New England Solar – Fire Safety Study

Stage 3 – 200 MW/400 MWh BESS

15 July 2025

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A	27-Sep-2024	Draft for ACEN and EV review and comments	O. Alim (Sherpa)	-	-
B	14-Feb-2025	Updated to reflect design revisions (60% design) and new BESS OEM information	O. Alim (Sherpa)	R. Lamblé (ACEN) B. Mohebbati (Energy Vault)	R. Weston (ACEN)
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Abbreviations

Abbreviation	Definition
AC	Alternating Current
AEGL	Acute Exposure Guideline Levels
AEMO	Australian Energy Market Operator
AGC	Automatic Generation Control
APU	Auxiliary Power Unit
APZ	Asset Protection Zone
BESS	Battery Energy Storage System
BMS	Battery Management System
BOM	Bureau of Meteorology
BOP	Balance of Plant
CFA	(Victoria) Country Fire Authority
DA	Development Application
DC	Direct Current
DG	Dangerous Goods
DPHI	(NSW) Department of Planning, Housing and Infrastructure
EIS	Environment Impact Statement
EMS	Energy Management System
EPC	Engineering, Procurement and Construction
ERC	Emergency Response Coordinator
ERPG	Emergency Response Planning Guideline
ERT	Emergency Response Team
ESIP	Emergency Services Information Package
FACP	Fire Alarm Control Panel
FERP	Fire and Emergency Response Plan
FDCIE	Fire Detection Control and Indicating Equipment

Abbreviation	Definition
FRNSW	Fire and Rescue New South Wales
FSS	Fire Safety Study
HMI	Human Machine Interface
HV	High Voltage
HVAC	Heating Ventilation and Air Conditioning
kL	Kilolitres
km	Kilometres
kV	Kilovolt
kW/m^2	Kilowatts per square metres
LEP	Local Environmental Plan
LFL	Lower Flammability Limit
LFP	Lithium Iron Phosphate
LGA	Local Government Area
LPG	Liquefied Petroleum Gas
MSB	Main Switchboard
MV	Medium Voltage
MW	Megawatt
MWh	Megawatt hours
NCC	National Construction Code
NEM	National Electricity Market
NES	New England Solar
NFPA	(US) National Fire Protection Agency
NSW	New South Wales
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
PCS	Power Control System

Abbreviation	Definition
PHA	Preliminary Hazard Analysis
PIP	Pre-Incident Planning
PPE	Personal Protective Equipment
PV	Photovoltaic
REZ	Renewable Energy Zone
RMC	Remote Monitoring Centre
RMU	Ring Main Unit
RFS	(NSW) Rural Fire Service
SCADA	Supervisory Control and Data Acquisition
SCBA	Self-Contained Breathing Apparatus
SSD	State Significant Development
UL	Underwriters Laboratories

Summary

Context and objective

ACEN Australia Pty Ltd (ACEN Australia) has approval to develop the New England Solar and Battery Project (NES). The approval was subject to conditions of consent issued for SSD-9255. Development of the NES is being staged with initial construction of a solar farm (Stages 1 and 2; completed) followed by the BESS in Stages 3 (200 MW/400 MWh) and 4 (1200 MW/2400 MWh; future). To address the requirements of Schedule 3 Condition 23 of the development consent and allow the construction of the Stage 3 BESS to proceed, a Fire Safety Study (FSS) was completed.

The overall objective of the FSS is to ensure that the proposed fire prevention and protection strategies and measures are appropriate for the specific fire hazard and adequate to meet the extent of the potential fires. The scope of this study covers the operations phase of the proposed BESS and include:

- Fires associated with Stage 3 BESS and associated equipment/infrastructure (e.g. battery enclosures, transformers, spares facility).
- Fires that could escalate to the Stage 3 BESS compound.

Approach

The study was undertaken following the methodology specified in the following guidelines:

1. NSW Department of Planning, Housing and Infrastructure (DPHI) (2011): Hazardous Industry Planning Advisory Paper (HIPAP) No 2, *Fire Safety Study Guideline*s.
2. Fire and Rescue NSW (FRNSW) (2023): Fire Safety Guideline Technical Information, *Large-scale external lithium-ion battery energy storage systems – Fire safety study consideration* (referred to as FRNSW BESS FSS Guideline hereinafter).

To better understand the requirements and expectations of the FRNSW BESS FSS Guideline, a consultation meeting with FRNSW was carried out on 21 November 2023.

Fire hazard identification

A fire hazard identification (HAZID) review was undertaken to identify credible fire hazards and scenarios associated with the proposed Stage 3 BESS, and other fire scenarios that could impact/escalate to the BESS facility (e.g. fires from the existing NES infrastructure, bushfire).

The following aspects were considered when identifying the fire hazards:

- Type of infrastructure and equipment
- Hazardous materials and Dangerous Goods (for the purposes of the FSS these are flammable or combustible materials)
- Proposed operation activities that could cause or contribute to a fire on site
- External events (e.g. bushfire).

A summary of the fire scenarios assessed in this study is provided in the table below.

Fire scenario	Carried forward for further analysis	Further analysis	
		Consequence modelling undertaken	Review of fire strategy and supporting measures
Existing infrastructure (Stages 1 and 2)			
A. PV fire	No[a]	-	-
B. Solar farm O&M building fire	No[a]	-	-
C. Solar farm warehouse fire	No[a]	-	-
D. Fire at the solar farm fuel storage area	Yes	Yes	Yes
E. Back-up generator fire at the substation	No[a]	-	-
F. HV transformer fire at NES1/NES2 substation	Yes	No	Yes
Proposed BESS (Stage 3)			
G. BESS unit battery compartment fire	Yes	Yes	Yes
H. BESS unit PCS/compartment fire	Yes	No	Yes[b]
I. BESS unit chiller compartment fire	Yes	No	Yes[b]
J. BESS MV transformer fire	Yes	No	Yes
K. Auxiliary transformer fire	Yes	No	Yes
L. General storage container fire	Yes	No	Yes
M. HV transformer fire at NE-BESS substation	Yes	No	Yes
Site wide			
N. Bushfire	Yes	No	Yes

Note
a) Escalation potential to Stage 3 BESS is not expected based on the separation distances.
b) Fire strategy for this scenario is covered by the fire strategy for BESS unit on fire scenario.

Analysis findings

For the scenarios that were carried forward for further analysis, consequence modelling and review of the fire strategies and the supporting measures (fire prevention, detection and protection) were completed.

The study findings are as follows:

- Based on the separation distances, fires from existing infrastructure from NES Stages 1 and 2 are not expected to escalate to the Stage 3 BESS compound. Bushfire is also not expected to impact the BESS compound accounting for the APZ provided for the overall NES site and the BESS compound.
- A credible fire scenario for the proposed BESS is a battery compartment fire which was analysed to understand the consequences of a BESS unit on fire. The analysis found that:

  Heat radiation impact

  - The 3 kW/m^2 heat radiation (emergency responder endangerment) does not impact the cooling water tanks and pump but may affect accessibility to some fire hydrants depending on the location of the BESS unit on fire. If a BESS unit on fire is impeding access to the closest hydrant, the next two closest hydrants will be accessible to provide cooling to nearby units (i.e. coverage redundancy included).
  - The 4.7 kW/m^2 heat radiation (personnel injury) does not impact the buildings within the BESS compound and remains within the BESS compound boundary (i.e. no offsite impact resulting in injury/fatality).
  - The 23 kW/m^2 heat radiation (propagation to non-combustible material) extends 5 m from the BESS unit on fire and propagation to the front adjacent BESS unit is theoretically possible in absence of any fire protection measures to prevent the fire spread. Protection measures on the adjacent BESS unit to minimise risk of fire propagation includes (1) 2-hour fire rated battery compartment walls, (2) liquid cooling on the battery modules and (3) cooling using fire hydrants.

  Dispersion of toxic combustion products

  - Distances to AEGL-1 (irritation), AEGL-2 (injury) and AEGL03 (fatality) remain within BESS compound boundary (i.e. no offsite impact resulting in injury/fatality).
- A Computational Fluid Dynamics (CFD) analysis was carried out to assess the thermal runaway or fire propagation potential to adjacent units in the event of a single battery unit burning. The CFD models reflect the project specific battery system and configuration (i.e. spaced 3 m apart on all sides) and did not account for the effects of any fire suppression systems or first responders (no intervention assumed). The analysis simulated the effects of single battery unit burning to adjacent battery units under (1) no wind and (2) the 99th percentile wind speed for Uralla, i.e. 30 miles per hour (mph) equivalent to 13.4 m/s. The findings are as follows:
  - Predicted air temperatures in the battery compartment of adjacent units do not approach the cell venting temperature in any wind conditions modelled. Therefore, propagation of a fire to thermal runaway in an adjacent unit is not expected.
  - Modelling results indicate that maximum heat fluxes on or near the surface of adjacent units may cause damage to components such as gaskets or rubber seals resulting in a path for flames or hot gases to be drawn into an adjacent unit leading to temperature rise and thermal runaway. To address this, the B-Vault AC system design includes a layer of steel covering the door gaskets/seals designed to reduce heat exposure. The exhaust fans on the outside of the enclosure are also protected with a steel damper when not in use. These additional barriers are designed to provide protection to the major vulnerable areas on the exterior of the enclosure.
  - Modelling results indicate that maximum temperatures on the outside of adjacent units could melt the door seals, creating new openings for hot gases to enter the

enclosures. To address this, the B-Vault AC system design includes a layer of steel covering the door gaskets/seals to protect the door seals. If the door seals are damaged, the steel is intended to block hot gases from entering the enclosure.

- In the event of a BESS unit on fire, a defensive fire response strategy will be adopted (i.e. allow the affected unit to burn in a controlled fashion until all fuel sources are depleted), where:
  - There is no requirement to apply water directly to the BESS unit on fire.
  - Cooling water may be applied to nearby equipment or structures for cooling as necessary using dedicated fire hydrants provided around the perimeter of the BESS array. Decision to provide cooling will be made in coordination between:
    - ACEN (facility owner)
    - Energy Vault (O&M Contractor and the OEM Subject Matter Expert)
    - FRNSW (emergency responder).
- The fire safety strategy and the supporting design features and/or control measures (fire prevention, detection and protection) are appropriate for the specific fire hazard and adequate to meet the extent of the potential fires.
- The combined volume of the cooling water supply (TK01-02) meets the demand which was based on the requirement to have 3 hydrant outlets with flow of 10 L/s for 4 hours (i.e. 432 kL).
- During a fire event requiring application of cooling water, the penstock valve at the drainage catchpit will be in closed position to prevent spent cooling water discharge to the stormwater drain. From the catchpit, the water is pumped into the spent cooling water tank (TK-03). The volume of the spent cooling water tank (432 kL) equals the volume of the cooling water supply tanks.

Recommendations

The study recommendations including those accepted for implementation or further assessment are presented in the following table.

In line with Condition 23 of Schedule 3 of the Development Consent, following the Secretary's approval of the Fire Safety Study, the Applicant is required to implement the recommendations described in the Fire Safety Study. Implementation of these recommendations will be audited for compliance through a number of mechanisms including:

- Design requirements through the Construction Certificate process.
- Confirming built infrastructure has been constructed in accordance with the design through the Occupation Certificate process.
- The Independent Audit process as nominated by Condition 11 of Schedule 4 of the Development Consent.

Additionally, any findings relating to fire and emergency response will be captured in the updated Fire and Emergency Response Plan as well as details of how the Battery Storage can be safely isolated in an emergency (Development Consent, Schedule 3, Condition 26).

Summary - study recommendations accepted for implementation or further assessment

No	Recommendations	Accepted for implementation / further assessment?	Remarks (ACEN and Energy Vault)
1	Energy Vault (O&M Contractor) to comply with the Certifier's requirements on provision of first aid fire protection for the BESS Compound buildings as part of the occupancy certification.	Yes	Accepted for implementation. First aid fire protection will be provided for the BESS compound buildings per the National Construction Code (NCC) requirements for each building. Energy Vault is finalising the design of the buildings. Once finalised and NCC requirements are known these will be provided to FRNSW.
2	ACEN and Energy Vault to investigate options to automate fire notification from the Stage 3 BESS facility to FRNSW. Note: In its feedback on the Rev 0 FSS submission, FRNSW recommends providing Alarm Signalling Equipment (ASE) or similar to ensure automatic notification.	Yes	Currently, the proposed design is based on manual notification by the Remote Monitoring Centre (RMC) operator in the event of an emergency. The BESS facility will be monitored 24/7 and remotely controlled from the RMC. The BESS control systems include notifications and alarms (audible and visual) to assist the RMC operator to troubleshoot and alert any abnormal events or an emergency. During an emergency, the RMC operator will notify: - Emergency Services (i.e. FRNSW) by calling 000 - The designated Emergency Response Coordinator (ERC) - Energy Vault's Support Engineer. The project has accepted the recommendation to provide automatic notification of a fire alarm to FRNSW. The engineering solution to provide automatic notification to FRNSW will be developed and implemented in consultation with FRNSW to ensure the specific requirements are met.

No	Recommendations	Accepted for implementation / further assessment?	Remarks (ACEN and Energy Vault)
3	ACEN to consider integrating all NES Fire Detection Control and Indicating Equipment (FDCIEs) including Stage 3 BESS to a site wide FDCIE. This will provide a site wide alert improving the emergency response coordination between the different O&M contractors for the solar farm and BESS. Currently, there are separate FDCIEs established across the different areas or infrastructure with the NES (e.g. substation, solar farm O&M building and warehouse have separate FDCIEs).	No	The BESS FDCIE will be kept separate from (1) the BESS substation FDCIE and (2) the solar farm FDCIE, i.e. these will not be tied together.
4	ACEN to update the NES Fire and Emergency Response Plan (FERP) to include emergency response actions for fire scenarios at the BESS compound, including: - Scenarios included in Section 8 *Incident Scenarios and Procedures* of the B-Vault ERP, Ref [1]. - Safe stand-off distance of 30 m shall be maintained between individuals and the BESS unit on fire, per the B-Vault ERP. - Specification of the required PPE and resource for emergency response personnel, including Self-Contained Breathing Apparatus (SCBA), portable gas detectors and thermal imaging devices. - Contact numbers of the Energy Vault Remote Monitoring Centre and Support Engineer. - Fire strategy and measures outlined in Sections 6.2 to 6.4.	Yes	Accepted for implementation. Recommendation is aligned with the Energy Vault Platform 2 ERP.
5	ACEN and/or Energy Vault (O&M Contractor) to coordinate Pre-Incident Planning (PIP) with the local fire services once the BESS is operational (typically within the first year of operation) and subsequent exercises as agreed with fire services. The PIP and exercises will assist to familiarise fire services with the site and access, the available firefighting/fire response equipment and water supply, and test the response time from notification to arriving on site.	Yes	Accepted for implementation.

No	Recommendations	Accepted for implementation / further assessment?	Remarks (ACEN and Energy Vault)
6	ACEN and/or Energy Vault (O&M Contractor) to develop an Emergency Services Information Package (ESIP) for the Stage 3 BESS facility in accordance with FRNSW Fire Safety Guideline – *Emergency services information package and tactical fire plans*. Alternatively, update the existing ESIP to include the Stage 3 BESS facility. Once developed, a copy of ESIP should be made available at the designated site entry point and other locations as determined by the regulatory authority.	Yes	Accepted for implementation.
7	Energy Vault (O&M Contractor) to ensure that the firewater/ cooling water system including the hydrants are tested in accordance with the relevant standards and/or regulatory requirement.	Yes	Accepted in principle. Way forward for implementation to be agreed between ACEN and Energy Vault.
8	ACEN to ensure that the updated FERP has identified local catchment areas and drainage pathways such that appropriate measures may be implemented in the event that the capacity of the provided containment system is exceeded (Ref: Clause 5.8.6 FRNSW BESS FSS Guideline).	Yes	Accepted in principle. The flood study completed for the NES Stage 1 development found that, Ref [2]: - There are 3 major overland flow paths traversing the site - The northern overland flow path drains to Saumarez Creek, while the two southern flow paths directly discharge into the Saumarez Creek Dam. The Stage 3 BESS is located in the southern array. A flood study is being prepared for the Stage 3 BESS. Note: As the volume of the spent cooling water tank (432 kL) equals the volume of the cooling water supply tanks, exceedance of the containment system is not expected.

No	Recommendations	Accepted for implementation / further assessment?	Remarks (ACEN and Energy Vault)
9	ACEN and Energy Vault (O&M Contractor) to ensure that the supporting management and procedures documentation for the BESS facility provide the following details on post incident cleanup and disposal (Ref: Clause 5.9.1 FRNSW BESS FSS Guideline): - Following an incident, how the affected BESS units will be handled and removed (including transportation) from site. - A procedure for testing of the spent cooling water and disposal options in accordance with the test result (i.e. if irrigation is acceptable). Note: As it is not used to suppress fire for the affected BESS unit, the spent water may be only lightly contaminated. Water that is tested and found to be not contaminated should be able to be disposed by on-site irrigation if possible, or to off-site stormwater drains	Yes	Accepted for implementation
10	Energy Vault (O&M Contractor) to ensure that if the temporary storage of battery units onsite is required it meets the requirements specified in FRNSW's position statement for Open Yard Storage of BESS.	Yes	Accepted for implementation where temporary storage onsite is required. Once delivered to site, the intent is to place the battery units onto the dedicated concrete pads where they will be installed with no requirement for temporary storage. This eliminates double handling and reduces risk during construction.
11	ACEN and/or Energy Vault (O&M Contractor) to provide signage at the entrance gate to ensure FRNSW personnel does not enter until a site representative is present	Yes	Accepted for implementation (per FRNSW recommendation).

No	Recommendations	Accepted for implementation / further assessment?	Remarks (ACEN and Energy Vault)
12	Energy Vault (O&M Contractor) to provide further details on the proposed buildings including all relevant NCC requirements. This includes the general storage container (BLD +07). Note: This recommendation was requested by FRNSW in its feedback on the Rev 0 FSS submission.	Yes	Accepted. Energy Vault is finalising the design of the BESS compound buildings. Once finalised and NCC requirements are known these will be provided to FRNSW. Current design are as follows: - All buildings will comply with the NCC requirements and be certified by an independent building certifier. - The fire alarms from each building will be wired back to the SCADA system providing visibility to the operators at the Energy Vault's Remote Monitoring Centre and alert emergency services if needed.
13	ACEN and Energy Vault to provide automated fire notification for the general storage container (BLD +07). Note: In its feedback on the Rev 0 FSS submission, FRNSW recommends ensuring that automatic notification of a fire to the nearest fire station is established for the containers with spare batteries.	Yes	The project notes FRNSW's recommendation to provide automatic notification of a fire to the nearest fire station for containers with spare batteries. The project views that the requirement for automatic notification for the building type and size will be determined by the NCC and Building Certifier's requirements. If automatic notification is required, an engineering solution to provide automatic notification to FRNSW will be developed and implemented in consultation with FRNSW.
14	ACEN and/or Energy Vault (O&M Contractor) to provide signages at appropriate locations (including but not limited to all entrances and the control room) warning the potential electrical and chemical hazards present at the BESS compound, taking into consideration guidance provided in Section 7 of AS 5139 *Electrical installations - Safety of battery systems for use with power conversion equipment.*	Yes	Accepted for implementation.

1 Introduction

1.1 Background

ACEN Australia Pty Ltd (ACEN Australia) has approval to develop the New England Solar and Battery Project (NES). The NES is a grid-connected solar generation facility with a Battery Energy Storage System (BESS) and associated infrastructure, approximately 6 kilometres (km) east of Uralla and 19 km south of Armidale, in the Uralla Shire Local Government Area (LGA). The NES is situated within the New England Renewable Energy Zone (REZ).

The NES was approved, subject to conditions, by the New South Wales (NSW) Independent Planning Commission on 9 March 2020 (SSD 9255). The Development Consent, Ref [3], was most recently modified on 26 May 2023 (MOD 2). Development of the NES is being staged with initial construction of a solar farm (Stages 1 and 2; completed) followed by the BESS in Stages 3 (200 MW/400 MWh) and 4 (1200 MW/2400 MWh; future).

This Fire Safety Study (FSS) report was prepared for the Stage 3 BESS. This report (Revision 1) has been updated to incorporate Fire and Rescue NSW (FRNSW) feedback on Revision 0 (report submitted for adequacy review to FRNSW).

1.2 Purpose of this study

This FSS was prepared to address the requirements of Schedule 3 Condition 23 of the NES Development Consent, Ref [3]. The condition and references where the requirements are addressed in this document are shown in Table 1-1.

This FSS has been prepared with input from:

- ACEN Australia: the facility owner.
- Entura: the facility owner's BESS consultant.
- Energy Vault Pty Ltd (Energy Vault): the Engineering Procurement and Construction (EPC) and Operations and Maintenance (O&M) contractor for NES Stage 3, and also the BESS Original Equipment Manufacturer (OEM).
- RJE Global Pty Ltd (RJE): the Balance of Plant (BOP) subcontractor for NES Stage 3.
- Consultation and feedback from FRNSW.

Table 1-1 Development consent requirements – Fire Safety Study

Requirements – Fire Safety Study, Ref **[3]**	Reference to development consent	Where addressed in this study
Prior to commencing construction of the battery storage facility, unless the Secretary agrees otherwise, the Applicant must prepare a Fire Safety Study for the development, in consultation with FRNSW and RFS and to the satisfaction of FRNSW and the Secretary. The study must:		

Requirements – Fire Safety Study, Ref **[3]**	Reference to development consent	Where addressed in this study
be consistent with the: • Department's Hazardous Industry Planning Advisory Paper No. 2 'Fire Safety Study' guideline; and • NSW Government's Best Practice Guidelines for Contaminated Water Retention and Treatment Systems;	23 (a)	Section 3
describe the final design of the battery storage facility;	23 (b)	Section 2
for the option of a purpose-built Battery Storage building, report the controls adopted and demonstrate consistency with the hazard controls described in the Preliminary Hazard Analysis (Sherpa, 21 August 2022) and New England Solar and Battery Project – Submissions Report dated 18 January 2023	23 (c)	Not applicable. A purpose-built battery storage building was not adopted
include reasonable worst-case bush fire scenario to and from the battery storage and the associated bush fire management; and	23 (d)	Section 4 Section 6
identify measures to eliminate the expansion of any fire incident including: • adequate fire safety systems and appropriate water supply • separation and/or compartmentalisation of battery units • strategies and incident control measures specific to the battery storage design.	23 (e)	Section 4 Section 5 Section 6 Section 7
Following the Secretary's approval, the Applicant must implement the Fire Safety Study.		

