approximately 25 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 the separation distance to the nearest development footprint boundary.

A review of the separation distance from the battery units to the development footprint boundary is provided in Section 6.

**Table 5.4: Battery unit on fire – heat radiation impact**

Battery system	Size – largest face of battery compartment (L x H, mm)	Distance (m) at receptor height (1.5 m) to heat radiation levels	
		4.7 kW/m <sup>2</sup> (injury)	12.6 kW/m <sup>2</sup> (fatality)
Concept design battery system	6,058 x 2,896	12	7

**Table 5.5: Battery unit on fire – toxic dispersion impact (HF)**

Battery system	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)
Concept design battery system	7.0	0.389	D5	25	11	9
			F2	3	2	2

### 5.4. Transformer fire

Excessive voltage, overloading, and degraded insulating material may result in internal arcing with sufficient energy to rupture the transformer oil tank and ignite the released oil resulting in a fire. The risk of harm from a transformer fire is managed by compliance with the relevant standards and codes. This includes requirements to provide, for

example, bunding, fire wall and/or clearances to other transformers/equipment and buildings, as per AS 2067:2016 *Substations and high voltage installations exceeding 1 kV*, Ref [3].

In this study, a transformer fire was not quantitatively modelled. Instead, a verification was completed to determine whether the concept design transformers' clearances meet the AS 2067 specified clearances. This is to ensure that the escalation risk of a transformer fault/fire is minimised.

Verification was conducted for the following:

1. BESS transformer: The BESS transformer integrated as part of the PCS unit would contain approximately 2,800 L of mineral oil, Ref [4].
2. BESS auxiliary transformer: The BESS auxiliary transformer would contain approximately 900 L of mineral oil, Ref [5].
3. Substation transformer: Sherpa has assumed that the HV transformer located at the project substation will use mineral oil with quantity exceeding 60,000 L per transformer.

The verification findings are presented in Table 5.6. Sherpa found that all transformers would meet the AS 2067 clearance specifications.

The clearance to combustible surfaces included in Table 5.6 implies the minimum distance required to prevent ignition of combustible surfaces, which is represented as 12.6 kW/m<sup>2</sup> in heat radiation level in HIPAP 4. For land use safety planning, 4.7 kW/m<sup>2</sup> heat radiation level is typically used for off-site impact assessment. For all types of transformers assessed, the separation distances to the nearest development footprint boundary are far greater than the AS 2067 specified clearances to combustible surfaces.

As heat radiation level reduces with distance and based on the separation distance to the development footprint boundary, the effects of a transformer fire are not expected to result in an off-site impact.

**Table 5.6: Clearances – outdoor transformers**

Transformer	Transformer type	Liquid volume (L)	AS 2067 horizontal clearances to...		Remarks	AS 2067 clearances met?
			Other transformers, equipment or non-combustible surfaces (m)	Buildings and combustible surfaces (m)		
BESS transformer (part of the PCS unit)	Oil insulated transformer <sup>(a)</sup>	> 2,000 ≤ 20,000	5	10	<p><u>Option A (Max centralised BESS)</u> Separation distance from PCS unit to:</p> <ul style="list-style-type: none"> <li>- Nearest battery unit: 5 m</li> <li>- Nearest auxiliary transformer: 12 m</li> <li>- Adjacent PCS unit: 26 m</li> <li>- Substation area: 70 m</li> <li>- Nearest development footprint boundary: 116 m</li> <li>- Operations &amp; Maintenance (O&amp;M area): &gt;1,400 m.</li> </ul> <hr/> <p><u>Option B (Max decentralised BESS)</u> Separation distance from transformer to</p> <ul style="list-style-type: none"> <li>- Nearest battery unit: &gt;5 m*</li> <li>- Nearest auxiliary transformer: 6.1 m</li> <li>- Nearest development footprint boundary: 28 m</li> <li>- O&amp;M area: 55 m</li> <li>- Substation area: 270 m.</li> </ul> <p>* Distance from a PCS unit to nearest battery unit is 4.6 m. The PCS unit comprises 2 inverters and 1 transformer. As the transformer is in the middle of the PCS unit, distance between the transformer and nearest battery unit is greater than 5 m.</p> <hr/> <p><u>Option C (Combined centralised &amp; decentralised)</u> As per above</p>	Yes

Transformer	Transformer type	Liquid volume (L)	AS 2067 horizontal clearances to...		Remarks	AS 2067 clearances met?
			Other transformers, equipment or non-combustible surfaces (m)	Buildings and combustible surfaces (m)		
BESS auxiliary transformer	Oil insulated transformer <sup>(a)</sup>	100 ≤ 1,000	1	6	<u>Option A (Max centralised BESS)</u> Separation distance from auxiliary transformer to: <ul style="list-style-type: none"> <li>- Nearest battery unit: &gt; 3 m</li> <li>- Nearest PCS unit: 12 m</li> <li>- Substation area: 95 m</li> <li>- Nearest development footprint boundary: 135 m</li> <li>- O&amp;M area: &gt;1,400 m.</li> </ul>	Yes
					<u>Option B (Max decentralised BESS)</u> Separation distance from auxiliary transformer to: <ul style="list-style-type: none"> <li>- Nearest auxiliary transformer: 1 m</li> <li>- Nearest battery unit: &gt; 7 m</li> <li>- Nearest development footprint boundary: 36 m</li> <li>- O&amp;M area: 63 m</li> <li>- Substation area: 278 m.</li> </ul>	
					<u>Option C (Combined centralised &amp; decentralised)</u> As per above	
Substation HV transformer	Oil insulated transformer <sup>(a)</sup>	> 60,000	23	30	Separation distance from the substation HV transformers to: <ul style="list-style-type: none"> <li>- Nearest development footprint boundary: 75 m</li> <li>- Substation area: 96 m</li> <li>- Nearest battery unit (centralised BESS): 309 m</li> <li>- Nearest battery unit (decentralised BESS): 455 m</li> <li>- O&amp;M area: &gt;1,100 m.</li> </ul>	Yes
Notes: (a) Mineral oil or synthetic insulating liquid with fire point less than or equal to 300°C, referred to as combustible liquids according to AS 1940 (Ref: AS 2067 Table 6.1, Note 1).						

## 6. BESS SEPARATION DISTANCES

### 6.1. Overview

In addition to demonstrating that the fire risks from the BESS can comply with the HIPAP No. 4 land use safety planning risk criteria, PHAs for renewable energy projects in NSW with a BESS facility with a 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 land area designated for the BESS accounting for separation distances between:

- The BESS sub-units (e.g. battery units, PCS units, 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 BESS units against codes and standards and OEM specification.
2. Verification that the required land area for the proposed BESS capacity would fit within the designated land area.
3. Review of separation distances between the BESS and onsite and off-site receptors.

### 6.2. Separation distances between BESS units

#### 6.2.1. NFPA 855

The National Fire Protection Agency (NFPA) 855 *Standard for the Installation of Stationary Energy Storage Systems* is widely recognised as a comprehensive best practice guide in the industry, Ref [6].

NFPA 855 specifies the default maximum allowable energy storage unit at 50 kWh (and 600 kWh for the overall BESS installation) and minimum separation of 914 mm between units and walls (for indoor installations). However, NFPA 855 also specifies that the BESS may be installed in units with larger energy capacities or smaller separation if they meet the fire and explosion testing in accordance with UL 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems, or equivalent test standard*<sup>1</sup>. As such, the results of the UL 9540A test (performed with clearances as specified by the BESS manufacturer) form a key parameter to determine clearances.

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<sup>1</sup> NFPA 855 (2023) Clause 9.1.5: Fire and Explosion Testing.

### 6.2.2. UL 9540A

The UL 9540A testing is a destructive test method used for evaluating the thermal runaway impacts in a BESS and gathering data to assist in assessing or developing mitigation measures for the failure event, propagation of the failure, or consequences of an event, such as an explosion or fire. It is currently considered to be an appropriate published methodology to provide comprehensive, consistent, and reliable data for battery failure testing.

At the time of this study, Lightsource bp 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 following the project’s DA approval. Sherpa assumed that the battery system would meet the safety performance requirements of the UL 9540A unit-level test.

### 6.2.3. Concept design clearances

The layout of the centralised BESS compound and the indicative configuration of the equipment are shown in Figure 6.1.

The layout of a decentralised BESS location and the indicative configuration of the equipment are shown in Figure 6.2. There will be up to 8 battery units at each location. Of the 128 locations, approximately 32 may be subject to reduced equipment numbers and limits on operation to ensure compliance with the relevant noise criteria.

Lightsource bp has advised that the indicative BESS configurations have been designed with considerations of the required clearances for operation and maintenance activities as well as safety (to minimise potential for fire risk propagation), from a survey of multiple OEMs with battery systems of similar size (20-ft container) and specification. Once the preferred OEM has been selected, the required clearances will be reviewed and layout will be revised where necessary.

Sherpa has assumed that the OEM specified clearances between units have taken into account the requirements of NFPA 855, UL 9540A, and/or large-scale burn test results. The clearances included in the concept design are summarised in Table 6.1.