1.3 Objective

The overall objective of the FSS is to ensure that the proposed fire prevention and protection strategies and measures are appropriate for the specific fire hazard and adequate to meet the extent of the potential fires.

The objectives of this FSS were to:

- Identify fire events associated with the proposed BESS.
- Identify fire scenarios from existing infrastructure that could impact/escalate to the BESS facility.
- Understand the consequences and impact from credible fire events.
- Outline the fire safety strategy and the supporting measures (prevention, detection and protection measures) for the identified fire events.
- Identify recommendations to improve fire detection and protection for the BESS facility.

1.4 Scope

The scope of the FSS covers the operations phase of the proposed BESS and include:

- Fires associated with Stage 3 BESS and associated equipment/infrastructure (e.g. battery enclosures, transformers, spares facility).
- Fires that could escalate to the Stage 3 BESS compound (e.g. fires from the existing NES infrastructure, bushfire).

Transport of BESS and associated equipment to-and-from the site and the future Stage 4 BESS (1,200 MW/2,400 MWh) are excluded from the study scope.

2 Development description

This section provides an overview of the features of the development that are relevant to the FSS. Further details can be found in the Environmental Impact Statement (EIS), Ref [4].

2.1 NES

An overview of the NES development is provided in Table 2-1. The NES site location and layout are provided in Figure 2-1 and Figure 2-2, respectively. The Substations and Stage 3 BESS compound area are shown in Figure 2-3.

Table 2-1 NES overview

Aspect	Description
Overview	The NES comprises a solar farm, a BESS, substations and supporting infrastructure. The NES generates electricity and supply to the electricity grid. The BESS would store excess energy during peak production periods to later transmit into the grid when required (e.g. peak demand periods) and support stabilising the supply of electricity to the National Electricity Market (NEM). The solar farm's total generation capacity is approximately 720 MW_{AC}. The BESS storage capacity will be approximately 1,400 MW/2,800 MWh developed over two stages (i.e. Stage 3 200 MW/400 MWh and Stage 4 (future) 1,200 MW/2,400 MWh). At the grid substation, the electricity generated from the solar arrays are stepped up to 330 kV and injected into the electricity grid via the Transgrid 330 kV transmission line which traverses through the NES.
Location and surrounding land uses	The NES is located at Lot 2, Big Ridge Road, Uralla, NSW 2358. The site is approximately 6 km east of Uralla and 19 km south of Armidale, in the Uralla Shire LGA. The land in the development footprint is zoned RU1 'Primary Production' under the Uralla Local Environmental Plan (LEP) 2012.
Access to site	Vehicle access to the site, including for emergency response, will be via New England Highway, Barleyfields Road (North) and Big Ridge Road.
Hours of operation	The NES is operational 24 hours per day. The site will be staffed during daylight hours generally between 7 am to 6 pm Monday to Friday. Staff will be on call during weekends and public holidays.
Operational workforce	The NES workforce is up 15 full time employees, responsible for ongoing operation and maintenance of the site, in addition to security monitoring of the infrastructure. Specialist contractors and /or equipment manufacturers will be engaged to perform operational and maintenance activities as required.
Security	A security fence is provided around the perimeter of the site. Site access will be controlled for authorised personnel only.

Figure 2-1 NES site location

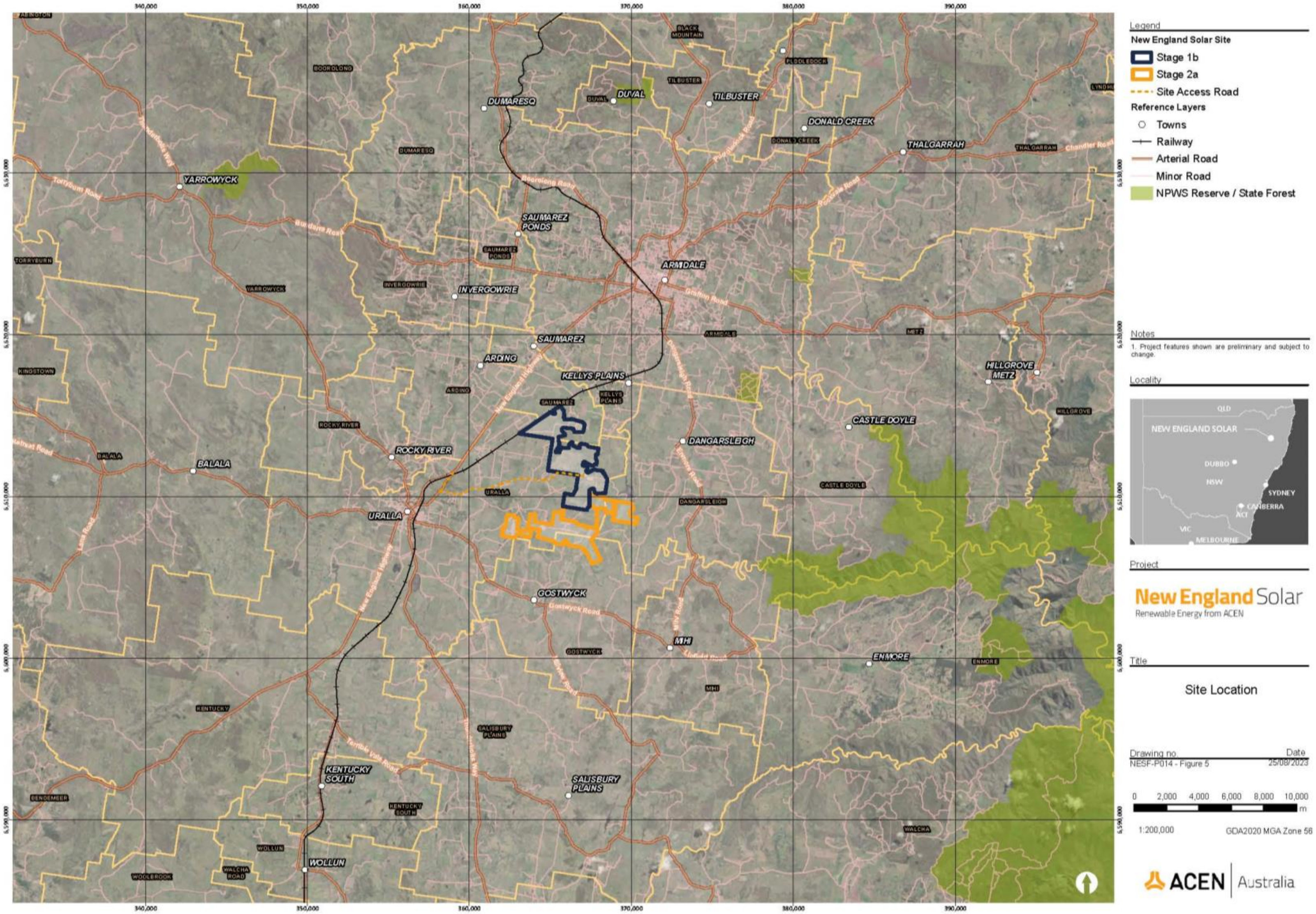


Figure 2-2 NES site layout

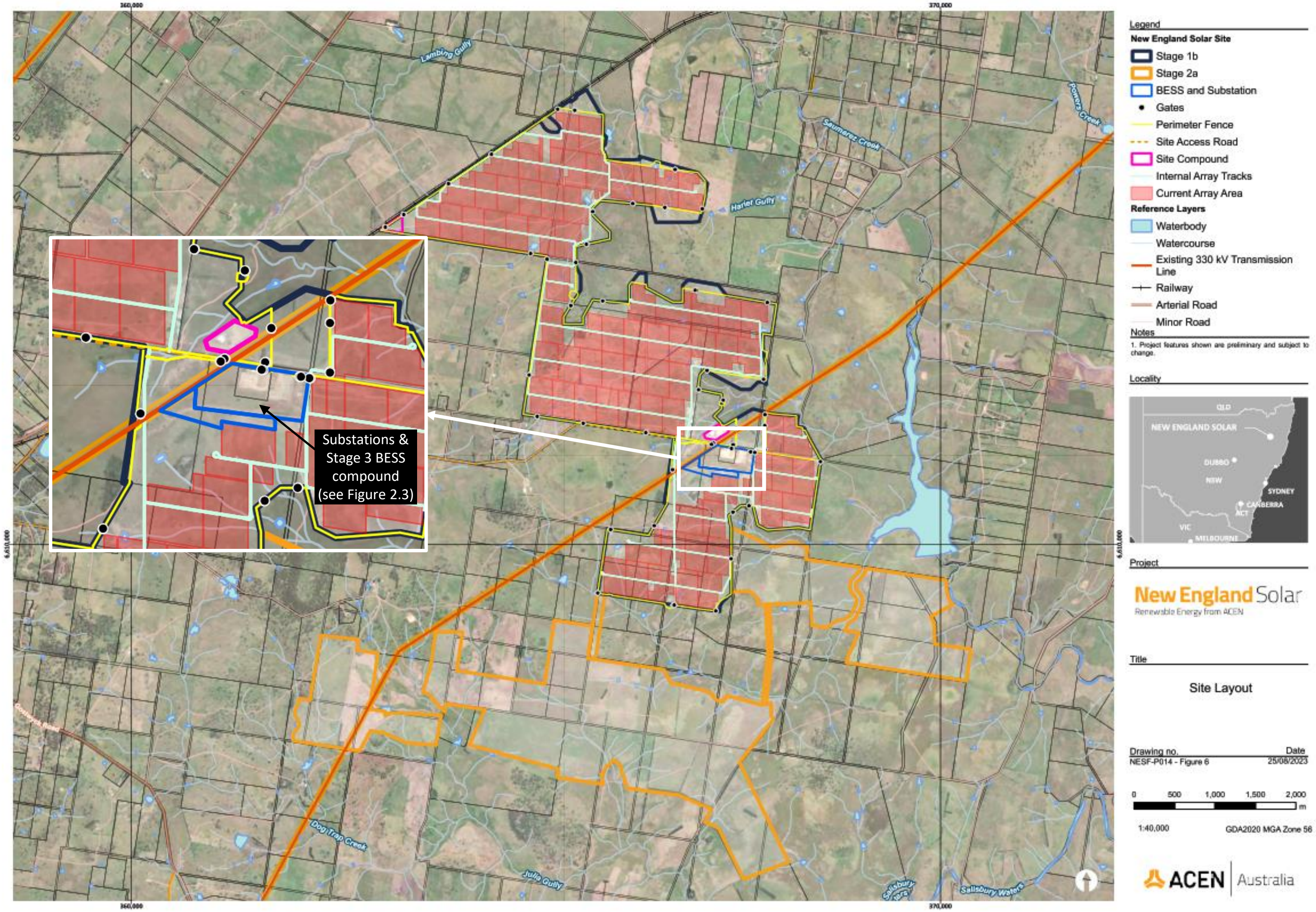


Figure 2-3 Substations and Stage 3 BESS compound area

2.2 Stage 3 BESS

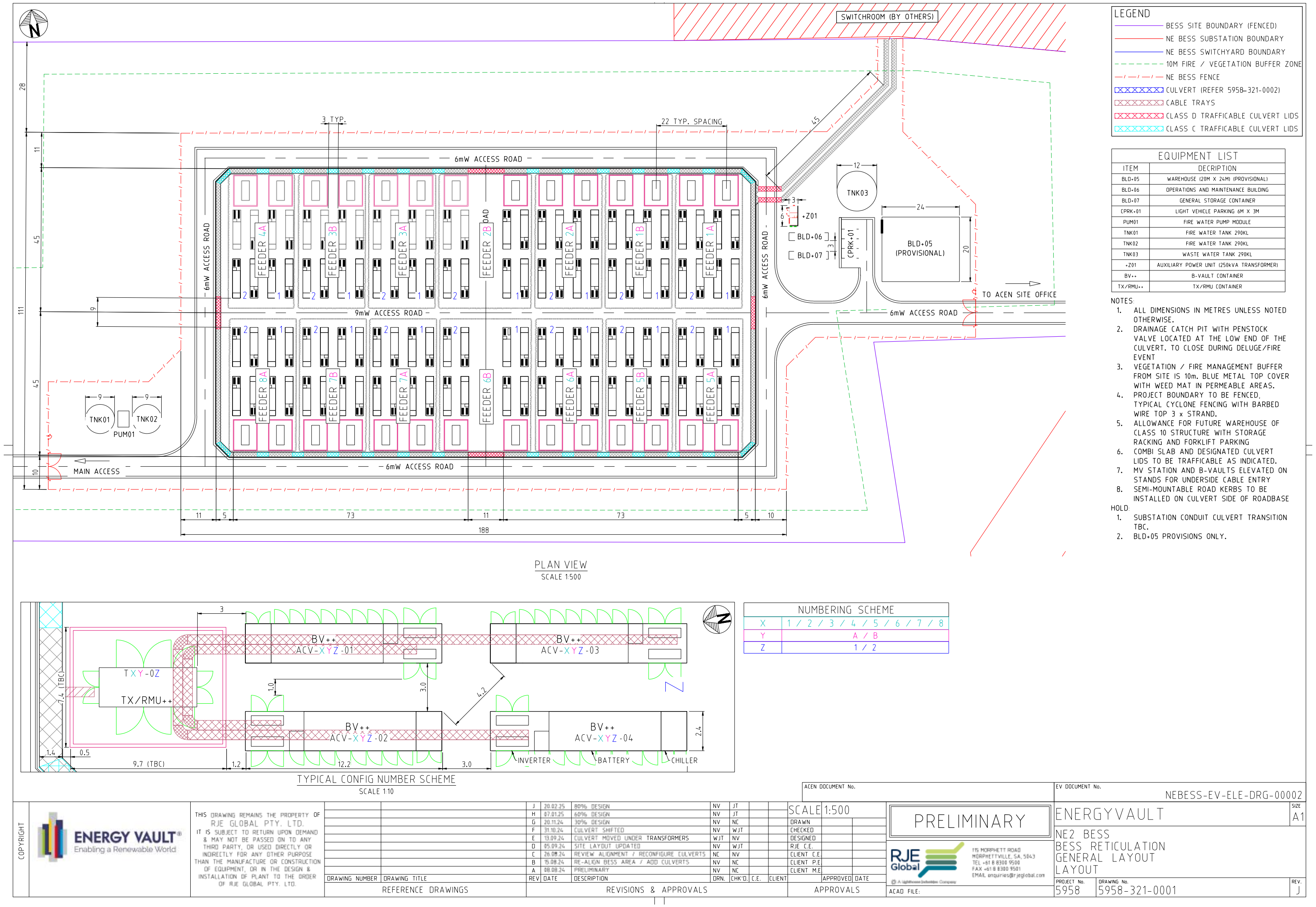
2.2.1 Overview

An overview of the Stage 3 BESS is presented in Table 2-2. The layout of the BESS compound is shown in Figure 2-4.

Table 2-2 Stage 3 BESS

NES Stage 3 BESS	Description
Location	The BESS compound is located adjacent to the grid substations in the central array area (as shown in Figure 2-2).
Installation	The BESS units will be installed outdoors in accordance with the OEM installation instructions, including clearance requirements.
Overall capacity	200 MW/400 MWh
BESS OEM	Energy Vault
BESS model	B-Vault AC BV 2.7
No of BESS enclosures	112 units Note: 56 units BV 2.7 (14 strings) + 56 units BV 2.7 (15 strings)
MV transformer OEM	Jiangsu Huapeng Transformer
No of MV transformers	28 units overall (each connected to 4 BESS units)
Supporting infrastructure	1. Switchroom building 2. Warehouse (provisional) 3. O&M building 4. General storage container 5. Firewater/cooling water tanks (2 x 216 kL effective capacity) 6. Firewater/cooling water pump module 7. Drainage catch pit with penstock valve (located at the low end of the culvert) and submersible pump 8. Spent cooling water tank (1 x 432 kL effective capacity) 9. Auxiliary Power Unit (APU), housing the Main Switchboard (MSB) and 250 kVA transformer 10. Light vehicle parking area 11. Security fence 12. Firebreak buffer (10 m)
Grid connection	A new substation will be established for Stage 3 BESS (i.e. NE BESS Substation), located north of the BESS compound. NES1 and NES2 Substations are the grid substations established for Stages 1 and 2 of the development.

Figure 2-4 NES Stage 3 BESS layout



2.2.2 Battery system

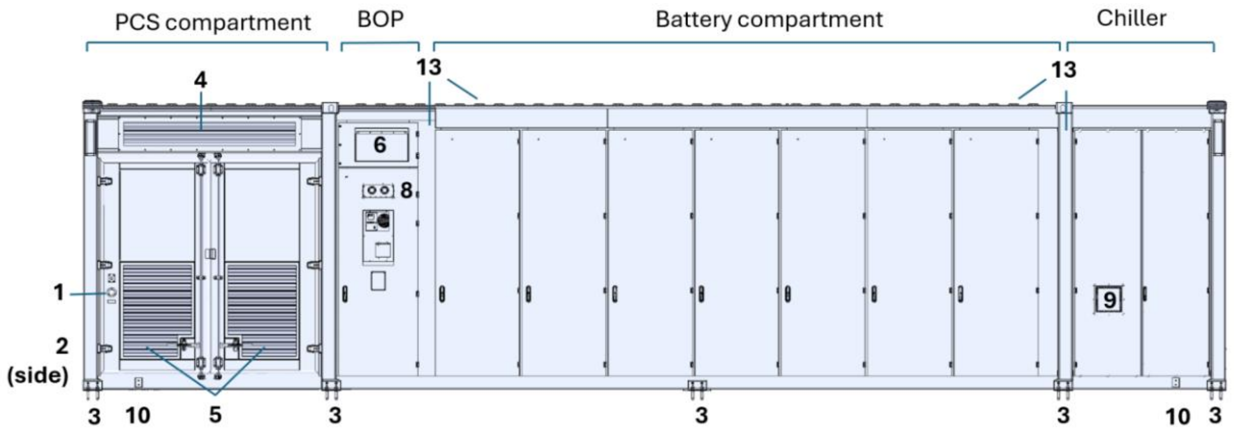
The components and features of the battery system are provided in Table 2-3, Ref [5] and [6]. Information on the fire prevention and protection systems are included in Section 6.

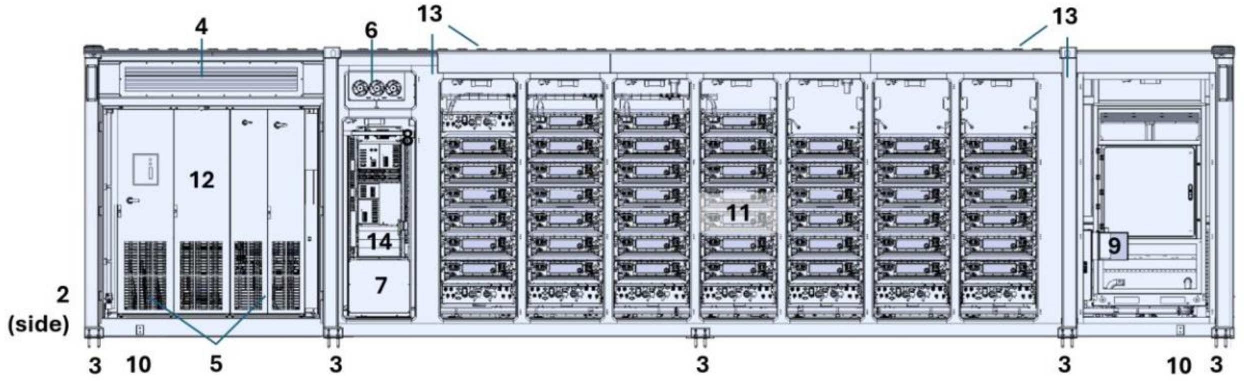
Table 2-3 Battery system overview

Component/features	Description
Overview	The B-Vault is a modular, fully integrated lithium battery BESS solution that is customisable with both AC and DC electrical outputs. The AC option includes an integrated Power Conversion System (PCS) and the enclosure is designed to connect directly to a Medium Voltage (MV) transformer. The B-Vault AC includes the following 4 compartments (the schematic view of the is shown in Figure 2-5): 1. PCS compartment: houses the inverter modules 2. BOP compartment: houses the following: o An internal auxiliary transformer o Auxiliary power distribution and circuit breakers o Battery Management System (BMS) o A Fire alarm and control panel (FACP) o Backup power supplies. 3. Battery compartment: each B-Vault AC BV 2.7 enclosure will include up to 15 battery strings, where a string consists of 3 battery modules. The 14 strings and 15 strings variants will consist of 42 modules and 45 modules respectively, distributed over 7 available racks. Each rack can accommodate up to 8 battery modules and is equipped with a dual switchgear box. For the 15 strings variant, a single switchgear box is provided at the top of the container for the 15th string. 4. Chiller compartment: houses the centralised chiller and the Heating Ventilation and Air Conditioning (HVAC) unit. The chiller cools all battery modules via a single liquid cooling loop. The HVAC controls the humidity and temperature inside the battery compartment.
Battery	Manufacturer: REPT* Cell capacity: 314 Ah Chemistry: Lithium Iron Phosphate (LFP) Module model no: Y104 (double deep) Module integration form: 1P104S (104 cells/module) Capacity per module: 104.499 kWh No of modules on each unit: 42 (14 strings) / 45 (15 strings) Capacity on each unit: 4.389 MWh (14 strings) / 4.702 MWh (15 strings) *The battery cells, modules, and racks that will be used in the B-Vault AC BV 2.7 are manufactured by REPT Battero Energy Co Ltd (REPT).