**Table 6.1: BESS clearances**

Aspect	Centralised BESS	Decentralised BESS
Front and back	3–4 m	4 m
Side	3 m	3 m

Figure 6.1: Centralised BESS – layout and indicative configuration

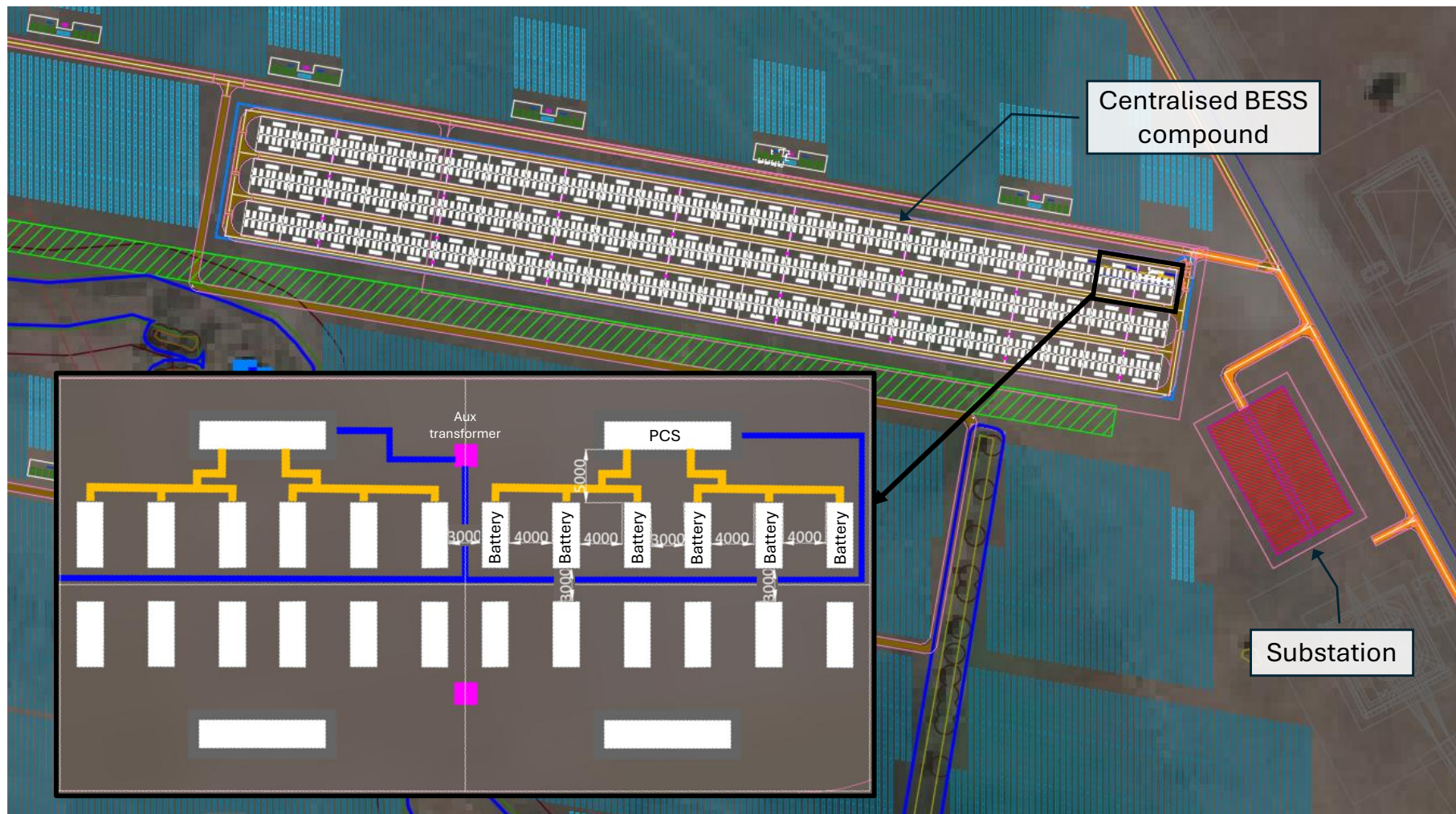
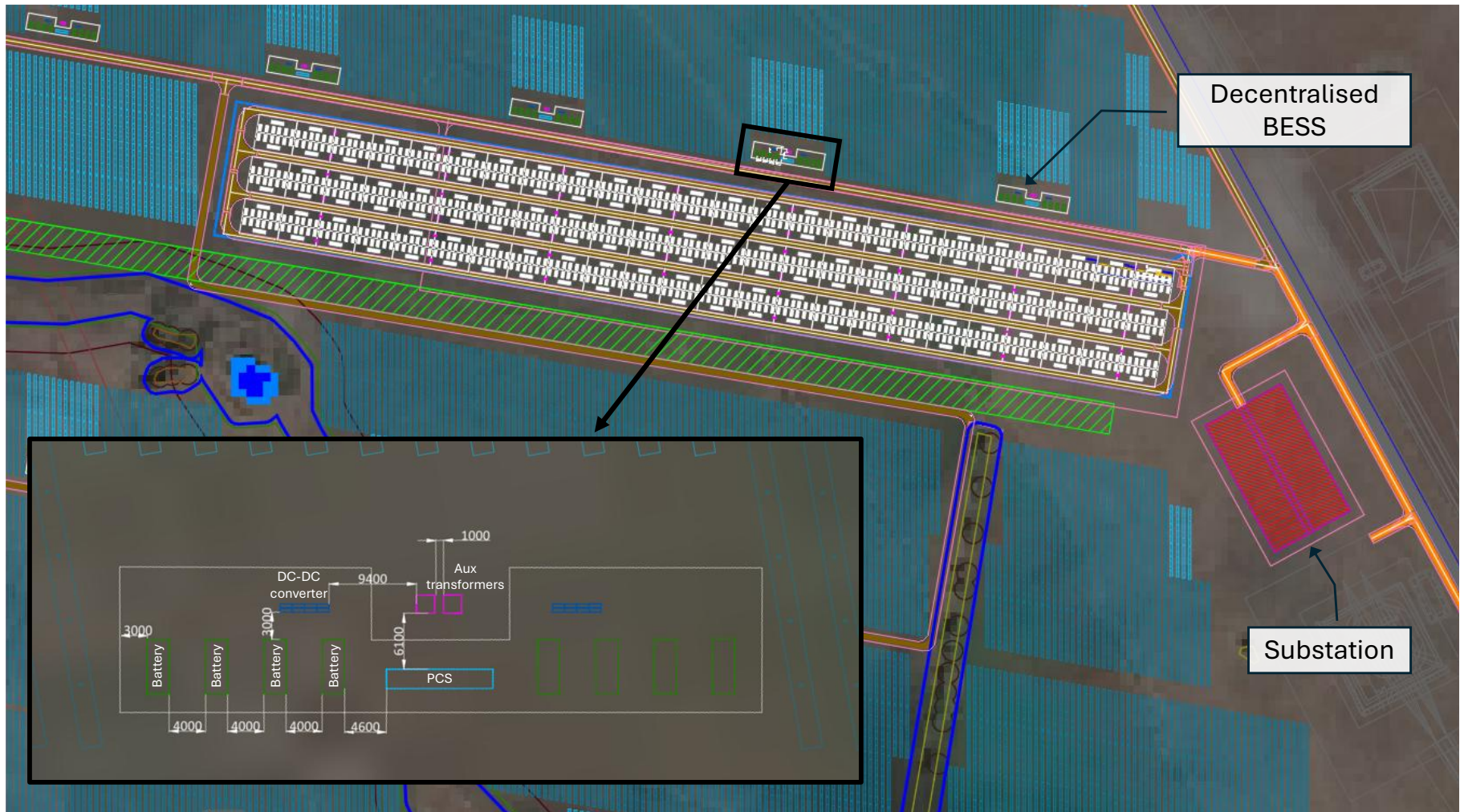


Figure 6.2: Decentralised BESS – layout and indicative configuration



### 6.3. Land area designated for the BESS

#### 6.3.1. Option A – Max centralised BESS

As shown in Figure 6.1, the designated land area for the centralised BESS compound is sufficient to accommodate the proposed BESS (battery units and associated equipment) including the expected OEM clearances.

#### 6.3.2. Option B – Max decentralised BESS

As shown in Figure 6.2, the designated land area for a decentralised BESS location is sufficient to accommodate the proposed BESS (battery units and associated equipment) including the expected OEM clearances.

Up to 128 decentralised BESS locations will be established across the development footprint to accommodate the proposed capacity, as shown in Figure 2.1.

#### 6.3.3. Option C – Combined centralised and decentralised BESS

Separate areas are allocated for the centralised and decentralised BESS as shown in Figure 6.1 and Figure 6.2, respectively. There is a sufficient area to accommodate the combined centralised and decentralised BESS option, as demonstrated by Option A (max centralised BESS) and Option B (max decentralised BESS).

### 6.4. Onsite receptors

The substation and the O&M facilities areas were identified as onsite receptors. For the centralised and decentralised BESS, the separation distances to these areas are shown in Table 6.2 and illustrated in Figure 6.3 and Figure 6.4, respectively. The temporary construction accommodation facility will be decommissioned prior to operation of the BESS, and hence, is not considered as an onsite receptor.

The closest onsite receptors are located well outside of the heat radiation injury contour (4.7 kW/m<sup>2</sup>). Escalation effect from a battery unit fire event is not considered credible.

**Table 6.2: Separation distances to onsite receptors**

Onsite receptors	Separation distance (m) from the nearest battery unit	
	Centralised BESS	Decentralised BESS
Substation area	63	250
O&M facilities area	1,431	40

### 6.5. Off-site receptors

In this study, compliance to HIPAP 4 criteria is considered achieved if:

- Fatality consequences (12.6 kW/m<sup>2</sup> heat radiation and AEGL-3 toxic concentration) remain onsite, and

- Injury ( $4.7 \text{ kW/m}^2$  heat radiation and AEGL-2 toxic concentration) and irritation (AEGL-1 toxic concentration) consequences do not reach sensitive and residential land uses.

The existing neighbouring land uses and non-associated residences are considered as off-site receptors. For a battery unit fire scenario, the impact distance is approximately 25 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.

For the centralised BESS:

- Separation distances to the nearest development footprint boundary and non-associated residence are approximately 108 m and 1,388 m (R06) respectively, as shown in Figure 6.5.
- Based on the completed consequence analysis for a battery unit fire and the separation distances, a battery unit fire is not expected to result in significant off-site impacts (i.e. serious injury due to heat radiation or irritation from toxic combustion products to the off-site receptors), and the HIPAP 4 criteria are met.

For the decentralised BESS:

- Separation distance to the nearest development footprint boundary is approximately 24 m. This was observed for the decentralised BESS located at the south-west corner of the project site, as shown in Figure 6.6.
  - The injury-level radiant heat flux (12 m) and toxic gas (HF) concentration (11 m) at receptor height are not expected to extend beyond the development footprint boundary, and the HIPAP 4 criteria are met.
  - The irritation-level HF concentration at receptor height (25 m) extends 1 m outside of the development footprint boundary for this decentralised BESS location only but does not affect any sensitive and/or residential land uses. For all other decentralised BESS locations, the separation distance to the development footprint boundary is at least 26 m. Therefore, the HIPAP 4 criteria are met.
- The nearest non-associated residence from a decentralised BESS location is approximately 290 m (R09), as shown in Figure 6.6. The effects from a battery unit fire are not expected to result in significant off-site impacts.