Component/features	Description
PCS	PCS or inverters are electrical devices that convert DC to AC or vice versa (i.e. bi-directional). The inverters function to convert the current between the battery and the solar farm or the grid. Siemens S120 Sinamics inverters are used for BV 2.7 (capacity 280 MVA).
Discharge and Charge duration	2 hours
Dimension	(L) 12.19 m x (W) 2.44 m x (H) 3.10 m
Ingress protection	IP 54, NEMA Type 3X
Temperature management	• Battery modules/packs: Liquid cooling system • Battery compartment: HVAC • PCS compartment: Forced convection
Safety systems	• Fire and Alarm Control Panel (FACP) • Heat and smoke detectors • Explosive gas detection and active ventilation system • 2-hour firewalls on battery compartment • Surge protection devices and circuit breakers • Back-up power supplies including 8-hour Uninterrupted Power Supply (UPS) for communication equipment and battery backup for the FACP (24-hour in idle or 2-hour for alarm and exhaust fans) • F-stop (or E-stop button).
Compliances/ certifications	• B-Vault: CSC, UN 3536, Complies to AS/NZS 3000 • Battery system: UL 1973, UL 1642, UN 38.3, UL 9540A, IEC 62619, IEC 63056, IEC 60730-1, NFPA 855, BS EN1364-1. • PCS: EN ISO 13849-1, EN 60146-1-1, EN 60204-1

Figure 2-5 Schematic view – B-Vault AC BV 2.7





Legend

1. E-Stop Button
2. Water hose hookup
3. Anchoring points
4. PCS air exhaust
5. PCS air intake
6. Exhaust damper & fan assembly
7. Common DC busbar (front) / auxiliary transformer (back)
8. Fire strobe and alarm
9. HVAC air exhaust
10. Grounding lug
11. Battery racks
12. PCS
13. Firewall (2-hour rated)
14. UPS & battery

2.2.3 Battery system fire tests

UL 9540A test

Energy Vault has completed a Unit-level test[1] in accordance with UL 9540A *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*[2] for its battery rack (Model No: Y104R04-314) with 8 battery modules overall, comprising 4 battery modules in series per string, Ref [7]. The purpose of the test was to assess the ability to contain thermal runaway in the initiating unit[3] and prevent a fire from spreading to adjacent target units. Energy Vault confirmed that the test result is also applicable for B-Vault AC BV 2.7 which uses 3 battery modules in series per string, Ref [8].

A summary of the test results is as follows:

- Flaming outside the initiating unit was not observed.
- Surface temperatures of modules within the target units adjacent to the initiating unit did not exceed the temperature at which thermally initiated cell venting occurs.
- For units intended for installation in locations with combustible constructions, surface temperature measurements on wall surfaces did not exceed 97°C (175°F) of temperature rise above ambient.
- Explosion hazards were not observed, including deflagration or detonation.
- Heat flux in the centre of the accessible means of egress did not exceed 1.3 kW/m^2.

The test concluded that the performance criteria of the Unit-level test have been met and therefore a UL 9540A installation level testing need not be conducted.

Full-scale burn test

The B-Vault AC BV 2.7 is designed specifically for NES Stage 3 BESS. Although a full-scale burn test has not been completed for the B-Vault AC BV 2.7 at the time of this FSS, a justification on the project's position has been provided to FRNSW on:

- How the risk of a battery unit on fire and potential for propagation will be adequately managed,
- Risk to firefighters is minimised (non-intervention strategy), and
- Completion of a full-scale burn test is not required.

This was provided as part of the response to FRNSW comments on the Revision 0 of this report and included in APPENDIX B.

[1] Test on a frame, rack, or enclosure that consists of a functional BESS that includes components and subassemblies such as cells, modules, battery management systems, ventilation devices, and other ancillary equipment.

[2] 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.

[3] In the context of the test results, Ref [4], the unit refers to a battery string comprised of 4 battery modules.

2.2.4 Buildings

The following buildings and/or structures will be built as part of the Stage 3 BESS development:

- BLD+05 Warehouse (future)

  Space for a future warehouse is reserved on the layout. If required, the warehouse would store equipment (including a forklift and maintenance vehicle) and materials for maintenance activities of the BESS compound.

- BLD+06 O&M building

  The O&M building will house a control room and amenities.

- BLD+07 General storage container

  A 40-ft High Cube container will be used to store spare batteries and parts for maintenance and service needs of the B-Vault battery system. The container will be equipped with temperature and humidity sensors, CO and smoke detectors, Ref [9].

All buildings will comply with the National Construction Code (NCC) and be certified by an independent building certifier. The fire alarms from each building including the general storage container will be wired back to the SCADA system via the Comms rack at BLD +06 O&M building, providing visibility to the operators at the Energy Vault's Remote Monitoring Centre to manage the response and alert emergency services as needed.

Recommendation 12: Energy Vault (O&M Contractor) to provide further details on the proposed buildings including all relevant NCC requirements. This includes the general storage container (BLD +07).

Recommendation 13: ACEN and Energy Vault to provide automated fire notification for the general storage container (BLD +07). In its feedback on the Rev 0 FSS submission, FRNSW recommends ensuring that automatic notification of a fire to the nearest fire station is established for the containers with spare batteries.

2.2.5 Operations

The BESS facility will operate 24 hours per day, seven days per week. The BESS will include a control and monitoring system enabling remote start-up, operation and troubleshooting (i.e. response to system notifications and alarms) from the following locations:

- Site control room - located in the BESS compound O&M building.
- Energy Vault's Remote Monitoring Centre (RMC).

Note: The B-Vault is designed to be remotely operated by VaultOS, Energy Vault's proprietary energy management system (EMS). Faults from the B-Vault is communicated to the EMS rack typically located at the BESS O&M or substation building. The EMS reports the faults to the Remote Monitoring Centre where they can be examined, and an appropriate maintenance action can be instructed. Critical safety functions are hardwired into the B-Vault and are not dependent on the EMS.

The BESS will be monitored 24/7 and normally controlled from Energy Vault's RMC to ensure safe and reliable operations.

The BESS will be connected via a Supervisory Control and Data Acquisition (SCADA) panel to the Transgrid (the Network Service Provider) Automatic Generation Control (AGC) system and also to the Australian Energy Market Operator (AEMO) (the Energy Regulator) systems.

In the event of an emergency requiring assistance from Emergency Services/combat agencies, the requests will be coordinated from the RMC. Further information on emergency response in the event of a BESS fire is provided in Section 6.8 (e.g. notification/callout, response time for NES personnel to attend to site during unmanned hours, support from Energy Vault Engineer to provide product specific advice).

2.3 Hazardous materials

Details on the hazardous materials stored or used on site including their Dangerous Goods (DG) classification, storage location and quantities are provided as follows:

- Table 2-4: Stages 1 and 2 (Existing infrastructure)
- Table 2-5: Stage 3 (Proposed BESS).

Table 2-4 Hazardous materials – Stages 1 and 2 (Existing)

NES development	Material	DG class	Category	Storage location	Notes
Stages 1 and 2 (Existing)	LPG	2.1	Flammable gas	O&M building	Minor quantity (2 x 9 kg cylinders) for BBQ.
				Warehouse	Minor quantity (1 x 9 kg cylinders) for heat guns.
	Gasoline	3 PG II	Flammable liquid	South of the solar farm warehouse	Used for refuelling site vehicles. Tank is double skinned (self-bunded) with capacity of 2,500 L.
				Warehouse	Jerry cans approximately 120 L (5 x 20 L and 2 x 10 L).
	Kerosene	3 PG III	Flammable liquid	Warehouse	Minor quantity (1 L).
	Turpentine	3 PG III	Flammable liquid	Warehouse	Minor quantity (5 L).
	Degreaser	8 PG II	Corrosive liquid	Warehouse	Minor quantity (20 L).
	LFP batteries	9	Miscellaneous	Warehouse	Spare batteries
	Diesel	C1	Combustible liquid	South of the solar farm warehouse	Used for refueling site vehicles and top-up supply for the backup power generator at the substation. Tank is double skinned (self-bunded) with capacity of 6,500 L.
				Warehouse	Minor quantity (1 x 20 L jerry can).
				Substation (back-up generator)	The backup generator at the substation is also self-bunded.
	Transformer oil (Mineral oil)	-	-	Substation	Used in transformers as insulating and cooling fluid. No spare transformer oil will be stored on site.

Table 2-5 Hazardous materials – Stage 3 (Proposed BESS)

NES development	Material	DG class	Category	Storage location	Notes
Stage 3 (Proposed BESS)	R134A/R410A/ R513A	2.2	Non-flammable Non-toxic gas	BESS units	Used as refrigerant for the BESS chiller compartment.
	R32	2.1	Flammable gas	BESS units	Used as alternative refrigerant for the BESS chiller compartment.
	LFP batteries	9	Miscellaneous	BESS units	Battery modules used for the BESS
				General storage container	Spare batteries
	Glysantin G30	-	-	BESS units	Used as liquid coolant for the battery packs/modules. Not classified as DG – included for completion only.
	Transformer insulating liquid (FR3)	-	-	MV transformers	Used as insulating and cooling fluid. No spare fluids will be stored on site. FR3 fluid has a high flash and fire points (≥ 330°C; twice as high as mineral oil). It is classified as a “less combustible” dielectric fluid for transformer application. The estimated volume is approximately 5,066 L for each MV transformer unit.
	Transformer oil (Mineral oil)	-	-	NE BESS Substation	Used in transformers as insulating and cooling fluid. No spare transformer oil will be stored on site.
	Note: A dry-type transformer will be used for the APU auxiliary transformer (i.e. does not contain transformer oil).				

3 Methodology

3.1 Overview

This FSS was completed following the methodology specified in the following guidelines:

1. NSW Department of Planning, Housing and Infrastructure (DPHI) (2011): Hazardous Industry Planning Advisory Paper (HIPAP) No 2, *Fire Safety Study Guideline*s, Ref [10].
2. Fire and Rescue NSW (FRNSW) (2023): Fire Safety Guideline Technical Information, *Large-scale external lithium-ion battery energy storage systems – Fire safety study consideration* (referred to as FRNSW BESS FSS Guideline hereinafter), Ref [11].

A review to ensure that the considerations specified in the FRNSW BESS FSS Guideline have been considered or incorporated is provided in APPENDIX A.

The flowchart showing the study approach and input is shown in Figure 3-1. The following steps were completed for the study:

- Establish FSS objectives and FRNSW expectations.
- Identify potential fire hazards, associated scenarios and their consequences.
- Undertake consequence analysis for the identified fire scenarios and propagation potential.
- Review of the fire prevention, detection and protection strategies and measures to support the strategies.
- Review the firefighting water design basis (supply and demand).
- Review of the volumes of spent cooling water against available containment.
- Review of the first aid firefighting/fire protection equipment in place
- Review findings and identify recommendations to improve fire safety.

The NSW Best Practice Guidelines for Contaminated Water Retention and Treatment Systems, Ref [12], was reviewed to ensure that provision for management of spent firewater/cooling water containment for the BESS compound meets the intent of the guideline (i.e. "ensure that the likelihood of significant adverse impact on the environment from contaminated water discharges is acceptably low").

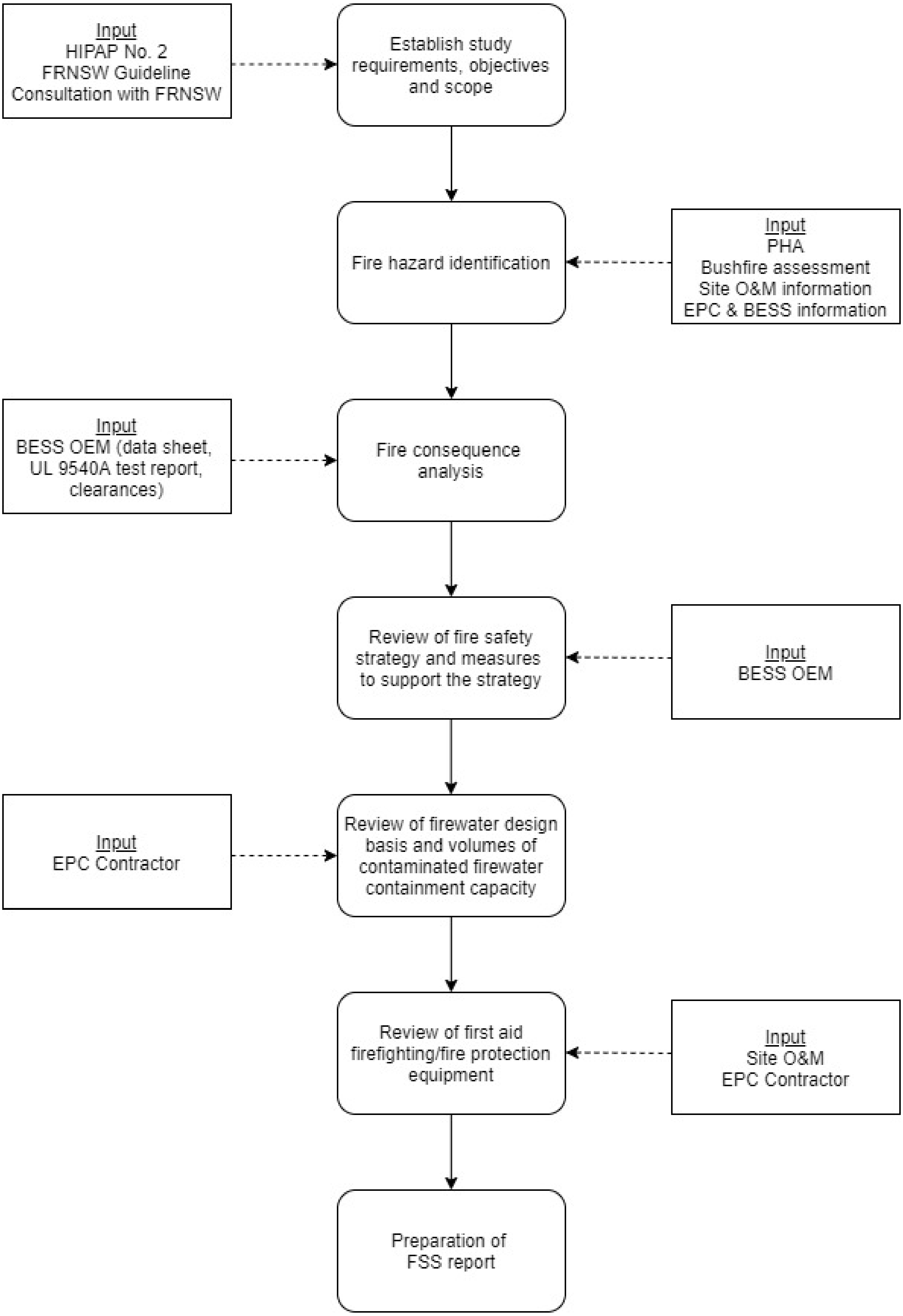
3.2 Consultation with FRNSW

FRNSW is the approving authority for the FSS. To better understand the requirements and expectations of the FSS considerations guideline for large-scale external lithium-ion BESS facilities, a consultation meeting with FRNSW was carried out on 21 November 2023.

3.3 Provision of supporting documents

As per Section 5.2.3 of FRNSW BESS FSS Guideline, Ref [11], supporting documents for the Stage 3 BESS referenced in this study (e.g. battery system datasheet, installation manual, test reports, emergency response procedure) will be provided as part of the FSS submission to FRSNW.

Figure 3-1 FSS approach



4 Fire hazard identification

4.1 Overview

A fire hazard identification (HAZID) review was undertaken to identify credible (1) fire hazards and scenarios associated with the proposed Stage 3 BESS, and (2) fire scenarios that could impact/escalate to the BESS facility (e.g. fires from the existing NES infrastructure).

The following aspects were considered when identifying the fire hazards:

- Type of infrastructure and equipment
- Hazardous materials and DG (for the purposes of the FSS these are flammable or combustible materials)
- Proposed operation activities that could cause or contribute to a fire on site
- External events (e.g. bushfire).

The following inputs were reviewed as part of the fire HAZID:

1. NES Preliminary Hazard Analysis (PHA), Ref [13]. This PHA was completed for input to the Environmental Impact Statement (EIS) to support the NES Development Application (DA). The scope included all proposed infrastructure for the NES, including the Stage 3 200 MW/400 MWh BESS.
2. NES Bushfire Hazard Assessment, Ref [14]. This assessment was also completed for the EIS to support the NES DA.
3. NES Fire and Emergency Response Plan (FERP), Ref [15]. The FERP covered Stages 1 and 2 of the NES.
4. Site O&M information. This includes a list of the hazardous materials and DG stored/used on site (summarised in Section 2.3), information on existing project infrastructure and activities undertaken on site.
5. Stage 3 BESS information obtained from Energy Vault (EPC Contractor and BESS OEM), including.

4.2 Fire HAZID

The fire HAZID table is shown in Table 4-1. It presents the identified fire scenarios including the hazard, location, causes and whether the scenario is carried forward for further analysis and review of the fire strategy and supporting control measures.

Table 4-1 Fire HAZID table

ID	Location	Hazard	Scenario/event	Cause	Remarks	Carried forward for further analysis and fire strategy review
1	Solar farm	Electrical	Photovoltaic (PV) module fire	• Faulty equipment • Electrical failure (e.g. short circuit, water ingress from rain/flood, lightning strike) • External events (e.g. bushfire)	Localised impact and not expected to impact the Stage 3 BESS compound. The separation distance from a BESS unit to the nearest solar array is approximately 50 m (south of the BESS compound).	No
2	Solar farm O&M building	LPG	O&M building fire	Loss of LPG containment from BBQ cylinders	Minor quantity stored. Localised impact and not expected to impact the Stage 3 BESS compound. The separation distance from the solar farm O&M building to the nearest BESS unit is approximately 235 m.	No
3	Solar farm O&M building	Electrical	O&M building fire	Electrical fire (e.g. control room, office, kitchen) escalating to combustible material present in vicinity.	The risk from a building fire is understood and managed by compliance with the National Construction Code (NCC) requirements, appropriate for the building classification. The building had been certified and an occupancy certificate acquired, Ref [16]. The separation distance from the solar farm O&M building to the nearest BESS unit is approximately 235 m.	No
4	Solar farm warehouse	Flammables and combustible liquid (e.g. LPG, gasoline, kerosene, turpentine, degreaser, diesel)	Warehouse fire	Loss of containment from packaging	Minor quantities stored in individual packaging. Localised impact and not expected to impact the Stage 3 BESS compound. The separation distance from the solar farm O&M building to the nearest BESS unit is approximately 205 m.	No
5	Solar farm warehouse	Lithium-ion batteries	Warehouse fire	Thermal runaway of lithium-ion batteries due to elevated temperature (e.g. fire involving flammables stored at the warehouse, bushfire)	Spare batteries are stored at the warehouse (i.e. not energised). Exposure to elevated temperature will be an escalation event. The initiating events are covered separately. The separation distance from the solar farm O&M building to the nearest BESS unit is approximately 205 m.	No

ID	Location	Hazard	Scenario/event	Cause	Remarks	Carried forward for further analysis and fire strategy review
6	Solar farm fuel storage area	Gasoline	Fire at the fuel storage area	Loss of containment: • From the storage tank (e.g. mechanical failure, overfill) • During vehicle refueling (e.g. hose leak)	The storage tanks are double skinned, providing a secondary layer of containment. As a conservative approach, this scenario was carried forward for further analysis to assess potential impact to the Stage 3 BESS compound from a tank rupture scenario (worst case fire scenario).	Yes
7	Solar farm fuel storage area	Diesel	Fire at the fuel storage area	Escalated fire from the adjacent gasoline storage tank (within 3 m) and refueling equipment.	The storage tanks are double skinned, providing a secondary layer of containment. Diesel is a combustible liquid. As a conservative approach, this scenario was carried forward for further analysis to assess potential impact to the Stage 3 BESS compound due to an escalated fire scenario from the adjacent gasoline tanks.	Yes
8	Substations (NES1, NES2, NE BESS)	Diesel	Back-up generator fire	Loss of containment of diesel fuel	The diesel stored within the generator fuel tank will have an internal bund (110% bunded skid base) and is not in the vicinity of any flammable liquid nor it shares the same bund with other flammable liquid.	No

ID	Location	Hazard	Scenario/event	Cause	Remarks	Carried forward for further analysis and fire strategy review
9	Substations (NES1, NES2, NE BESS)	Transformer oil (Mineral oil)	HV transformer fire	• Mechanical failure • Electrical overload due to voltage and current surges • Internal arcing • Faulty equipment • External factors (bushfire, lightning)	Excessive voltage (spikes), overloading and degraded insulating material may result in internal arcing with sufficient energy to rupture the oil tank and ignite the released oil resulting in a bund fire. The risk of harm from a transformer fire is understood and managed by compliance with the relevant standards and codes. This includes requirements to provide (1) bunding, (2) firewall and (3) clearances to other transformers/equipment and buildings, as per AS 2067:2016, Ref [17]. The NE-BESS substation transformer is the closest to the BESS compound. The AS 2067 clearance zones for the NE-BESS HV transformer are as follows: 1. To other transformers and non-combustible surfaces: 23 m 2. To combustible surfaces: 30 m. As the separation distance between the NE-BESS substation to the nearest battery unit is approximately 70 m, these do not encroach to the BESS compound. Refer to the substation layout drawings provided in APPENDIX C. This scenario was carried forward for further analysis to highlight the fire prevention and protection measures in place.	Yes