Figure 6.3: Separation distance to onsite receptors – Centralised BESS



Figure 6.4: Separation distance to onsite receptors – Decentralised BESS

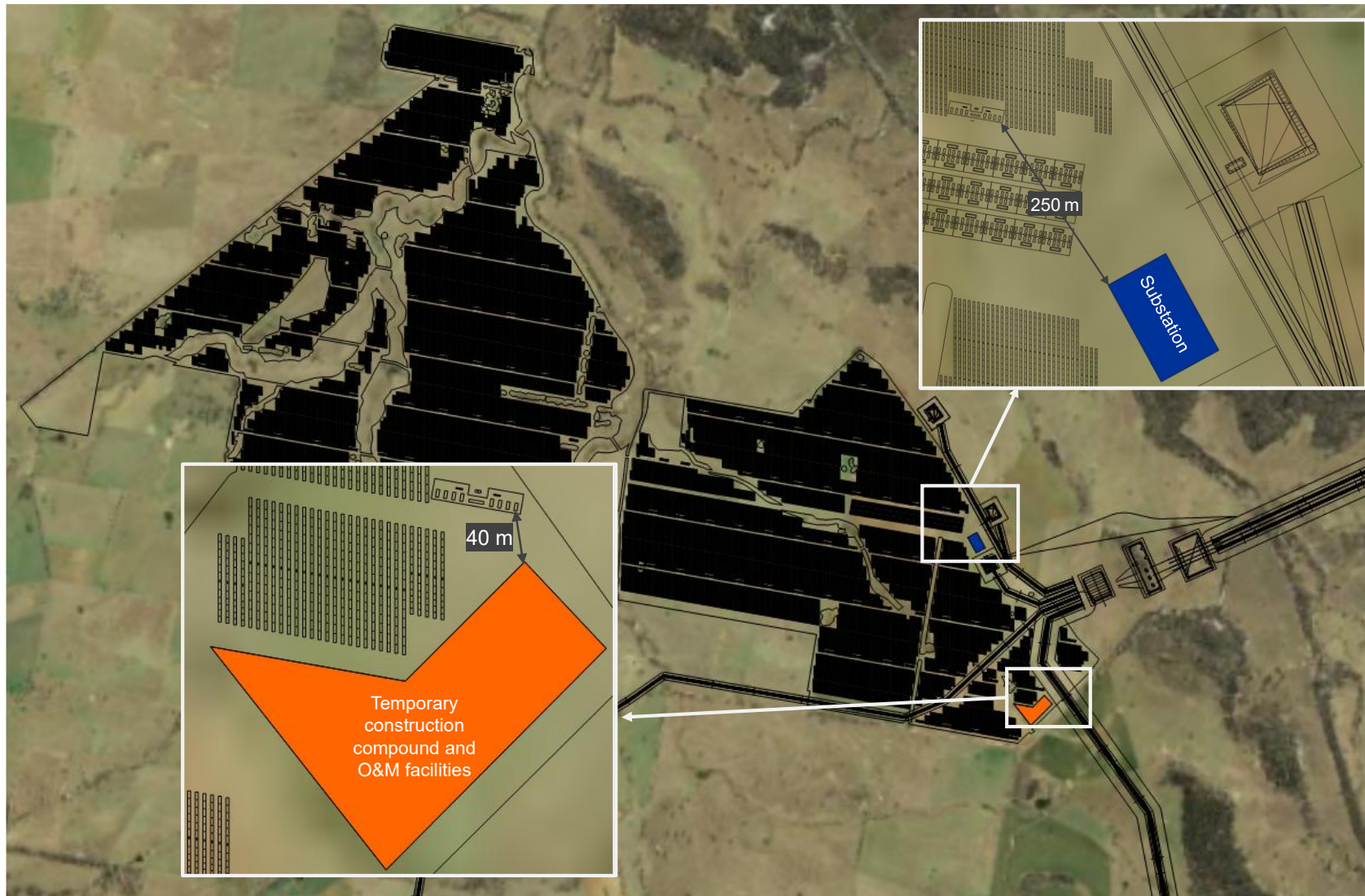


Figure 6.5: Separation distance to nearest off-site receptors – Centralised BESS

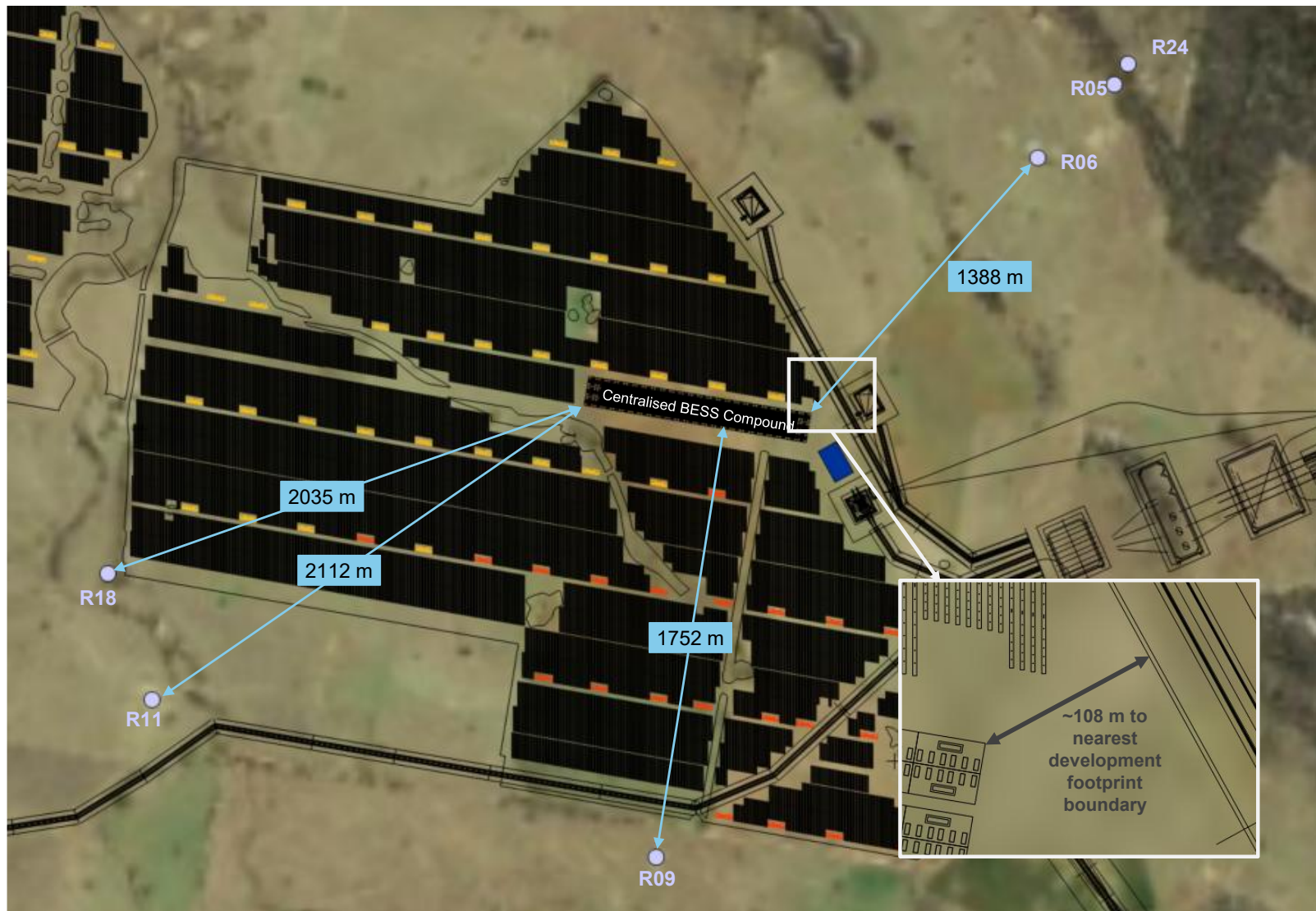
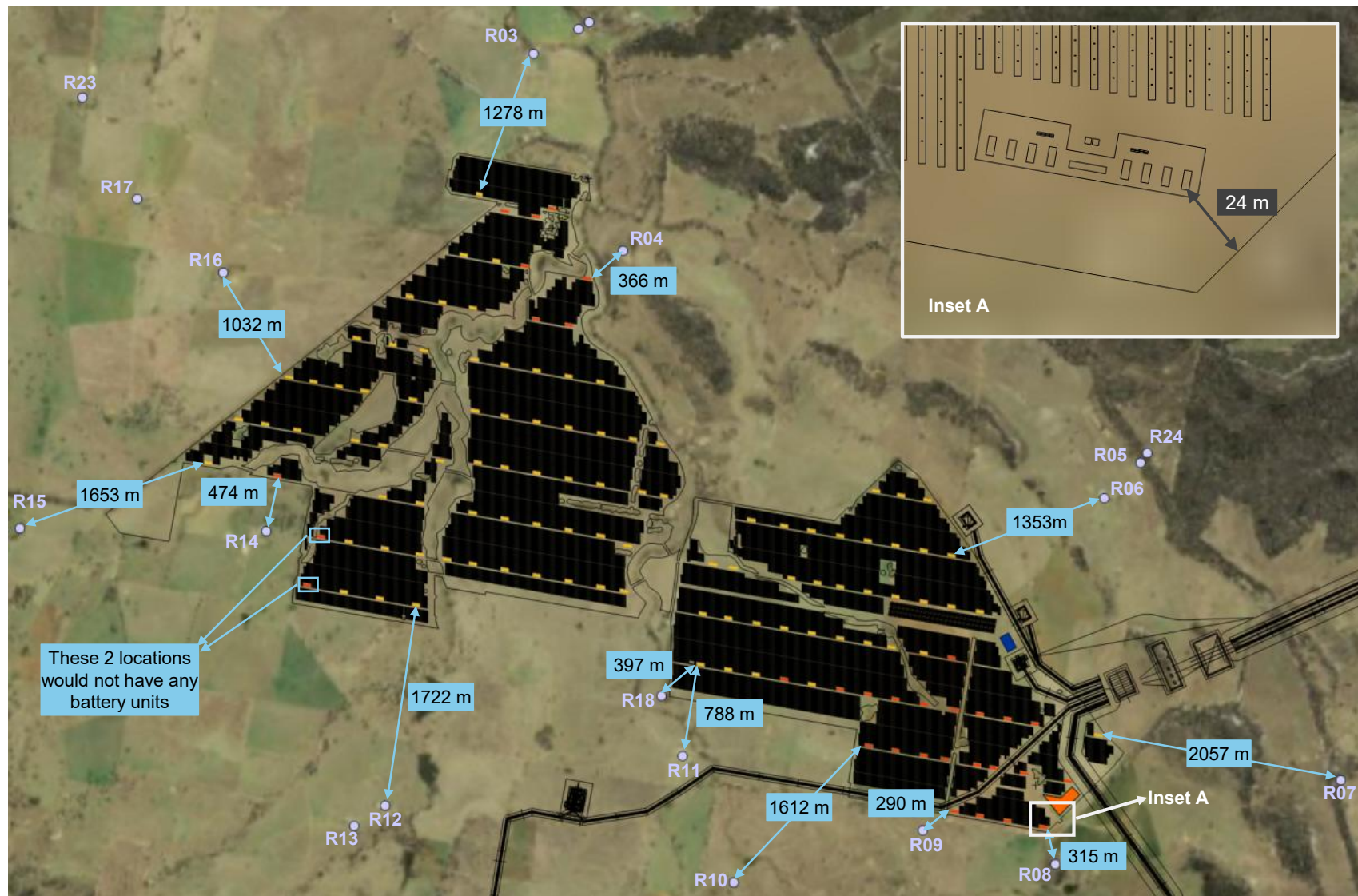