ID	Location	Hazard	Scenario/event	Cause	Remarks	Carried forward for further analysis and fire strategy review
10	Stage 3 BESS compound (BESS units)	Lithium-ion batteries	BESS unit battery compartment fire	Thermal runaway due to: • Faulty battery (defect) • Electrical failure (e.g. short circuit, excessive voltage, overcharge) • Mechanical damage (e.g. crush, puncture) • Ingress of coolant to battery and short circuit • Fire from adjacent infrastructure (e.g. MV transformer) • External events (bushfire, water ingress from rain/flood, lightning strike	The consequences for a thermal runaway event include: 1. Fire in the battery compartment. 2. Release of toxic combustion products from the battery fire. 3. Explosion due to accumulation of vented gas in the battery compartment.	Yes
11	Stage 3 BESS compound (BESS units)	Electrical	BESS unit PCS or BOP compartment fire	• Faulty equipment • Electrical failure (e.g. short circuit, arc flash) • External events (water ingress from rain/flood, lightning strike	Potential escalation to the battery compartment resulting in thermal runaway in batteries - not separately assessed to the above (battery compartment fire). A firewall is provided between the battery compartment and the PCS-BOP compartment.	Yes
12	Stage 3 BESS compound (BESS units)	R32 (compressed flammable gas)	BESS unit chiller compartment fire	Explosion due to exposure to elevated temperature (e.g. BESS unit on fire, MV transformer fire, bushfire)	R32 is an alternative refrigerant for the BESS chiller compartment. Other refrigerants include R134A, R410A, or R513A are non-flammable gases. Exposure to elevated temperature will be an escalation event. The initiating events are covered separately (e.g. bushfire, BESS unit on fire).	Yes
13	Stage 3 BESS compound (MV transformer)	Transformer insulating liquid (FR3 type)	Transformer fire	• Mechanical failure • Electrical overload due to voltage and current surges • Internal arcing • Faulty equipment • External events (bushfire, lightning)	Refer to remarks above on HV transformer fire. FR3 fluid will be used as the insulating liquid. It is classified as a “less flammable” dielectric fluid for transformer application due to its higher flash and fire points compared to the conventional mineral oil. This scenario was carried forward for further analysis to highlight the fire prevention and protection measures in place.	Yes

ID	Location	Hazard	Scenario/event	Cause	Remarks	Carried forward for further analysis and fire strategy review
14	Stage 3 BESS compound (Auxiliary transformer)	Electrical	Transformer fire	• Faulty equipment • Electrical failure (e.g. short circuit, arc flash) • External events (water ingress from rain/flood, lightning strike	Dry-type transformers are considered to have reduced fire risk compared to oil-filled transformers, primarily as they do not contain insulating oil. This scenario was carried forward for further analysis to highlight the fire prevention and protection measures in place.	Yes
15	Stage 3 BESS compound (General storage container)	Lithium-ion batteries	General storage container fire	Thermal runaway of lithium-ion batteries due to elevated temperature (e.g. BESS unit on fire, MV transformer fire, bushfire)	Spare batteries will be stored in dedicated racks. Charging of the spare batteries will be during maintenance charging only (6-monthly), which will be an attended operation and under a procedure (i.e. charging to be completed one battery pack/module at a time). Exposure to elevated temperature will be an escalation event. The initiating events are covered separately (e.g. bushfire, BESS unit on fire).	Yes
16	Stage 3 BESS compound	External fire	Bushfire	• Encroachment of offsite bushfire • Escalated event due to fire from adjacent infrastructure	Bushfire risk is understood and managed by compliance with the RFS Planning for Bushfire Protection 2019, Ref [18], and implementing recommendations from the bushfire hazard assessment, Ref [19]. This scenario was carried forward for further analysis to highlight the fire prevention and protection measures in place.	Yes

4.3 Scenarios carried forward for further analysis

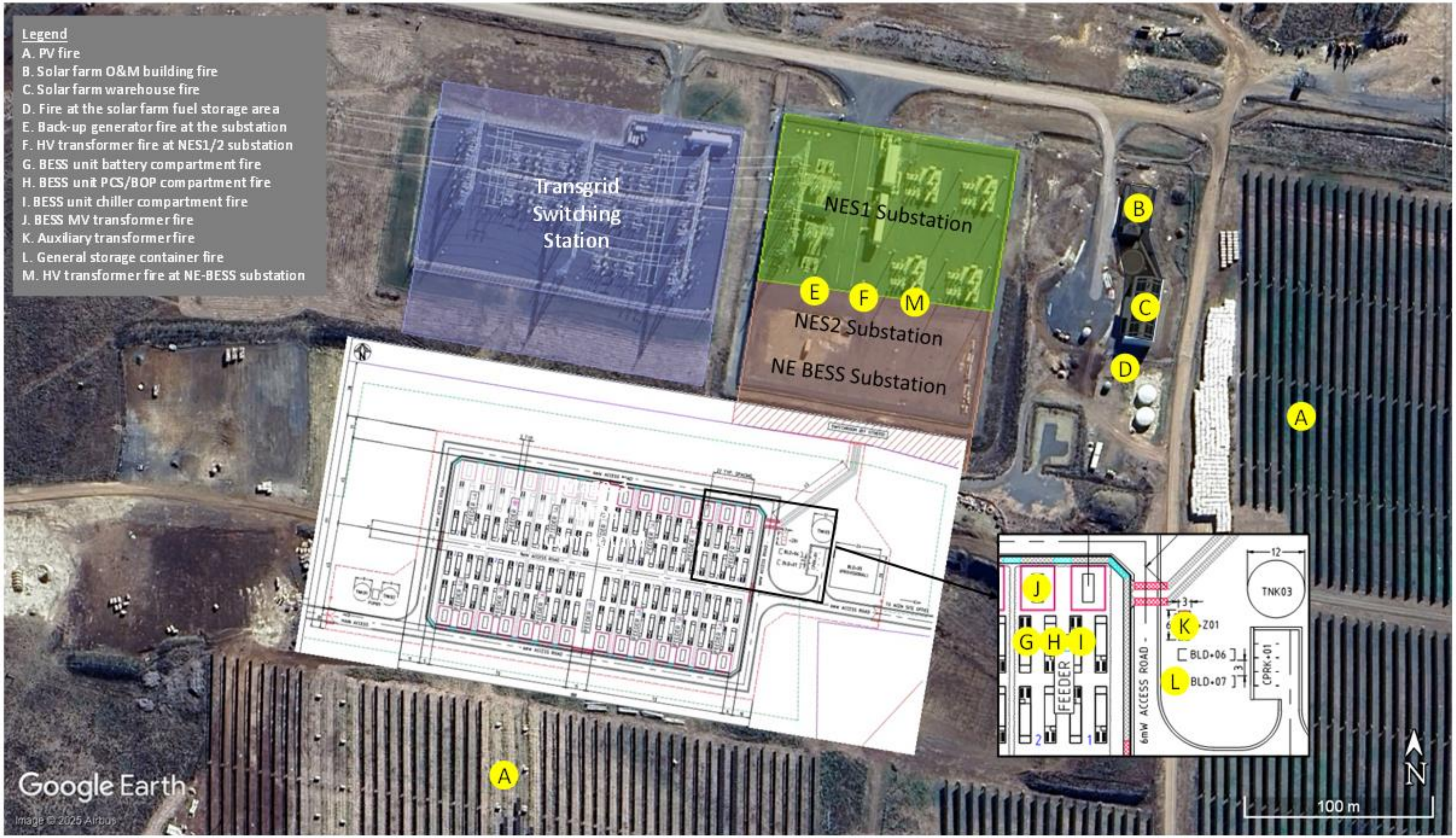
Locations of the fire scenarios are shown in Figure 4-1. A summary of the fire scenarios carried forward for further analysis is provided in Table 4-2.

Table 4-2 Fire scenarios carried forward for further analysis

Fire scenario	HAZID table reference	Carried forward for further analysis	Further analysis	
			Consequence modelling undertaken (Section 5)	Review of fire strategy and supporting measures (Section 6)
Existing infrastructure (Stages 1 and 2)				
A. PV fire	1	No[a]	-	-
B. Solar farm O&M building fire	2, 3	No[a]	-	-
C. Solar farm warehouse fire	4, 5	No[a]	-	-
D. Fire at the solar farm fuel storage area	6, 7	Yes	Yes	Yes
E. Back-up generator fire at the substation	8	No[a]	-	-
F. HV transformer fire at NES1/NES2 substation	9	Yes	No	Yes
Proposed BESS (Stage 3)				
G. BESS unit battery compartment fire	10	Yes	Yes	Yes
H. BESS unit PCS/BOP compartment fire	11	Yes	No	Yes[b]
I. BESS unit chiller compartment fire	12	Yes	No	Yes[b]
J. BESS MV transformer fire	13	Yes	No	Yes
K. Auxiliary transformer fire	14	Yes	No	Yes
L. General storage container fire	15	Yes	No	Yes
M. HV transformer fire at NE-BESS substation	9	Yes	No	Yes
Site wide				
N. Bushfire	16	Yes	No	Yes

Note
c) Escalation potential to Stage 3 BESS is not expected based on the separation distances.
d) Fire strategy for this scenario is covered by the fire strategy for BESS unit on fire scenario.

Figure 4-1 Locations of fire scenarios



5 Consequence analysis

5.1 Overview

The objectives of the consequence analysis were to:

- Determine the extent of impact from the fire scenarios carried forward for analysis. These include (a) BESS unit fire and potential for propagation to adjacent units and (b) Fire at the solar farm fuel storage area, as identified in Table 4-2.
- Identify potential for external fires to impact the Stage 3 BESS facility.
- Identify potential impacts to offsite receptors.
- Provide information for the emergency response teams as input to update the FERP.

A description of the modelling approach, assessment criteria, analysis results and findings are presented in the following sections.

5.2 Impairment criteria

The impairment criteria used are shown in Table 5-1. Distances are recorded at receptor height of 1.5 m.

Table 5-1 Impairment criteria

Event	Impact level	Potential effect	Reference
Fire (heat radiation)	3.0 kW/m^2	Emergency responder endangerment Note: for a 10-minute operation with direct thermal radiation.	AS 1940, Ref [20].
	4.7 kW/m^2	Will cause injury after 30 seconds' exposure.	HIPAP No 4, Ref [21].
	12.6 kW/m^2	Significant chance of fatality for extended exposure. High chance of injury. Potential propagation to combustible material.	
	23 kW/m^2	Likely fatality for extended exposure and chance of fatality for instantaneous exposure. Potential propagation to non-combustible material.	
Toxic dispersion (airborne concentration)	AEGL-1* (HF 1 ppm)	Airborne concentration of a substance above which it is predicted that the general population could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.	Acute Exposure Guideline Levels (AEGL) for Selected Airborne Chemicals Volume 4, Ref [22].
	AEGL-2* (HF 24 ppm)	Airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.	

Event	Impact level	Potential effect	Reference
	AEGL-3* (HF 44 ppm)	Airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.	
Note: * The AEGLs for HF are almost identical to the corresponding Emergency Response Planning Guideline (ERPG) levels that account for exposure for up to 60 minutes.			

5.3 Wind and weather conditions

The wind and weather parameters used for consequence modelling were based on data from the Bureau of Meteorology (BOM) Armidale Airport weather station, as shown in Table 5-2.

Table 5-2 Wind and weather parameters

Parameter	Value	Remarks
Day		
Mean temperature	16ºC	Average mean 9am and 3pm conditions, Ref [23]
Mean relative humidity	63%	Average mean 9am and 3pm conditions, Ref [23]
Mean wind speed	5 m/s	Average mean 9am and 3pm conditions, Ref [23]
Pasquill stability class and wind speed used for analysis	D5	Neutral condition (Class D); wind speed of 5 m/s
Night		
Mean temperature	10ºC	Average night temperature, Ref [24]
Mean relative humidity	63%	Assumed same as day condition
Mean wind speed	2 m/s	Assumed based on typical (low wind condition)
Pasquill stability class and wind speed used for analysis	F2	Very stable condition (Class F); wind speed of 2 m/s

5.4 BESS unit fire

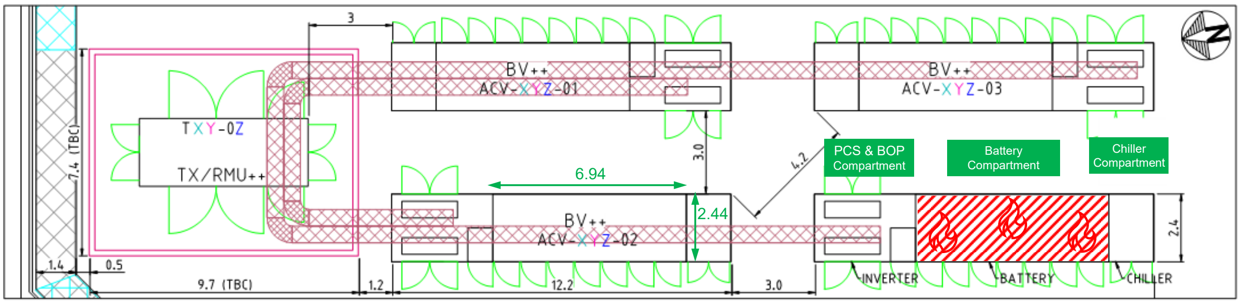
5.4.1 Scenario

A UL 9540A Unit-level test was completed for the battery rack proposed for the B-Vault AC BV 2.7, Ref [7]. The result found that the test performance criteria were met, where (1) no module-to-module thermal runaway propagation, (2), no explosive discharge of gases, and (3) no flaming were observed. Further information on the fire tests is provided in Section 2.2.3. At the time of this study, Energy Vault has not completed a full-scale burn test for the B-Vault AC BV 2.7.

A battery compartment fire on a BV 2.7 unit was modelled to understand the consequences of a BESS unit on fire which is not covered by the UL 9540A test, including potential propagation to adjacent BESS units and also impact to offsite receptors. This event was identified as a credible scenario for a long duration fire on the BESS unit, rather than a fire involving the overall enclosure as the batteries (fuelling the fire) are situated in the battery compartment. The battery compartment with respect to the overall enclosure is shown in Figure 5-1. The effect of the 2-hour rated battery compartment firewalls was disregarded.

The modelled consequences include impacts from (1) fire heat radiation and (2) dispersion of toxic combustion products represented by hydrogen fluoride (HF).

Figure 5-1 Illustration – Battery compartment fire



5.4.2 Modelling approach

<u>Heat radiation impact</u>

Consequence modelling was undertaken based on the Stefan–Boltzmann correlation to analyse the heat transfer effect between two parallel planes, simulating the BESS unit on fire and the heat radiation exposure to a receptor, as shown in Figure 5-2. Distances to heat radiation levels specified in Table 5-1 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, σ is the Stefan-Boltzmann constant and T is the surface temperature.

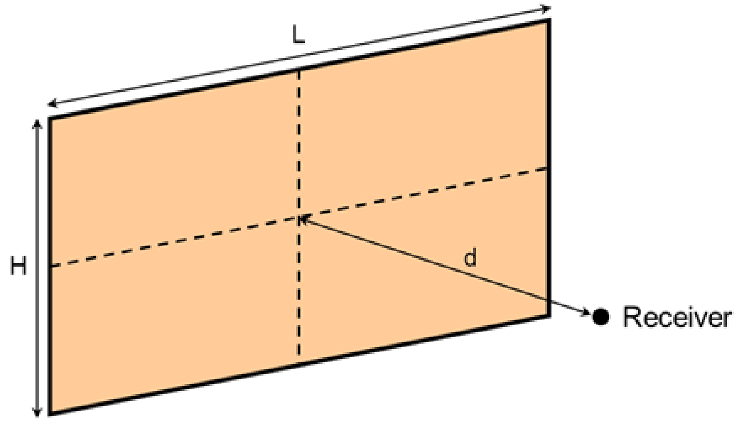
The heat flux received was estimated using the view factor method, where *d* is receiver distance to BESS unit on fire:

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

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

To calculate the heat radiation experienced by the receptor at height 1.5 m (approximately half of the BESS unit height and representative of a person), the surface area of the BESS unit (front aspect) is divided into 4 equal sections. Figure 5-2 illustrates the graphical depiction of the parameters used in the calculation.

Figure 5-2 Battery compartment fire - Graphical depiction of modelling parameters



The modelling input and assumptions used are as follows:

- The flame temperature of the emitting surface was conservatively set at 1000°C, which is value typical for pure lithium metallic fires, Ref [25].
- An emissivity value of 0.9 (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 BESS 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.

<u>Explosion</u>

During a thermal runaway or fire event, vented flammable gases may accumulate in the battery compartment (enclosed/confined area), leading to an explosion. It was assumed that this 'early explosion' would result in a fully developed battery compartment fire and hence was not modelled separately. The battery system safety feature for explosion prevention is described in Section 6.2.4.

<u>Toxic combustion products</u>

In the event of a fire, there is a potential for toxic gas to be generated (1) from decomposition of the battery electrolyte and/or (2) as a result of combustion products. For LFP batteries, during a BESS fire event there is a potential for hydrogen fluoride (HF) to be generated following decomposition of lithium hexafluorophosphate in the battery electrolyte. In the absence of a full-scale burn test, a conservative approach was adopted, and dispersion of HF gas was modelled to assess potential impact to receptors. In this study, HF was considered to be the most toxic decomposition product based on the concentration (ppm) required to cause harm (i.e. irritation, injury and fatality) when compared[5] to other potential products such as carbon monoxide (CO) and benzene.

Consequence modelling was performed using the Gexcon EFFECTS v12.3 software (Plume Rise from Fire model) to simulate HF dispersion during a BESS fire. The HF generation rate was based upon published experimental literature for LFP batteries. The downwind distances to the AEGL levels (as specified in Table 5-1) at receptor height of 1.5 m were calculated.

[5] Based on comparison of the for Acute Exposure Guideline Level (AEGL) values.

The modelling input and assumptions used are as follows:

- Hydrogen fluoride is considered the most toxic decomposition products from the batteries fire, Ref [26].
- A lithium-ion battery cell experiment, Ref [26], 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, 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 BESS 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/m2, Ref [27].
- The plume was assumed to be released from the top of the BESS unit. This is viewed as a reasonable approach, based on observation from recent BESS fire incidents (e.g. Victorian Big Battery fire).
- Receptor height was set at 1.5 m.

5.4.3 Findings – heat radiation impact

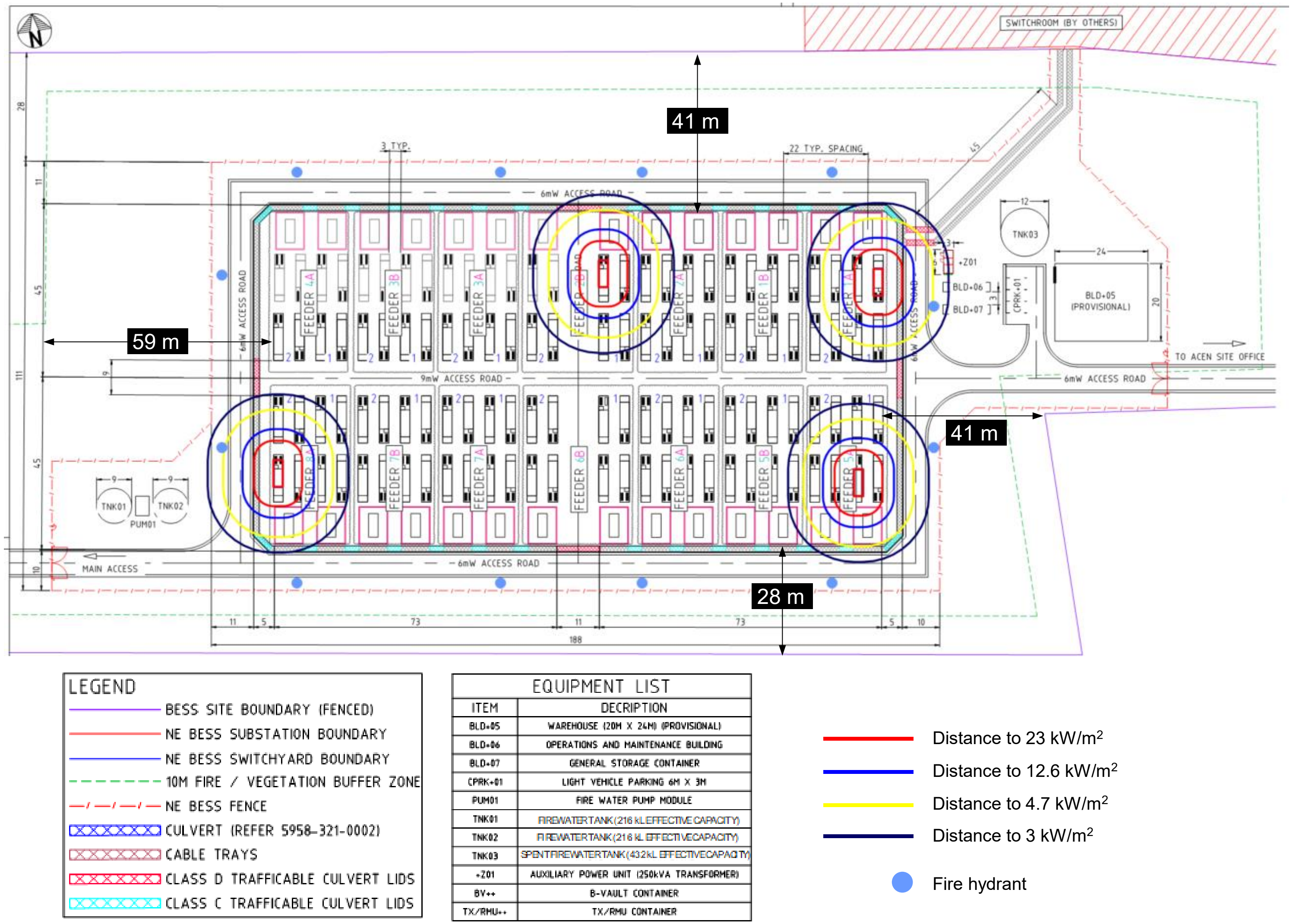
The BESS unit on fire modelling results are provided in Table 5-3 and illustrated in Figure 5-3, which shows the distances to heat radiation from the battery compartment wall on fire.