Figure 6.6: Separation distance to nearest off-site receptors – Decentralised BESS



## 7. RISK ASSESSMENT

### 7.1. Level of analysis

The Multi-Level Risk Assessment guideline, Ref [7], sets out three levels of risk assessment for a land use safety planning assessment, as shown in Table 7.1.

Consequence analysis for a battery unit fire found that the resulting consequences are not expected to have significant off-site impacts (i.e. serious injury due to heat radiation or irritation from toxic combustion products) based on the separation distances to the development footprint boundary and off-site receptors. A qualitative approach was determined appropriate for this study.

**Table 7.1: Level of assessment**

Level	Assessment type	Appropriate/can be justified if
1	Qualitative	There are no potential events with significant off-site consequences and societal risk is negligible.
2	Partially quantitative	The frequency of occurrence of risk contributors having off-site consequences is low.
3	Quantitative	There are significant off-site risk contributors, and a Level 2 analysis is unable to demonstrate that the risk criteria will be met.

### 7.2. Assessment against HIPAP No. 4 criteria

Assessment against the HIPAP No. 4 qualitative land use planning risk criteria is provided in Table 7.2.

**Table 7.2: Assessment against HIPAP No. 4 qualitative risk criteria**

HIPAP 4 qualitative criteria	Remarks	Complies
<p><i>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.</i></p>	<p>The separation distance from the battery unit to the nearest development footprint boundary was used to determine off-site impact. Based on the completed consequence analysis for a battery unit fire and the separation distances to the development footprint boundary and nearest existing off-site receptor, the effects from a battery unit on fire are not expected to result in significant off-site impacts.</p> <p>The project site is suited for the proposed operation, situated within the CWO-REZ, in a rural area with large separation distance to off-site receptors to avoid off-site risks</p> <p>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 LFP batteries.</p>	Yes
<p><i>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.</i></p>	<p>Based on the completed consequence analysis for a battery unit fire and the separation distances to the development footprint boundary and off-site receptors, the effects from a battery unit 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).</p>	Yes
<p><i>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.</i></p>	<p>Events with high probability of occurrence are expected to be contained within the boundaries of the project site.</p> <p>Based on the completed consequence analysis for a battery unit fire and the separation distances to the development footprint boundary and off-site receptors, 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).</p>	Yes
<p><i>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.</i></p>	<p>There are no hazardous developments (in the context of the State Environmental Planning Policy – Resilience and Hazards, Ref [8]) in the vicinity of the project site.</p>	Yes

## 8. CONCLUSION

For all configuration options, the study concluded that:

- Based on the completed consequence analysis and separation distances to the nearest development footprint boundary and off-site receptors, 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 amendment still complies with the HIPAP No.4 qualitative risk criteria.
- The findings of the PHA remain valid for the proposed amendment.

Once the project's design is finalised or upon any significant changes, this study should be reviewed and updated as required to ensure that all aspects are considered (e.g. battery OEM, control measures, clearances between battery units, separation distance to off-site receptors) and assessments made in this report are still valid.