Please note that Figure 5-3 shows the heat radiation distances for the front aspect of the BESS applied equally to all sides (i.e. overestimation of the heat radiation emitted from the side aspect of the BESS). The BESS units on the outer array were used to determine impact to other infrastructure within the compound and impact beyond the BESS compound boundaries on all sides (north, east, south, west).

Table 5-3 Battery compartment fire - Heat radiation impact

Aspect of the battery compartment (m)	Surface temperature (°C)	Distance (m) at receptor height of 1.5 m			
		3.0 kW/m^2 (Emergency responder endangerment)	4.7 kW/m^2 (injury)	12.6 kW/m^2 (propagation to combustible material)	23 kW/m^2 (propagation to non-combustible material)
Front (W x H) 6.94 x 2.95	1000°C	17	13	8	5
Side (D x H) 2.44 x 2.95	1000°C	10	8	5	3

Figure 5-3 Battery compartment fire - Heat radiation impact



EQUIPMENT LIST

ITEM	DECRIPTION
BLD-05	WAREHOUSE (20M X 24M) (PROVISIONAL)
BLD-06	OPERATIONS AND MAINTENANCE BUILDING
BLD-07	GENERAL STORAGE CONTAINER
CPRK-01	LIGHT VEHICLE PARKING 6M X 3M
PUM01	FIRE WATER PUMP MODULE
TNK01	FIREWATER TANK (216 kL EFFECTIVE CAPACITY)
TNK02	FIREWATER TANK (216 kL EFFECTIVE CAPACITY)
TNK03	SPENT FIREWATER TANK (432 kL EFFECTIVE CAPACITY)
+Z01	AUXILIARY POWER UNIT (250kVA TRANSFORMER)
BV++	B-VAULT CONTAINER
TX/RMU++	TX/RMU CONTAINER

The findings are as follows:

- The 3 kW/m^2 heat radiation (emergency responder endangerment) does not impact the cooling water tanks and pump but may affect accessibility to some fire hydrants depending on the location of the BESS unit on fire. A total of 12 fire hydrants will be provided around the perimeter of the BESS array, spaced accordingly such that all units and equipment are within reach of a 10 m hose stream at the end of a 60 m hose length connected to a fire hydrant outlet. If a BESS unit on fire is impeding access to the closest hydrant, the next two closest hydrants will be accessible to provide cooling to nearby units (i.e. coverage redundancy included).
  - For north and south facing BESS units, the perpendicular distance from the outer BESS unit (side aspect) to the fire hydrant is 21 m with radiant heat flux of approx. 1 kW/m^2.
  - For east and west facing BESS units, the perpendicular distance from the outer BESS unit (front aspect) to the fire hydrant is 13 m with radiant heat flux of approx. 4.7 kW/m^2.
- The 4.7 kW/m^2 heat radiation (personnel injury) does not impact the buildings within the BESS compound and remains within the BESS compound boundary (i.e. no offsite impact resulting in injury/fatality). The extent of the injury level radiant heat flux is within the 30 m safe distance specified in the B-Vault AC Emergency Response Plan[6], Ref [1]:

  > *"A safe stand-off distance of 100' (~30 m) shall be maintained between individuals and the BESS enclosure(s) exhibiting fire conditions."*

- The 23 kW/m^2 heat radiation extends 5 m from the BESS unit on fire and propagation to the front adjacent BESS unit is theoretically possible in absence of any fire protection measures to prevent the fire spread.
  - This finding disregards the effects of fire protection on the adjacent BESS unit which includes (1) 2-hour fire rated battery compartment walls, (2) liquid cooling on the battery modules and (3) cooling using fire hydrants.
  - The front clearance between unit is currently set at 3 m (refer to Figure 5-1), which is based on the OEM specification, Ref [6], and insurer's requirements, Ref [28]. At 3 m, the calculated heat radiation is approximately 50 kW/m^2, assuming sustained fire with 1000°C flame.

5.4.4 Findings – dispersion of toxic combustion products

The distances to AEGL concentrations at receptor height of 1.5 m are presented in Table 5-4. Distances for the D5 wind and weather condition are shown in Figure 5-4. The BESS units on the outer array were used to determine impact to other infrastructure within the compound and impact beyond the BESS compound boundaries on all sides (north, east, south, west).

The findings are as follows:

- The distance to AEGL-1 concentration (irritation threshold) is within the 30 m safe distance specified in the B-Vault AC Emergency Response Plan, Ref [1]:

  > *"A safe stand-off distance of 100' (~30 m) shall be maintained between individuals and the BESS enclosure(s) exhibiting fire conditions."*

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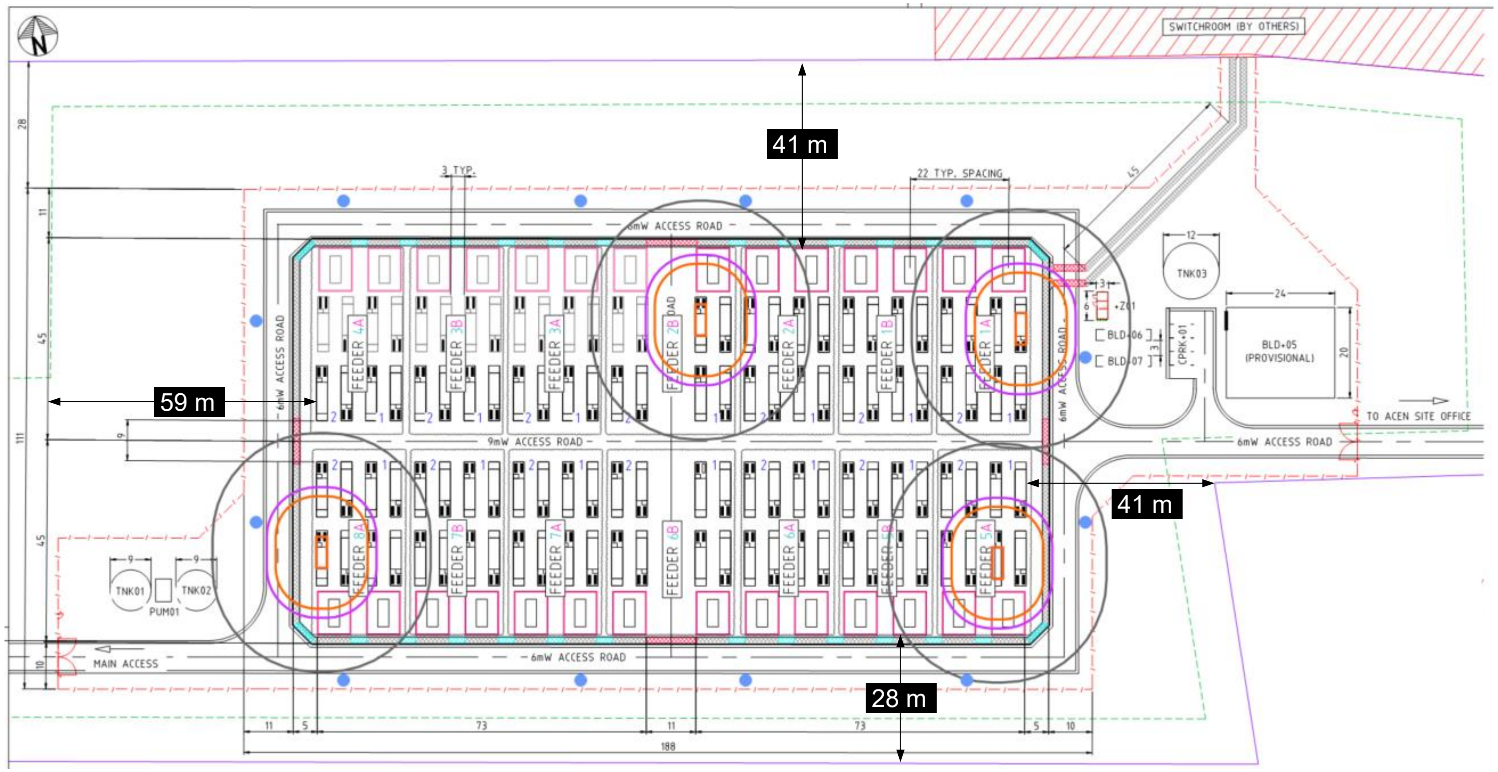
[6] Although Revision 2 of the B-Vault AC Emergency Response Plan reflects B-Vault AC 2.5, however it is also equally applicable to B-Vault AC 2.7, Ref [34].

- The distance to AEGL-2 (injury) and AEGL-3 (fatality) concentrations do not impact the buildings with the BESS compound and remains within the BESS compound boundary (i.e. no offsite impact resulting in injury/fatality).

Table 5-4 Battery compartment fire – Dispersion of toxic combustion products

Capacity per unit (MWh)	HF generation rate (kg/s)	Heat release (kW/m^2)	Wind and weather stability condition	Distance (m) at receptor height of 1.5 m		
				AEGL-1 (irritation)	AEGL-2 (injury)	AEGL-3 (fatality)
4.702	0.26	882	D5	23	11	9
			F2	4	3	2

Figure 5-4 Battery compartment fire – Dispersion of toxic combustion products



LEGEND

- BESS SITE BOUNDARY (FENCED)
- NE BESS SUBSTATION BOUNDARY
- NE BESS SWITCHYARD BOUNDARY
- 10M FIRE / VEGETATION BUFFER ZONE
- NE BESS FENCE
- CULVERT (REFER 5958-321-0002)
- CABLE TRAYS
- CLASS D TRAFFICABLE CULVERT LIDS
- CLASS C TRAFFICABLE CULVERT LIDS

EQUIPMENT LIST

ITEM	DECRIPTION
BLD-05	WAREHOUSE (20M X 24M) (PROVISIONAL)
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+Z01	AUXILIARY POWER UNIT (250kVA TRANSFORMER)
BV--	B-VAULT CONTAINER
TX/RMU--	TX/RMU CONTAINER

- Distance to AEGL-1 (Irritation)
- Distance to AEGL-2 (Injury)
- Distance to AEGL-3 (Fatality)
- Fire hydrant

5.5 BESS unit fire propagation potential

5.5.1 Overview

Energy Vault commissioned a Computational Fluid Dynamics (CFD) analysis to assess the thermal runaway or fire propagation potential to adjacent units in the event of a single battery unit burning, Ref [29]. The CFD analysis method, metrics of interest, scenarios modelled, and findings are summarised in the following sections.

CFD models were created using Fire Dynamics Simulator (FDS), a CFD software developed by the US National Institute of Standards and Technology (NIST) which has been validated for a variety of scenarios involving fire, smoke, gas dispersion and other transport phenomenon, Ref [29].

For the analysis, CFD models were developed to estimate the following over time:

- The interior air temperature of adjacent battery units, where the temperature data was recorded using point measurements inside each target units.
- The surface temperature and incident heat flux on the exterior of the adjacent units, where the data were recorded using measurement panels placed on the walls of the target units. The average and maximum values were recorded. The readings were analysed to evaluate the potential damage to the adjacent target units.

The metrics of interest for the CFD analysis are shown in 5.

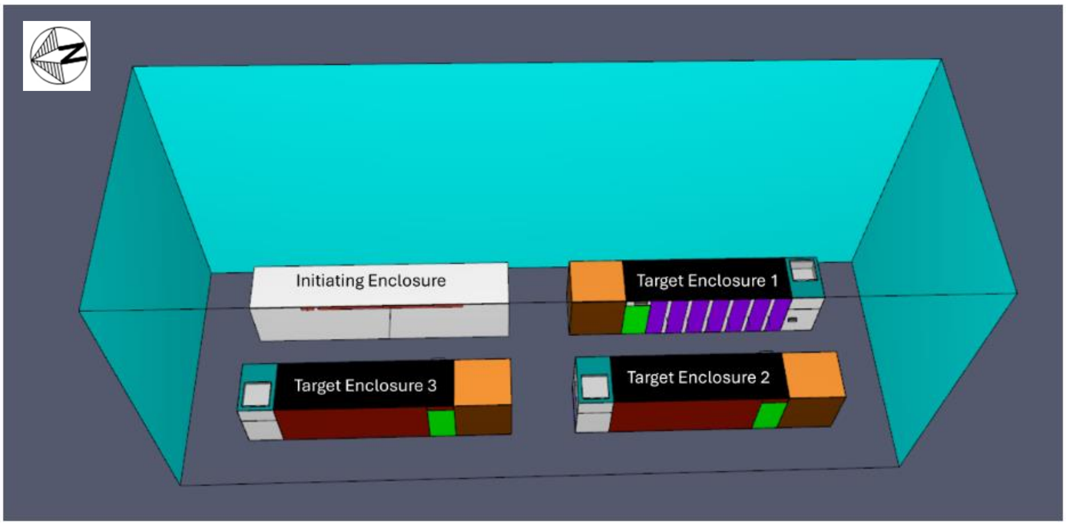
Table 5-5 Metrics of interest for the CFD analysis

Metrics of interest	Notes
Internal temperatures of adjacent battery units	• The air temperature inside the battery compartment were compared to the cell venting temperature to assess the potential for thermal runaway propagation. • The cell venting temperature for the REPT BATTERO Energy Co., Ltd CB75 cells, is 127.9 °C. Thermal runaway is unlikely if the air temperature inside the target unit does not reach the cell venting temperature.
External surface temperatures of adjacent battery units	• Damage due to pyrolysis is not expected if the surface temperature does not reach the pyrolysis temperature.
Heat flux on adjacent battery units	• Prolonged exposure to heat fluxes above 20 kW/m^2 is expected to cause ignition for most flammable materials[1]. • Heat flux values exceeding 60 kW/m^2 indicate flames in direct contact with the surface.
Note: 1. This is more conservative compared to the heat radiation level specified in HIPAP No. 4 (23 kW/m^2).	

The CFD models reflect the project specific battery system and configuration (i.e. spaced 3 m apart on all sides) and did not account for the effects of any fire suppression systems or first responders (no intervention assumed).

The geometric layout of the model is shown in Figure 5-5 Geometric layout of the CFD mode.

Figure 5-5 Geometric layout of the CFD model



5.5.2 Scenarios modelled

The analysis was carried out to simulate (1) no wind and (2) the 99th percentile wind speed for Uralla, i.e. 30 miles per hour (mph) equivalent to 13.4 m/s.

The following scenarios were modelled:

1. A single-enclosure fire with no wind
2. A single-enclosure fire with 30 mph northerly wind
3. A single-enclosure fire with 30 mph southerly wind
4. A single-enclosure fire with 30 mph easterly wind
5. A single-enclosure fire with 30 mph westerly wind.

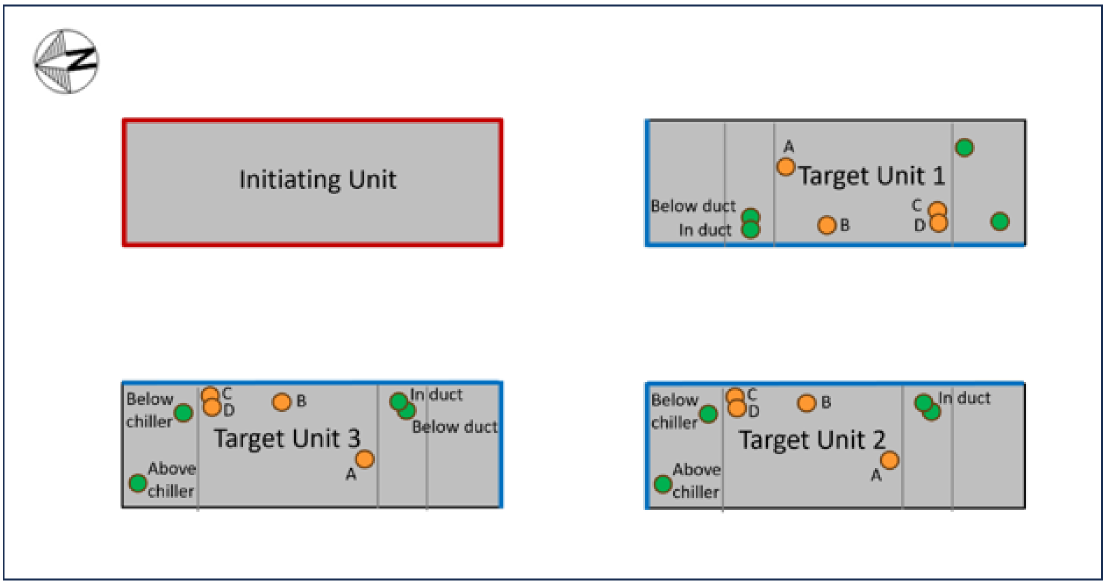
The plan view showing the initiating and target units and locations where data measurements are recorded is shown in Figure 5-6.

The orange circles inside each target unit mark the location of internal air temperature analysis points inside the battery compartment. The green circles inside each target unit mark the location of air temperature analysis points inside the auxiliary compartments. The blue lines mark the walls where heat flux and external temperature data are analysed.

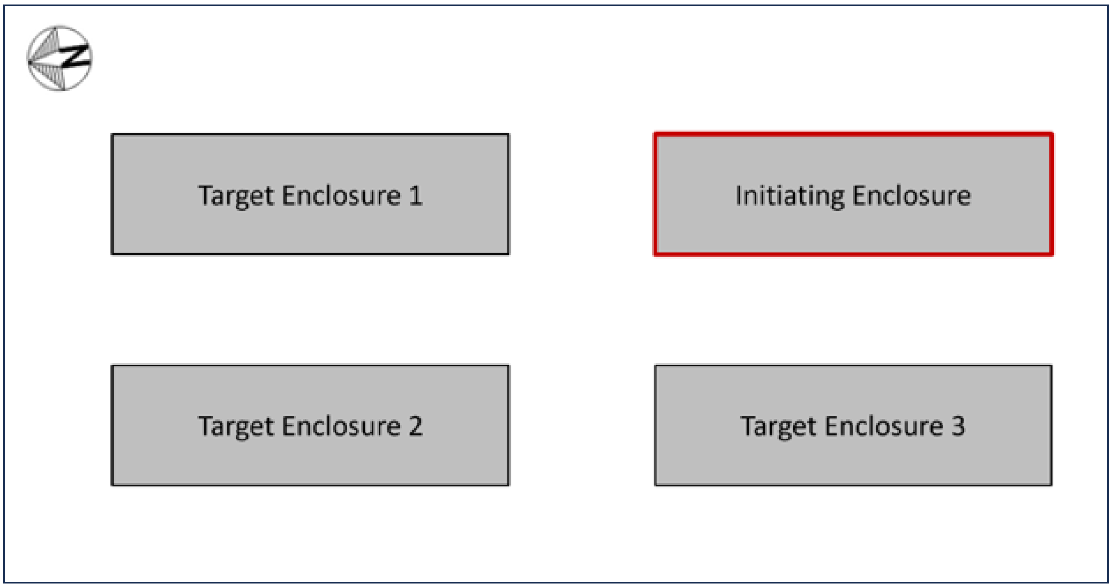
3D view of the CFD models for each scenario are shown in Figure 5-7 to Figure 5-11.

Figure 5-6 Plan view of the CFD model

(a) No wind and 30 mph northerly, easterly and westerly wind

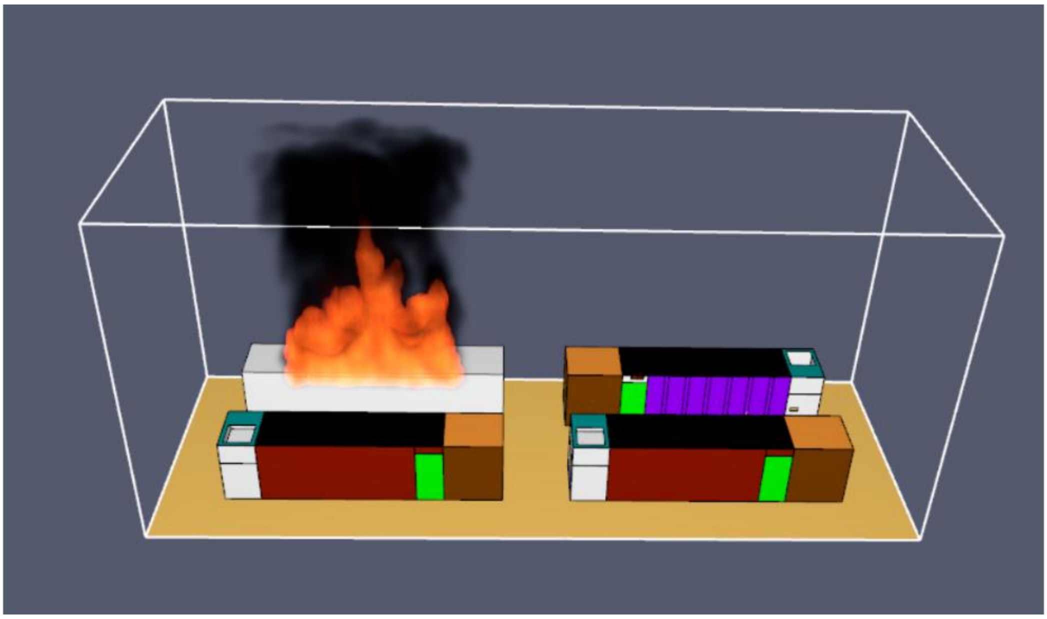


(b) 30 mph southerly wind



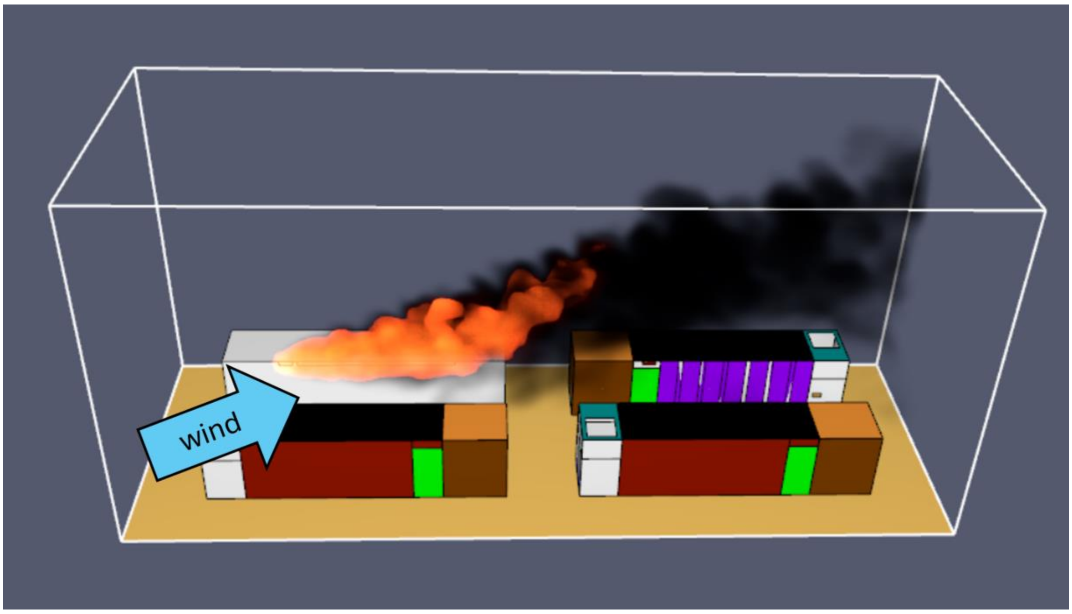
Note: For the wind coming from the south, the model geometry was modified to assess impact on downwind target unit.

Figure 5-7 3D view of the fire model – No wind



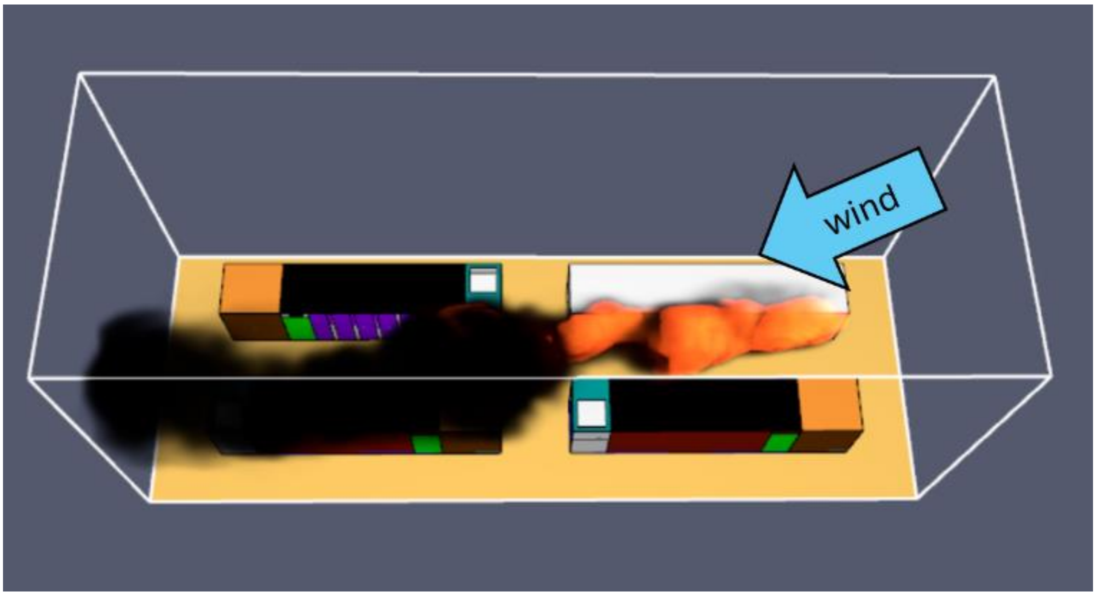
Note: In the absence of wind, the flames and smoke extend directly up from the burning unit.

Figure 5-8 3D view of the fire model – 30 mph northerly wind



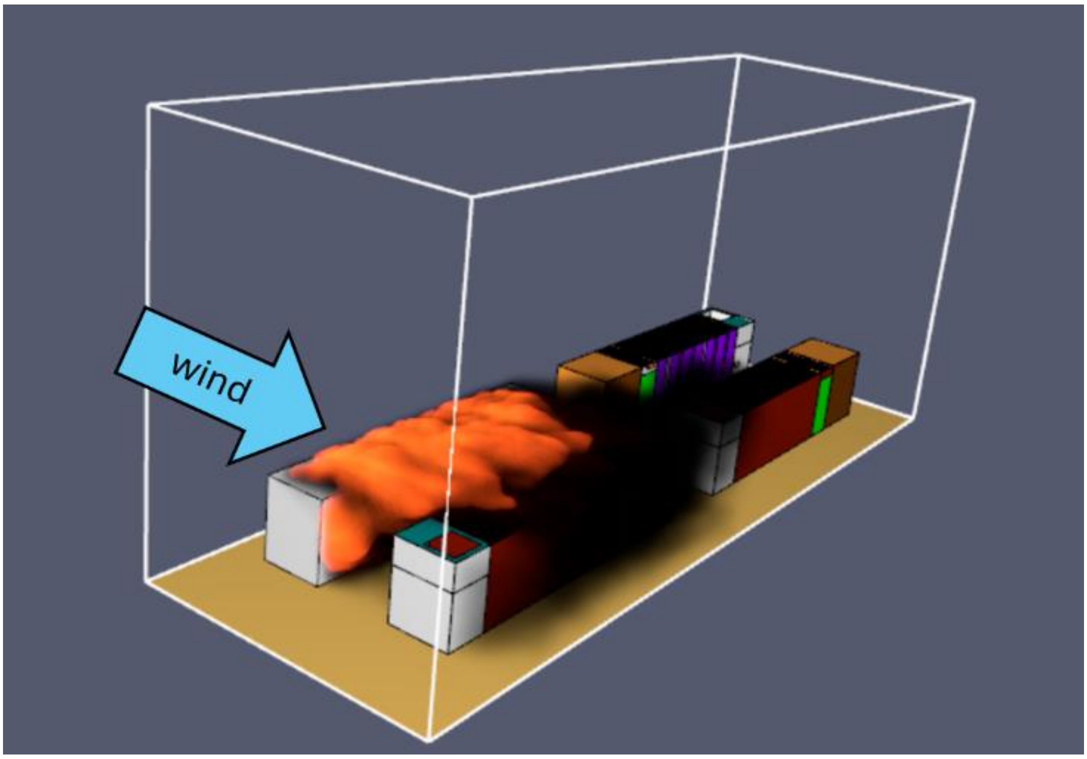
Note: The wind from the north causes the flames to lean toward target unit 1.

Figure 5-9 3D view of the fire model – 30 mph southerly wind



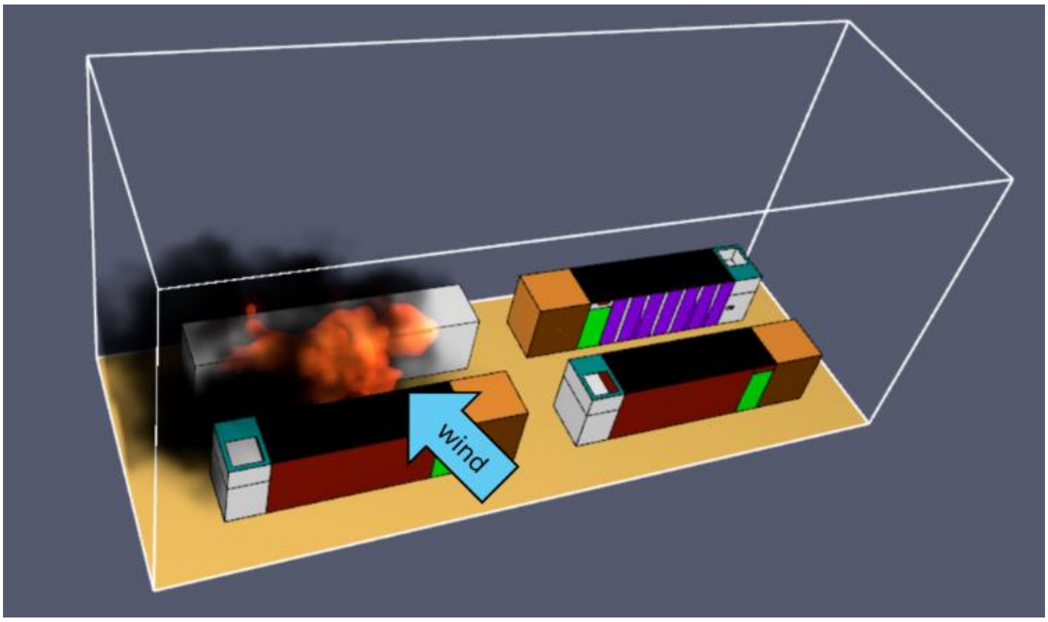
Note: The wind from the south causes the flames to lean towards target units 2 and 3.

Figure 5-10 3D view of the fire model – 30 mph easterly wind



Note: Wind from the east causes the flames to lean toward target unit 3. Flames can also be seen on the roof of the initiating unit. As the wind moves around the initiating unit, it creates a small low-pressure zone on top of the initiating unit. The flames escaping from the front of the unit move against the wind to occupy this low-pressure zone.

Figure 5-11 3D view of the fire model – 30 mph westerly wind



Note: The westerly wind blows away from target unit 3 and towards the initiating unit. The smoke and flames do not appear to move in the direction of the wind as a result of the way the wind interacts with the target units. The wind moving across target unit 3 creates a wind curtain over the top of the aisle way. This wind curtain pushes the flames and smoke into the aisle between target unit 3 and the initiating unit.

5.5.3 Findings

The CFD analysis results for the adjacent battery units are shown in Table 5-6 (internal air temperature), Table 5-7 (exterior surface temperature) and Table 5-8 (heat flux).

Table 5-6 CFD analysis – Air temperature in battery compartment of adjacent units

Scenario	Enclosure 1	Enclosure 2	Enclosure 3
No wind	50.1 ºC	50.6 ºC	66.2 ºC
30 mph northerly wind	78.8 ºC	52.4 ºC	62.4 ºC
30 mph southerly wind	60.7 ºC	52.5 ºC	73.0 ºC
30 mph easterly wind	50.1 ºC	49.6 ºC	58.0 ºC
30 mph westerly wind	49.4 ºC	50.0 ºC	65.4 ºC

Table 5-7 CFD analysis – Surface temperature data on adjacent units

Scenario	Enclosure 1	Enclosure 2	Enclosure 3
No wind	105.9 ºC	78.6 ºC	392.0 ºC
30 mph northerly wind	332.5 ºC	116.2 ºC	308.8 ºC
30 mph southerly wind	140.0 ºC	251.5 ºC	736.6 ºC
30 mph easterly wind	76.2 ºC	71.7 ºC	959.6 ºC
30 mph westerly wind	73.5 ºC	64.7 ºC	752.0 ºC

Note: The numbers in red indicate the maximum external temperatures above the pyrolysis temperature of the door seals

Table 5-8 CFD analysis – Heat flux data on adjacent units

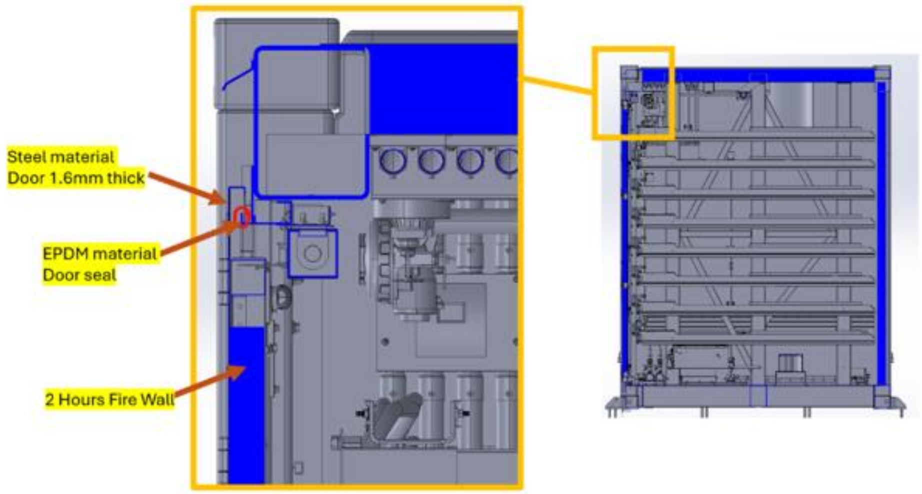
Scenario	Enclosure 1	Enclosure 2	Enclosure 3
No wind	1.8 kW/m^2	1.3 kW/m^2	15.2 kW/m^2
30 mph northerly wind	16.2 kW/m^2	3.4 kW/m^2	14.3 kW/m^2
30 mph southerly wind	4.4 kW/m^2	8.9 kW/m^2	100.1 kW/m^2
30 mph easterly wind	1.8 kW/m^2	1.9 kW/m^2	153.3 kW/m^2
30 mph westerly wind	1.4 kW/m^2	1.3 kW/m^2	100.9 kW/m^2

Note: The numbers in red indicate the maximum heat fluxes above the expected value for flames touching a surface.

The findings are as follows:

- Predicted air temperatures in the battery compartment of adjacent units do not approach the cell venting temperature in any wind conditions modelled. Therefore, propagation of a fire to thermal runaway in an adjacent unit is not expected.
- Modelling results indicate that maximum heat fluxes on or near the surface of adjacent units may cause damage to components such as gaskets or rubber seals resulting in a path for flames or hot gases to be drawn into an adjacent unit leading to temperature rise and thermal runaway. To address this, the B-Vault AC system design includes a layer of steel covering the door gaskets/seals designed to reduce heat exposure. The exhaust fans on the outside of the enclosure are also protected with a steel damper when not in use. These additional barriers are designed to provide protection to the major vulnerable areas on the exterior of the enclosure. A diagram showing the location of the door seal on a B-Vault enclosure is presented in Figure 5-12.
- Modelling results indicate that maximum temperatures on the outside of adjacent units could melt the door seals, creating new openings for hot gases to enter the enclosures. To address this, the B-Vault AC system design includes a layer of steel covering the door gaskets/seals to protect the door seals. If the door seals are damaged, the steel is intended to block hot gases from entering the enclosure.

Figure 5-12 Location of door seal on the B-Vault enclosure



5.6 Fire at the solar farm fuel tank area

5.6.1 Scenario

A fire at the solar farm fuel tank area was analysed to identify potential escalation to the Stage 3 BESS compound. A pool fire resulting from a tank rupture scenario involving the whole contents of the gasoline and diesel tanks was modelled. Double-skinned design feature of the tanks was disregarded[7]. This scenario was identified as the worst-case scenario which accounts for a gasoline fire propagating to the adjacent diesel tank. The radiant heat from the fire was assessed.

5.6.2 Modelling approach

Consequence modelling was performed using the Gexcon EFFECTS v12.3 software (Pool Fire model). Distances to heat radiation levels specified in Table 5-1 were calculated.

The modelling input and assumptions used are as follows:

- Total fuel volume of 9,000 litres (gasoline 2,500 litres and diesel 6,500 litres).
- Gasoline was used as the substance/fuel.
- Pool spread was unconfined.
- Receptor height was set at 1.5 m.

5.6.3 Findings

The BESS unit on fire modelling results are provided in Table 5-9. Distances to heat radiation for pool fire at 5 m/s are illustrated in Figure 5-13.

The findings are as follows:

- Potential escalation from a fire at the solar farm fuel storage tank area is not expected based on the separation distance to the Stage 3 BESS compound.
- The resulting heat radiation does not result in offsite impact.

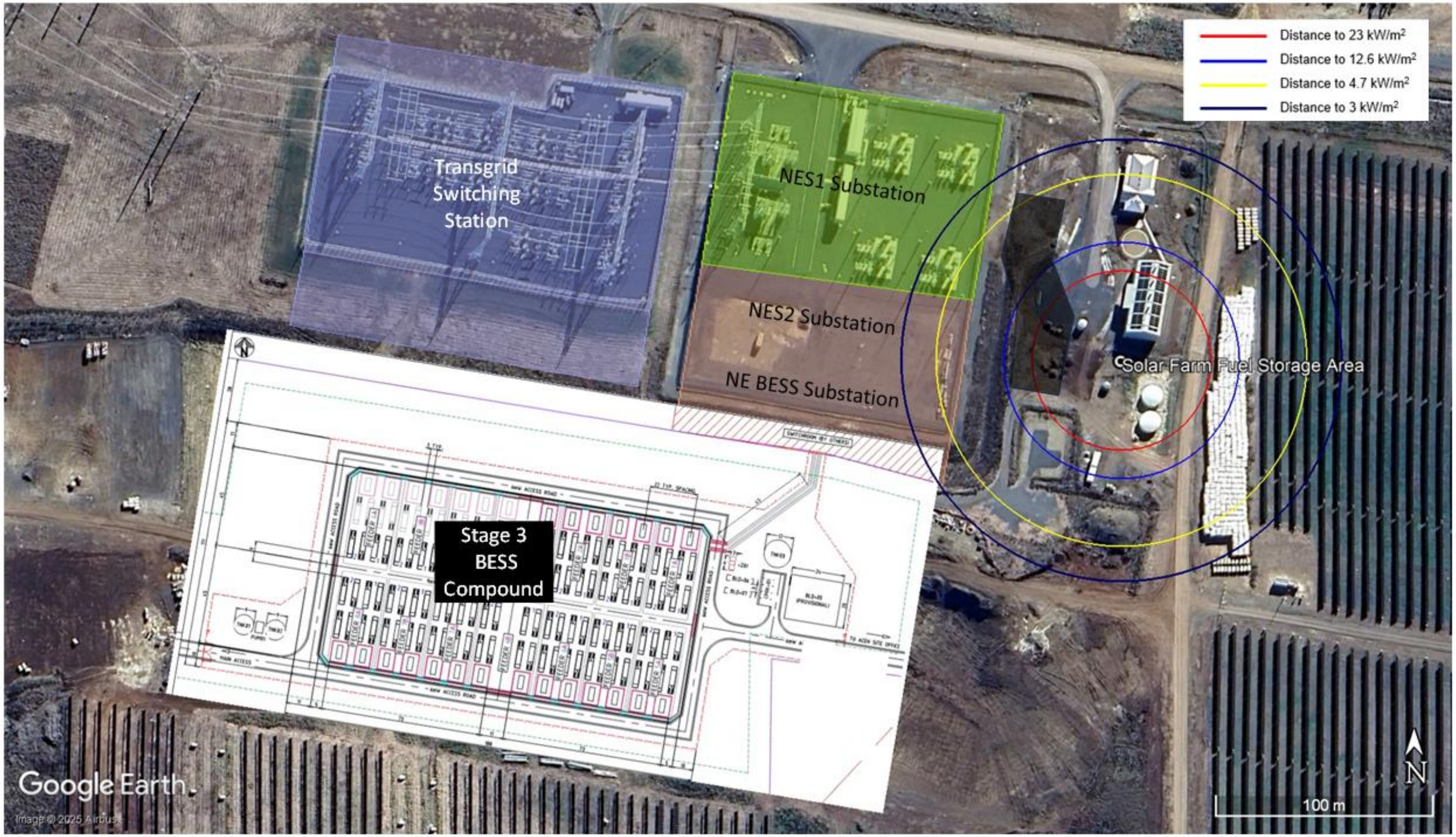
---

[7] Loss of containment from a double skinned tank is a very low likelihood scenario.

Table 5-9 Fire at the solar farm fuel storage area - Heat radiation impact

Pool diameter (m)	Wind speed	Distance (m) at receptor height of 1.5 m			
		3.0 kW/m^2 (Emergency responder endangerment)	4.7 kW/m^2 (injury)	12.6 kW/m^2 (propagation to combustible material)	23 kW/m^2 (propagation to non-combustible material)
49	5 m/s	101	85	54	41
	2 m/s	90	74	47	37

Figure 5-13 Fire at the solar farm fuel storage tank and refueling area - Heat radiation impact



6 Fire strategy and control measures

6.1 Introduction

For each scenario, the fire safety strategy is supported by measures to prevent, detect, alert and respond to fire incidents. The fire safety strategy and control measures were reviewed for the following scenarios:

1. BESS unit on fire
2. Transformer fire (Substation HV transformer, BESS MV transformer, aux transformer)
3. Fire at the solar farm fuel storage area
4. Bushfire.

6.2 BESS unit on fire

6.2.1 Fire safety strategy

The fire safety strategy for BESS unit on fire and the supporting design features and/or control measures are presented in Table 6-1, Ref [1], [30], [31].

The fire safety system is designed to detect and swiftly respond to any fire hazards using a combination of active and passive fire safety features. Details on the B-Vault AC BV 2.7 fire safety system are provided in the subsequent sections.