## 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 of 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 sensitive 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 unit on fire and the heat radiation exposure to a receptor, as shown in Figure C.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 BESS unit on fire, the emitted heat flux was calculated using the Stefan - Boltzman 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 BESS unit on fire:

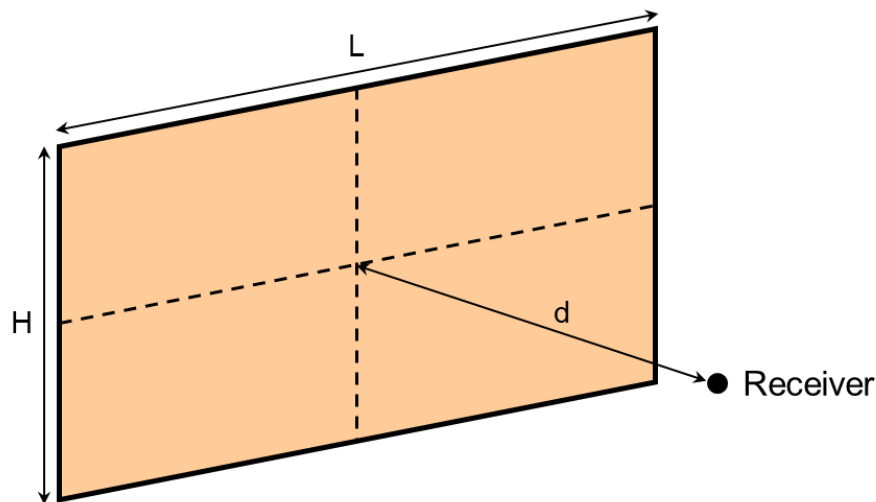
$$\phi = \frac{1}{2\pi} \left[ \frac{a}{(1+a^2)^{1/2}} \tan^{-1} \frac{b}{(1+a^2)^{1/2}} + \frac{b}{(1+b^2)^{1/2}} \tan^{-1} \frac{a}{(1+b^2)^{1/2}} \right]$$

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

To calculate the heat radiation experienced by the receptor at height 1.5 m (approximately half of the BESS unit height), the surface area of the BESS unit (front aspect) is divided into 4 equal sections. Figure B1 illustrates the graphical depiction of the parameters used in the calculation.

$$E_{received} = 4 \phi E_{emitted}$$

**Figure A.1: The graphical depiction of the parameters (L, H, d)**



### A2.2. Input 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 value typical for lithium metallic fires, Ref [9].
- 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 unit and assumed a full planar fire. This is conservative as the front aspect has the largest surface area and consequently 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 A.1. The distance to the injury level (4.7 kW/m<sup>2</sup>) was used to determine potential for off-site impact, which is approximately 12 m.

**Table A.1: Battery unit on fire – heat radiation impact**

Battery system	Size – largest face of battery compartment (L x H, mm)	Distance (m) at receptor height (1.5 m) to heat radiation levels	
		4.7 kW/m <sup>2</sup> (injury)	12.6 kW/m <sup>2</sup> (fatality)
Concept design battery system	6,058 x 2,896	12	7

### **A3. Dispersion of toxic gas**

#### **A3.1. Modelling approach**

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

Consequence modelling was performed using the Gexcon EFFECTS v12.5.2 software (Plume Rise from Fire model) to simulate HF dispersion during a battery unit fire. The HF generation rate was based upon published experimental literature for LFP batteries. The downwind distances to AEGL concentrations for HF were determined.

#### **A3.2. Input 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 [10].
- A lithium-ion battery cell experiment, Ref [10], 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 unit 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 (represents low crops and occasional large obstacles).
- The heat release rate from the battery (with 100% state of charge) is estimated to be 882 kW/m<sup>2</sup>, Ref [11].
- The plume was assumed to be released from the top of the battery unit. This is viewed as a reasonable approach, based on observation from previous BESS fire incidents (e.g. VBB 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 A.2. As a conservative approach, the distance to the irritation level (AEGL-1) was used to determine potential for off-site impact. This was found to be 25 m at D5 conditions.

**Table A.2: Battery unit on fire – toxic dispersion impact (HF)**

Battery system	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)
Concept design battery system	7.0	0.389	D5	25	11	9
			F2	3	2	2

## APPENDIX B. REFERENCES

- [1] Sherpa Consulting Pty Ltd, "Preliminary Hazard Analysis - Sandy Creek Solar Farm," 21611-RP-001-Rev0, 2023.
- [2] NSW Department of Planning, "Hazardous Industry Planning Advisory Paper No. 4 - Risk Criteria for Land Use Safety Planning," 2011.
- [3] Committee EL-043, "AS 2067:2016 Substations and high voltage installations exceeding 1 kV," Standards Australia, 2016.
- [4] Lightsource bp, *Email 27 August 2025 - Response to Sherpa RFI (BESS transformer)*.
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- [7] NSW Department of Planning, "Assessment Guideline: Multi-level Risk Assessment," 2011.
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- [11] P. P. e. al, "Study of the fire behaviour of high-energy lithium ion batteries with full-scale burning test," *Journal of Power Sources*, vol. 285, pp. 80-89, 2015.