Table 6-1 Fire safety strategy – BESS unit on fire

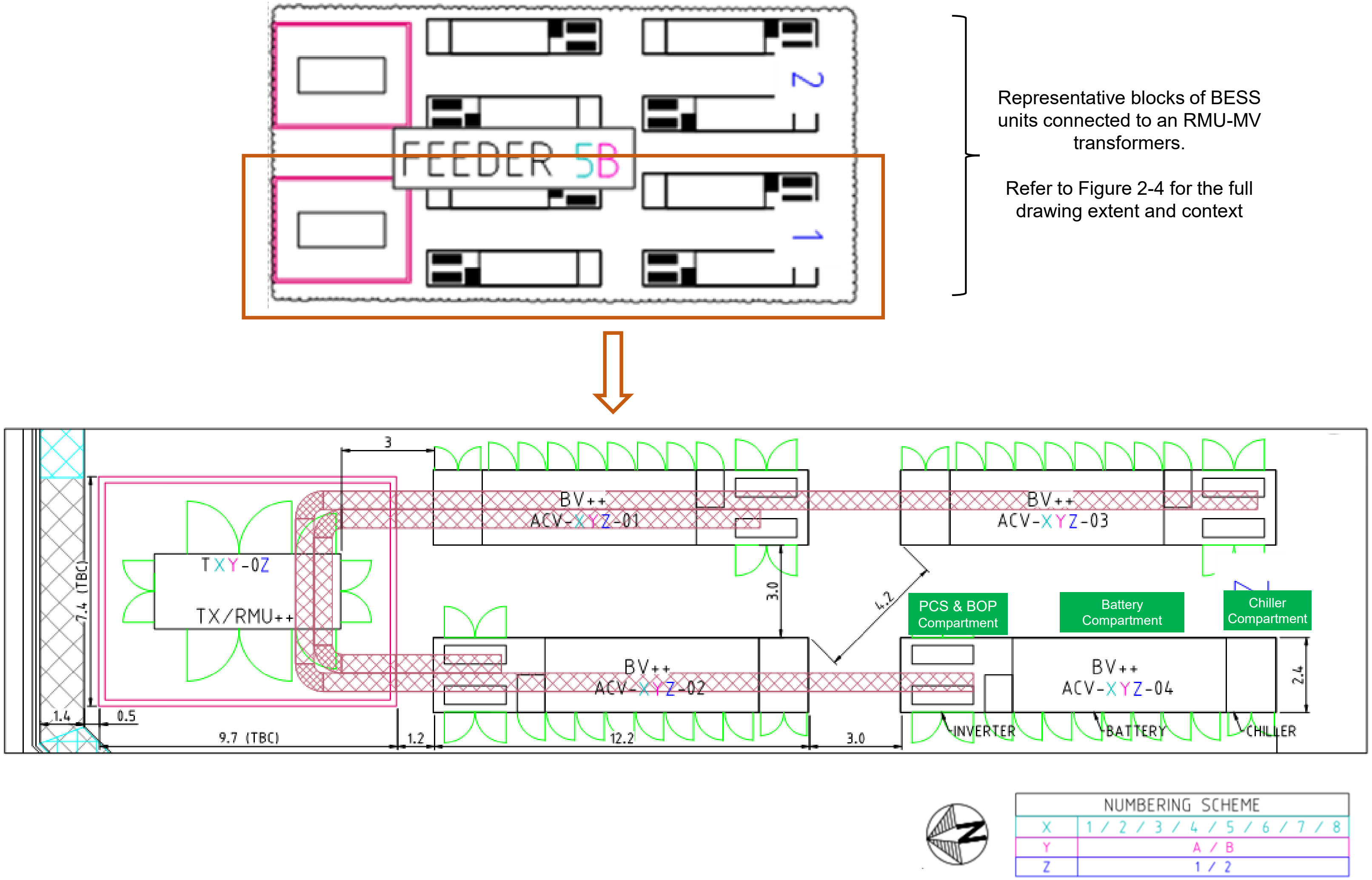
Strategy	Design features and/or control measures
1. Prevent battery thermal runaway	• Battery cells are designed to withstand some level of deviation (e.g. high temperature, overcharge).
	• The liquid cooling system provides thermal management for the batteries and maintain the battery cells within their operating limits and prevent overheating.
	• The HVAC system manages and controls the air temperature and humidity within the BESS unit enclosure to prevent corrosion as well as malfunctioning and overheating of equipment.
	• The PCS and BOP electrical system safety features include AC circuit breakers and surge protection device.
	• The BMS disconnects the affected battery string from the system in the event of abnormal conditions that may be a precursor to thermal runaway. <u>Note</u>: The BMS monitors the cell voltage and current, module temperature, energy management, thermal management, fault diagnosis management, and communication with the Energy Management System (EMS). The BMS has safety features for the cases of under/over voltage, temperature and current and loss of communications.

Strategy	Design features and/or control measures
	• The EMS will electrically isolate the affected BESS unit(s) or otherwise place it in a safe condition upon detection of potentially hazardous temperatures or other hazardous conditions. Note: The EMS provides power commands at the site level to operate each individual BESS unit. The EMS will process communication from the individual units' BMS and perform safety actions based on the conditions.
2. Slow cascading effects of thermal runaway and prevent propagation to a fully developed BESS unit on fire	• Thermal insulation within battery module and air gaps between modules.
	• Detectors (heat, gas, smoke) with alarms and notification to the remote monitoring centre for response action.
	• The exhaust ventilation system is designed to remove flammable gas generated during battery failure when the gas detector set point is reached and prevent explosion.
	• The aerosol fire suppression device (QRR0.144G/S) extinguishes fires by inhibiting the chain chemical reactions present in combustion
	• The battery compartment walls are fire rated for 2 hours, reducing the propagation potential to other compartments.
	• The EMS will electrically isolate the affected BESS unit(s) or otherwise place it in a safe condition upon detection of hazardous conditions (i.e. confirmed smoke detection).
3. Defensive fire response	• In the event of a BESS unit on fire, a defensive fire response strategy will be adopted (i.e. allow the affected unit to burn in a controlled fashion until all fuel sources are depleted). There is no requirement to apply water directly to the BESS unit on fire as this will not stop a thermal runaway event and may potentially delay eventual combustion of the entire BESS product.
4. Minimise the risk of fire propagation to adjacent BESS units and infrastructure	• As part of the defensive firefighting strategy, water may be applied to nearby equipment or structures for cooling as necessary using dedicated fire hydrants provided around the perimeter of the BESS array. Decision to provide cooling will be made in coordination between: ○ ACEN (facility owner) ○ Energy Vault (O&M Contractor and the OEM Subject Matter Expert) ○ FRNSW (emergency responder). Note: Where required, application of cooling water will be undertaken by FRNSW using their equipment connected to the onsite fire hydrants. Water will be drawn from the cooling water supply tanks.
	• Clearances around the BESS units (shown in Figure 6-1) are as follows: ○ Front and back: 3 m ○ Side: 3 m. This clearance is in accordance with the OEM's specification (informed by the UL 9540A test results), Ref [6], and insurer's requirements, Ref [28]. The following will also be observed:

Strategy	Design features and/or control measures
	○ Clearance of ≥ 3 m from any accessible means of egress and exposures (e.g. buildings, public ways, and hazards not associated with electrical grid infrastructure as defined in the International Fire Code and NFPA 855. ○ The BESS units will not be installed under combustible objects and will maintain clearance of ≥ 1.5 m on all sides from combustible objects including trees, structures, wooden fences, structures.
	• The battery compartment walls are fire rated for 2 hours, reducing the propagation potential to adjacent BESS units.
	• Based on the separation distances from the closest BESS units, impact to personnel (injury/fatality) at the BESS O&M building and escalation to other infrastructure within the BESS compound is not expected. Refer to consequence analysis results in Section 5.4. The BESS array layout ensures no dead-ends or obstruction preventing personnel evacuating in the event of a fire whilst on field.

Recommendation 10: Energy Vault (O&M Contractor) to ensure that if the temporary storage of battery units onsite is required it meets the requirements specified in FRNSW's position statement for Open Yard Storage of BESS.

Figure 6-1 BESS unit clearances



6.2.2 Fire detection, alarm and notification

Detection

Each B-Vault AC BV 2.7 unit is equipped with:

- Battery compartment: Heat, smoke and hydrogen gas detectors (x2 each)
- PCS compartment: Smoke detector (x1).

The exact sensor which triggers the alarm can be identified via VaultOS. The detectors are connected to a dedicated FACP installed in each B-Vault.

Alarm

Trouble signal is an indication that the fire detection or suppression system is experiencing a control issue. A special supervisory alarm will go off and a signal will be sent to the Remote Monitoring Centre (RMC) via the EMS.

Fire alarm is initiated if any hydrogen sensor, or two of the smoke and heat detectors (2 smoke sensors active, 2 heat sensors active, or 1 heat and 1 smoke sensor active) are triggered. An alarm and flashing light will activate locally, and the EMS will indicate and alarm.

Notification

Remote monitoring of the BESS units is undertaken by the RMC. In the event of a battery related failure transmitted by the BMS/EMS, alarm notifications and information on the state of the BESS will be sent to inform potential emergency response procedures required (including assistance request from the Emergency Services).

6.2.3 Fire suppression system

The B-Vault AC BV 2.7 is equipped with an aerosol suppression system to extinguish battery fires and prevent propagation to a larger fire. The aerosol is released directly in the affected battery module to extinguish flaming gases if they are ignited by an external ignition source (e.g. electrical arc). No flaming occurred during the UL9540A testing of the battery system and the UL9540A results are not dependent on this system.

Each aerosol fire suppression device has its own temperature detection device, i.e. a 3 m long thermal sensor line encased in a fiberglass tube. The thermal sensor line is routed throughout the battery module to cover as much surface area as possible. When any part of the thermal sensor line reaches a temperature of 175 - 195°C, it will trigger the aerosol release, Ref [31].

REPT BATTERO Energy Co., Ltd, the battery manufacturer and supplier for the B-Vault AC BV 2.7 had conducted a performance test for the aerosol fire suppression device (QRR0.144G/S; potassium nitrate-based) following REPT's testing procedure. The test found that the aerosol device was effective to extinguish the fire and have no re-ignition phenomenon afterwards, Ref [32].

6.2.4 Explosion prevention system

The B-Vault AC BV 2.7 is equipped with a continuous gas detection system. When the hydrogen detector set point is reached (1000 ppm), it automatically activates the mechanical ventilation system to exhaust the flammable off-gas formed due to battery thermal runaway, which include the following actions:

- F-stop circuit triggered

- Exhaust damper opened
- Intake damper opened
- Exhaust fans started.

The system is designed to maintain flammable gases below 25% Lower Flammable Limit (LFL) per NFPA 69 and NFPA 855. The exhaust ventilation can only be triggered by the gas detectors or manually started via the EMS.

The system will remain operational until the FACP is reset (either locally or remotely) or if auxiliary power is lost and battery back-up is exhausted. The gas detection system is provided with a minimum of two (2) hours of standby power in alarm mode, and twenty-four (24) hours of back-up power in standby mode.

6.2.5 Fire Alarm Control Panel (FACP)

Each B-Vault AC BV 2.7 is equipped with a FACP, which has a software programmed to perform any necessary actions during a thermal event. The FACP operates automatically without input from the operator. A HMI is mounted on the front of the FACP which can be used to monitor the status of the panel.

The FACP is integrated with an F-stop circuit, real-time zone monitoring and reserve power from battery backup (24-hour in idle or 2-hour in alarm with exhaust fans). The inputs are from the heat, smoke and hydrogen gas sensors. The outputs are sent to a water solenoid valve, mechanical ventilation system, circuit checks and alarms.

6.2.6 Emergency shut-off

In the event of a fire or other thermal event that results in the activation of the fire alarm system, fire suppression system or mechanical ventilation system, the BESS will automatically go into an emergency stop that shuts down the system and disconnect power to the BESS unit.

Automatic emergency stop is initiated from any of the following triggers:

- Hydrogen sensor (signals H_2 concentration set point reached)
- Activation of the F-stop button (external to the unit/enclosure)
- Fire alarm (signals smoke and/or heat)
- Activation of the PCS smoke sensor
- PCS door, DC Disconnect door, and all battery door alarms (‘door open’), except the BOP and Chiller compartment doors
- Automatic activation from the battery BMS.

6.2.7 Firewalls

The B-VAULT is equipped with firewalls, providing an additional layer of passive fire safety from either a balance of plant fire or adjacent unit fire. Proprietary refractory materials are installed in all the walls and roof of the battery compartment and have completed testing as per EN1364-1 to demonstrate that it maintains its insulation and integrity for 120 minutes, Ref [34] and [35]. In combination with the equipment spacing in the layout, this minimizes the risk of unit-to-unit propagation.

The B-VAULT wall linings are illustrated in Figure 6-2, Ref [29].

Figure 6-2 B-Vault firewall linings

Time	Color
Materials: 2 hours | 45mm	
2 Hr. | 75mm	
1 Hr. | 100mm Rockwool	
0.2 Hr. | 25mm Rockwool	
2 Hr. | 75mm+35mm PE Foam	

Time	Color
0 Hr. | 100mm Rockwool	
0 Hr. | 200mm Rockwool	
0 Hr. | 45mm PE Foam	
0 Hr. | 60mm PE Foam	

6.3 Transformer fire

The fire safety strategy for a transformer fire and the supporting design features and/or control measures are presented in Table 6-2, Ref [15] and [17].

Table 6-2 Fire safety strategy – Transformer fire

Strategy	Design features and/or control measures
1. Minimise the risk of a fire starting	• Transformer specification considered insulation levels, operating temperatures, cooling systems, protection systems, operation and maintenance practices (including the effect of prolonged overloading).
	• Current and voltage overload protection (e.g. circuit breaker).
	• Preventative maintenance and replacement of faulty equipment.
	• NES1, NES2 and NE BESS HV transformers are provided with a lightning mast.
2. Minimise the risk of transformer failure developing into an oil fire propagation to a fully developed transformer fire	• Selection of insulating liquids type, tank strength, low explosion risk bushings and pressure relief.
	• For the BESS MV transformers, FR3 fluid will be used which has a high flash and fire points (≥ 330°C; twice as high as mineral oil). It is classified as a “less combustible” dielectric fluid for transformer application.
	• The auxiliary transformer at the BESS Compound APU will be a dry-type transformer and would have reduced fire risk (i.e. do not contain insulating oil).
3. Firefighting response	• The ERT will activate the firefighting trailer/strike vehicle to either extinguish the fire or contain the fire until Emergency Services arrive, when safe to do so, Ref [15].
4. Minimise the risk of fire spreading to adjacent transformers, control building and other structures	• Provision of oil containment system (i.e. bunding) to minimise spread of fire and contamination to the environment, in accordance with the requirements of AS 2067 and AS 1940 requirements. The oil containment system for HV transformers typically include flame trap and an underground containment tank to separate oil from ignition source.
	• NES1, NES2 and NE BESS HV transformers are provided with a 2-hour rated fire resistance wall.
	• Separation distances meeting the required clearances specified in Table 6.1 of AS 2067 (G1-G4) for outdoor transformers in accordance with the transformer type and volume of insulating liquid.

6.4 Fire at the solar farm fuel tank area

The fire safety strategy for a fire at the solar farm fuel tank area and the supporting design features and/or control measures are presented in Table 6-3, Ref [15].

Table 6-3 Fire safety strategy – Fire at the solar farm fuel tank area

Strategy	Design features and/or control measures
1. Prevent loss of containment	• The gasoline and diesel storage tanks are double skinned, providing a secondary layer of containment.
	• The storage tanks and refueling facility comply with AS 1940 requirements.
	• Preventative maintenance and replacement of faulty equipment.
2. Clean-up of spills	• Clean-up of spills or small leaks using spill kit.
3. Control of ignition	• Work procedures in place to minimise potential of ignition (i.e. use of appropriate PPE (non-static), mobile phones not used during refueling).
4. Firefighting response /	• The ERT will assess based on the situation (i.e. size of leak) to either extinguish the fire or contain the fire until fire services arrive, when safe to do so, Ref [15]. ABE extinguishers are provided at the solar farm O&M building and also on site vehicles.
5. Minimise the risk of fire spreading	• Housekeeping of the fuel storage tank area to remove non-essential combustible materials in vicinity of the fuel storage tanks

6.5 Fire at the general storage container

The fire safety strategy for a fire at the BESS compound general storage container (BLD +07) and the supporting design features and/or control measures are presented in Table 6-4, Ref [9].

Table 6-4 Fire safety strategy – Fire at the general storage container (BLD +07)

Strategy	Design features and/or control measures
1. Prevent battery thermal runaway during charging	• Spare batteries are shipped from factory at 40% state of charge.
	• The HVAC system of the general storage container maintains the batteries within the specified long term storage requirement (i.e. temperature and humidity) as specified by the battery OEM (REPT).
	• At the general storage container, spare batteries will be stored in dedicated racks. Charging of the spare batteries will only be undertaken during maintenance charging (6-monthly), which will be an attended operation and under a procedure (i.e. charging to be completed one battery pack/module at a time).

Strategy	Design features and/or control measures
	• Spare batteries will be maintained as per the OEM requirements. This includes (1) voltage check every 3 months and (2) maintenance charging every 6 months using REPT maintenance equipment.
	• The Control Cabinet (BOP) electrical system safety features include AC circuit breakers and surge protection device.
	• Battery cells are designed to withstand some level of deviation (e.g. high temperature, overcharge).
2. Fire detection	• Sensor (temperature) and detectors (CO and smoke) with alarms and notification via SCADA to the remote monitoring centre for response action.
3. Defensive fire response	• In a fire event involving the general storage container, a defensive fire response strategy will be adopted (i.e. allow the container to burn in a controlled fashion until all fuel sources are depleted). There is no requirement to apply water directly to the container on fire as this may potentially delay eventual combustion of the entire container.
4. Minimise the risk of fire propagation to adjacent BESS units	• As part of the defensive firefighting strategy, water may be applied to nearby equipment or structures for cooling as necessary using dedicated fire hydrants provided around the perimeter of the BESS array. Decision to provide cooling will be made in coordination between: o ACEN (facility owner) o Energy Vault (O&M Contractor and the OEM Subject Matter Expert) o FRNSW (emergency responder). Note: Where required, application of cooling water will be undertaken by FRNSW using their equipment connected to the onsite fire hydrants. Water will be drawn from the cooling water supply tanks.
	• The quantity of spare batteries to be stored at the containers are limited (up to 32 battery modules; expected around 12 battery modules will be stored).
	• The container walls are fire rated for 30-45 minutes with R-value of 2.6 and doors are PE foam insulated with R-value of 2.
	• Based on a conservative assumption that the radiant heat impact is similar to a BESS unit on fire (refer to Section 5.4) and separation distance to closest BESS units (15 m), escalation to the BESS units is not expected. A BESS unit will contain larger stored energy compared to the quantity of spare batteries stored in the container.

6.6 Bushfire

The fire safety strategy for a bushfire and the supporting design features and/or control measures are presented in Table 6-5.

Table 6-5 Fire safety strategy – Bushfire

Strategy	Design features and/or control measures
1. Management of fuel load	• Landscaping (within the solar array, any shelter belts, screens and buildings)
	• Monitoring of grass land curing status and management based on curing level.
	• Housekeeping - removal of non-essential combustible materials in vicinity of the perimeter fence (e.g. wooden pallets, mulch piles, timber stockpiles).
2. Management of Asset Protection Zones (APZs)	• 10 m APZ (firebreak buffer zone) within the BESS compound boundary
	• The BESS compound is surrounded by other NES infrastructure (e.g. solar arrays, substation) and would benefit from APZs of the surrounding infrastructure: ○ 20 m APZ around buildings and fuel storage ○ 10 m APZ around the perimeter of the solar array.
3. Monitoring of weather condition	• Daily and potentially hourly site fire weather monitoring actions during the bushfire season and on days of heightened bushfire risk.
4. Control of ignition	• Work procedures in place to minimise potential of ignition, for example: ○ Use of appropriate PPE (non-static) ○ Mobile phones not used during refuelling ○ Requirement for a hot work permit ○ No hot work on total fire ban condition.
	• Lightning mast
5. Provision for emergency response	• A bushfire within a 30 km radius 'Hazard Zone' of the NES triggers the bushfire emergency response procedure as per the FERP, Ref [15].
	• Provision of a 60,000 L static water supply.
	• Provision of 4 water carts for the solar farm: ○ Two 600 L, located at (1) north-west corner adjacent to rail line and (2) southern extent of NES Stage 1 ○ Two 2400 L (new), to be strategically stored at the solar farm area. Note: ERT personnel have completed specific training (August 2024) for firefighting first response to support the water cart operation.
6. Minimise risk of impact to buildings	• All NES buildings are constructed in accordance with AS 3959:2018 Construction in bushfire-prone areas.
	• Buildings on site are maintained for bushfire preparedness so as not to present a fire risk (e.g. 20 m APZ, gutters cleaned).

6.7 First aid fire protection

The specification of first aid fire protection (e.g. fire extinguishers, hose reels) to be provided for the BESS Compound buildings are not known at this stage. However, the required provision per the National Construction Code (NCC) requirements for each building will be complied with.

Recommendation 1: Energy Vault (O&M Contractor) to comply with the Certifier's requirements on provision of first aid fire protection for the BESS Compound buildings as part of the occupancy certification.

6.8 Fire Emergency Services

6.8.1 Notification and call-out

General

The NES is generally staffed 5 days a week (Monday to Friday) between 7am to 6pm. Staff will be on call during weekends and public holidays. As per the FERP, Ref [15], it is the responsibility of the person discovering the fire to alert (1) Emergency Services by calling 000 and (2) the Emergency Response Coordinator (ERC).

Each contractor will have a designated ERC (and deputy) for the relevant stage it is engaged for. Either the ERC and/or the deputy ERC will always be present on site. The ERC is responsible for:

- Responding to incidents/emergencies in accordance with the FERP.
- When evacuation is required, ensuring that personnel that are affected are evacuated.
- Liaise and coordinate with Emergency Services providing up to date information.
- Direct Emergency Services to the incident scene from the designated site access location.

Each ERC may appoint an Emergency Response Team (ERT) to respond or assist in the response to an emergency. The ERT will follow the directions of the ERC. The ERC may appoint an ERT Leader who has the overall responsibility of the ERT. The ERT Leader has the responsibility to:

- Coordinate any rescue and respond to all emergency situations
- Control the incident scene
- Coordinate the emergency response from the scene of the incident.

BESS

The BESS facility will be normally unmanned and remotely controlled from the RMC. The BESS control systems (e.g. BMS and EMS) include notifications and alarms (audible and visual) to assist the remote operator to troubleshoot and alert any abnormal events or an emergency. During an emergency, the remote operator will notify:

- Emergency Services (i.e. FRNSW) by calling 000
- The designated ERC
- Energy Vault's Support Engineer, who will provide information on the BESS and advice to the attending Emergency Services personnel.

The proposed location for the BESS facility's Fire Detection Control and Indicating Equipment (FDCIE) is next to the fire hydrant booster assembly.

Recommendation 2: ACEN and Energy Vault to investigate options to automate fire notification from the Stage 3 BESS facility to FRNSW.

Recommendation 3: ACEN to consider integrating all NES FDCIEs including Stage 3 BESS to a site wide FDCIE. This will provide a site wide alert improving the emergency response coordination between the different O&M contractors for the solar farm and BESS. Currently, there are separate FDCIEs established across the different areas or infrastructure with the NES (e.g. substation, solar farm O&M building and warehouse have separate FDCIEs).

Recommendation 4: ACEN to update the NES Fire and Emergency Response Plan (FERP) to include emergency response actions for fire scenarios at the BESS compound, including:

- Scenarios included in Section 8 *Incident Scenarios and Procedures* of the B-Vault ERP, Ref [1].
- Safe stand-off distance of 30 m shall be maintained between individuals and the BESS unit on fire, per the B-Vault ERP.
- Specification of the required PPE and resource for emergency response personnel, including Self-Contained Breathing Apparatus (SCBA), portable gas detectors and thermal imaging devices.
- Contact numbers of the Energy Vault Remote Monitoring Centre and Support Engineer.
- Fire strategy and measures outlined in Sections 6.2 to 6.4.

6.8.2 Fire services

FRNSW is the fire services unit that will respond to fires and rescue emergencies. Either FRNSW and/or RFS will respond to grassfires or bushfires subject to location and availability, Ref [15]. The fire services units will liaise with the ERC and/or ERT Leader when on site and thereafter will take command of the fire ground. When the site in unattended, FRNSW personnel will standby at the site entrance for a representative to arrive (i.e. will not enter an unattended site).

Outside of the normal staffed hours, the response time for a site representative to arrive on site in the event of an emergency is 2 hours. This is per the service agreement timeframe between ACEN and Energy Vault (O&M Contractor) for local response time for *Critical* priority alarms.

Note: *Critical* priority alarms are associated with failures that stop the correct operation and generation of at least one or more DC to AC conversion block or a failure that affects the correct operation of any safety system (e.g. fire detection, fire suppression and battery cooling systems).

The closest FRNSW fire stations and RFS brigades are shown in Table 6-6, Ref [15].

Recommendation 5: ACEN and/or Energy Vault (O&M Contractor) to coordinate Pre-Incident Planning (PIP) with the local fire services once the BESS is operational (typically within the first year of operation) and subsequent exercises as agreed with fire services. The PIP and exercises will assist to familiarise fire services with the site and access, the available firefighting/fire response equipment and water supply, a test the response time from notification to arriving on site.

Recommendation 6: ACEN and/or Energy Vault (O&M Contractor) to develop an Emergency Services Information Package (ESIP)[8] for the Stage 3 BESS facility in accordance with FRNSW Fire Safety Guideline – *Emergency services information package and tactical fire plans*. Alternatively, update the existing ESIP to include the Stage 3 BESS facility. Once developed, a copy of ESIP should be made available at the designated site entry point and other locations as determined by the regulatory authority.

Recommendation 11: ACEN and/or Energy Vault (O&M Contractor) to provide signage at the entrance gate to ensure FRNSW personnel does not enter until a site representative is present.

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[8] The ESIP is a complete, self-container, portable package intended to provide emergency services with specific information that can be used during operations and develop effective strategies and tactics to manage a fire or emergency incident. It includes the following information:

- Site overview
- Emergency contact list
- Evacuation overview
- Tactical check lists
- Hazardous chemicals
- Tactical fire plans.

Table 6-6 FRNSW stations and RFS fire brigades nearest to NES site

Station / Brigade	Impact level	Distance	Phone
FRNSW stations			
Uralla	28 Salisbury St, Uralla NSW 2358	15 km	(02) 6778 4010 Emergency: 000
Armidale	66 Barney St, Armidale, NSW 2350	30 km	(02) 6771 5076 Emergency: 000
Guyra	73 Ollera St, Guyra, NSW 2365	66 km	(02) 6779 1448 Emergency: 000
RFS brigades			
Diggings (Rocky River)	Duzus, 301 Thunderbolts Way, Rocky River, NSW 2358	15 km	Emergency: 000
Diggings (Bilga Road)	Bilga Road, Ivergowrie, NSW 2350	25 km	Emergency: 000
Kentucky	Kingston Road, Uralla, NSW 2358	28 km	Emergency: 000
Dumaresq	10 Mann St, Armidale, NSW 2350	30 km	(02) 6771 2400 Emergency: 000

6.8.3 Emergency vehicle access

The main access to the BESS compound is via the New England Highway, Barleyfields Road (North) and Big Ridge Road, as shown in Figure 6-3. A new access road approximately 600 m long will be built connecting the Big Ridge Road to the BESS compound, as shown in Figure 6-4. The access road will have a minimum width of 7.2 m, Ref [36].

The BESS compound is provided with 2 vehicle access points (one to the east and one to the west). An internal access road is provided within the compound. The perimeter access road will have a width of 6 m and the access road traversing the battery arrays will have a width between 9 -11 m, as shown in Figure 6-5. The design is intended to allow vehicles direct route out in an emergency event without needing to reverse.

The access roads will be of all-weather construction and capable of accommodating vehicles with cargo loads of up to 48 tonnes (i.e. heaviest vehicles anticipated for construction and delivery of BESS products and associated equipment). The access roads have been designed to accommodate a prime mover and long semi-trailer with overall length of 25 m, including a 15 m curb to curb turning radius and 0.540 m minimum body ground clearance. The access roads will enable emergency services to access all areas of the compound, including fire service infrastructure (i.e. cooling water services and hydrants).

The fire hydrant system will comply with AS 2419.1 *Fire hydrants installations*, including requirement for hardstand area. A designated 13 m x 6 m hardstand area[9] will be provided adjacent to the fire hydrant booster assembly and FDCIE cabinet, as shown in Figure 6-6. The design will allow the fire truck to be parked max 4.5 m from the fire hydrant booster assembly. The internal access road can also function as hardstand areas.

[9] The hardstand areas are intended to provide a safe working space for firefighters to exit the vehicle and move around the fire appliance to remove and use equipment, including connecting fire hoses, Ref [33].

Figure 6-3 Traffic access to site

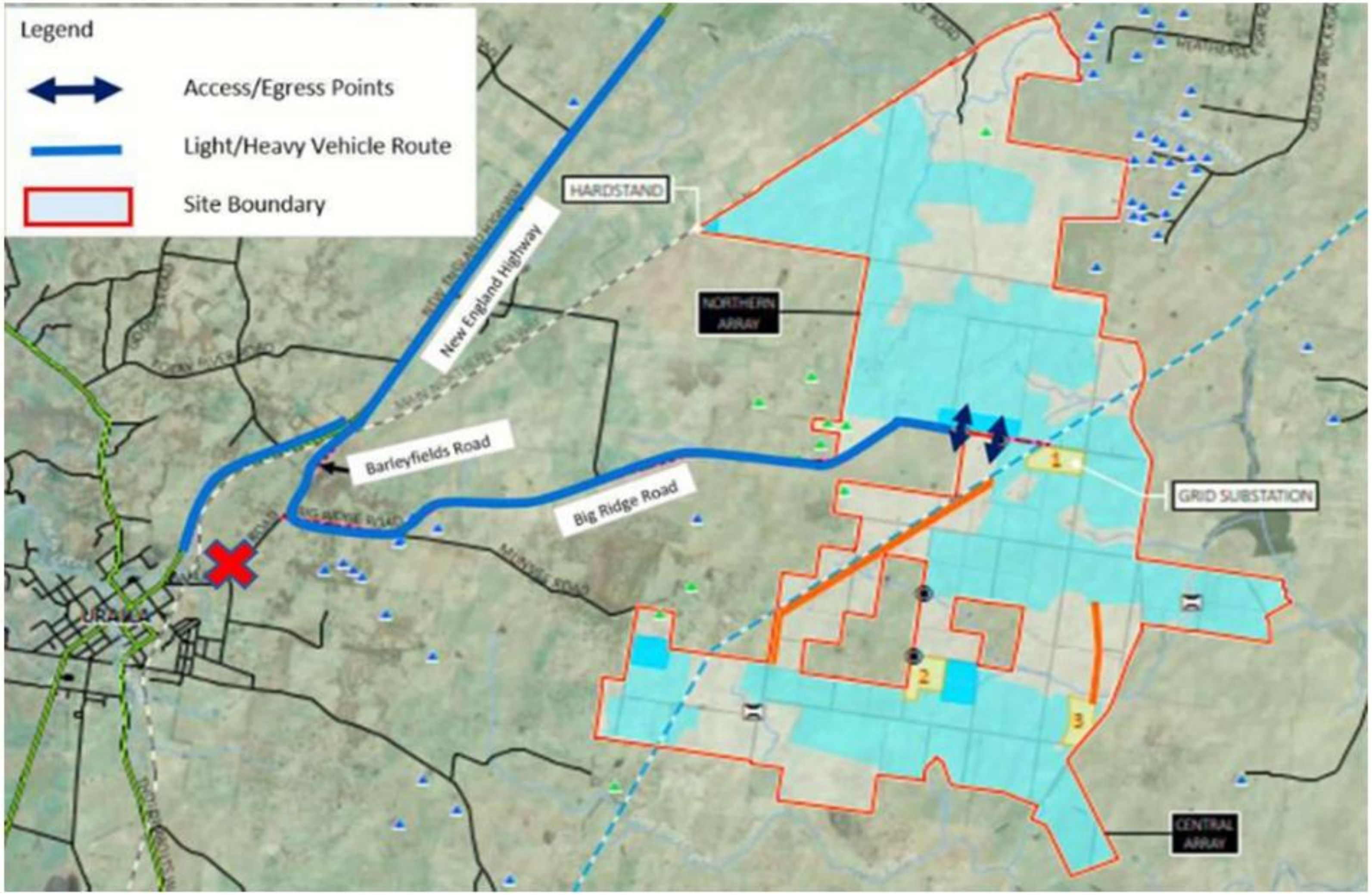


Figure 6-4 Internal access road to BESS compound

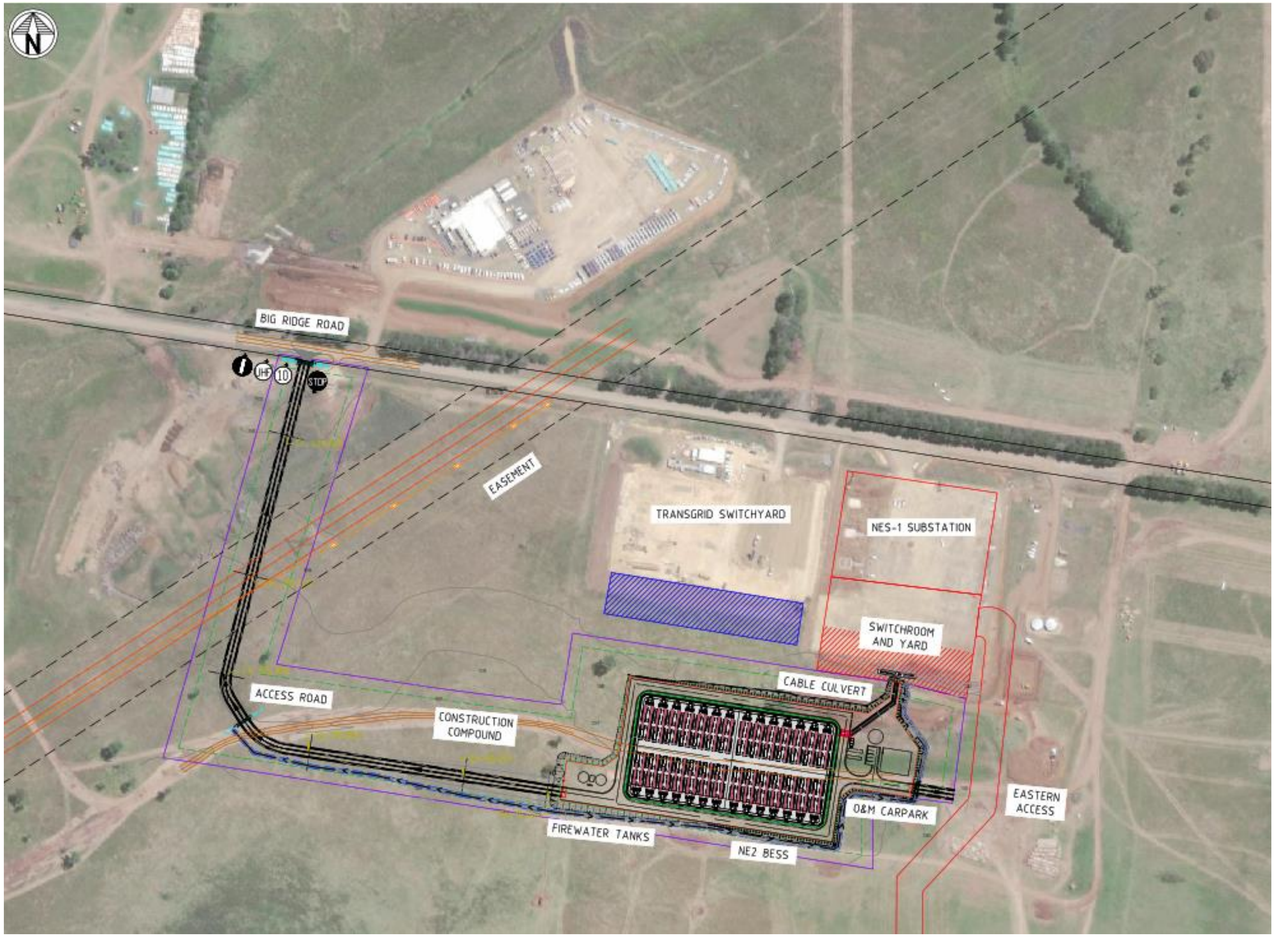


Figure 6-5 BESS compound access road

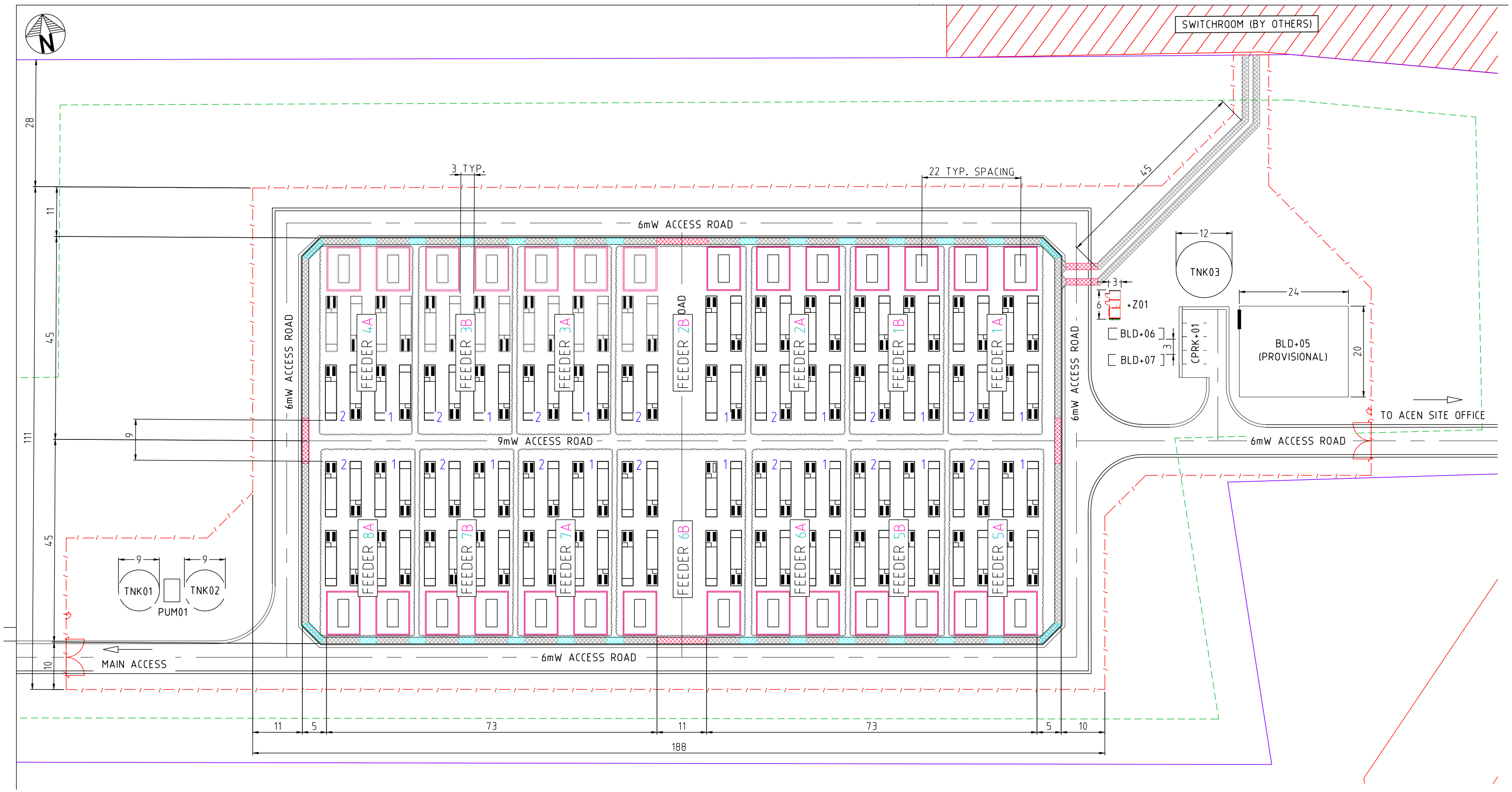
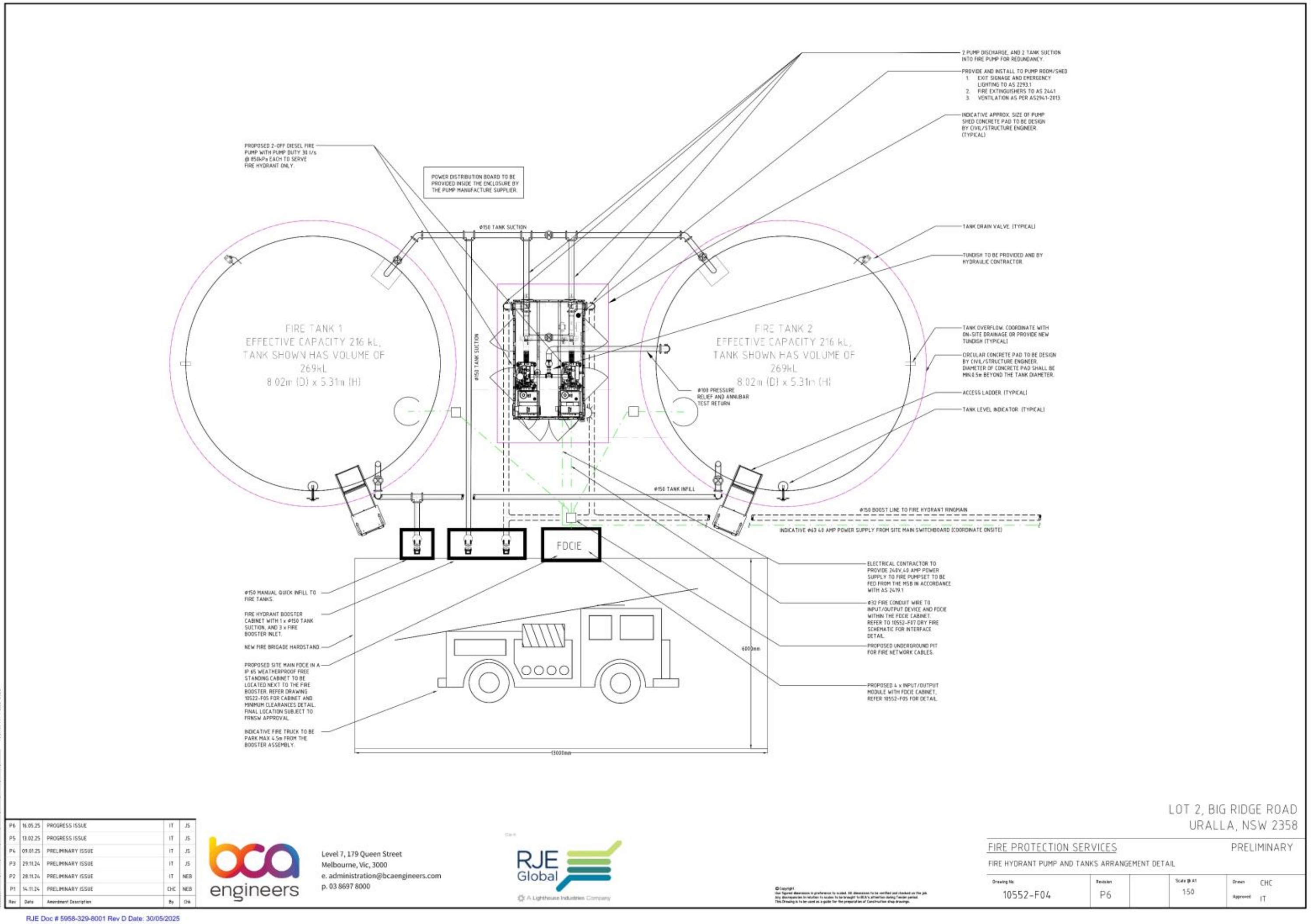


Figure 6-6 Fire hydrant tanks, booster assembly and hardstand



7 Cooling water

7.1 Cooling water demand and supply

In the event of a BESS unit on fire, a defensive fire response strategy will be adopted (i.e. allow the affected unit to burn in a controlled fashion until all fuel sources are depleted). Water will be applied to nearby units for cooling as necessary using dedicated fire hydrants provided around the perimeter of the BESS array. Decision to provide cooling will be made in coordination between:

- ACEN (facility owner)
- Energy Vault (O&M Contractor and the OEM Subject Matter Expert)
- FRNSW (emergency responder).

The water demand for the fire hydrants was determined based on the requirements specified in Victoria Country Fire Authority (CFA) *Design Guidelines and Model Requirements for Renewable Energy Facilities*, Ref [37], for centralised BESS facilities which requires that:

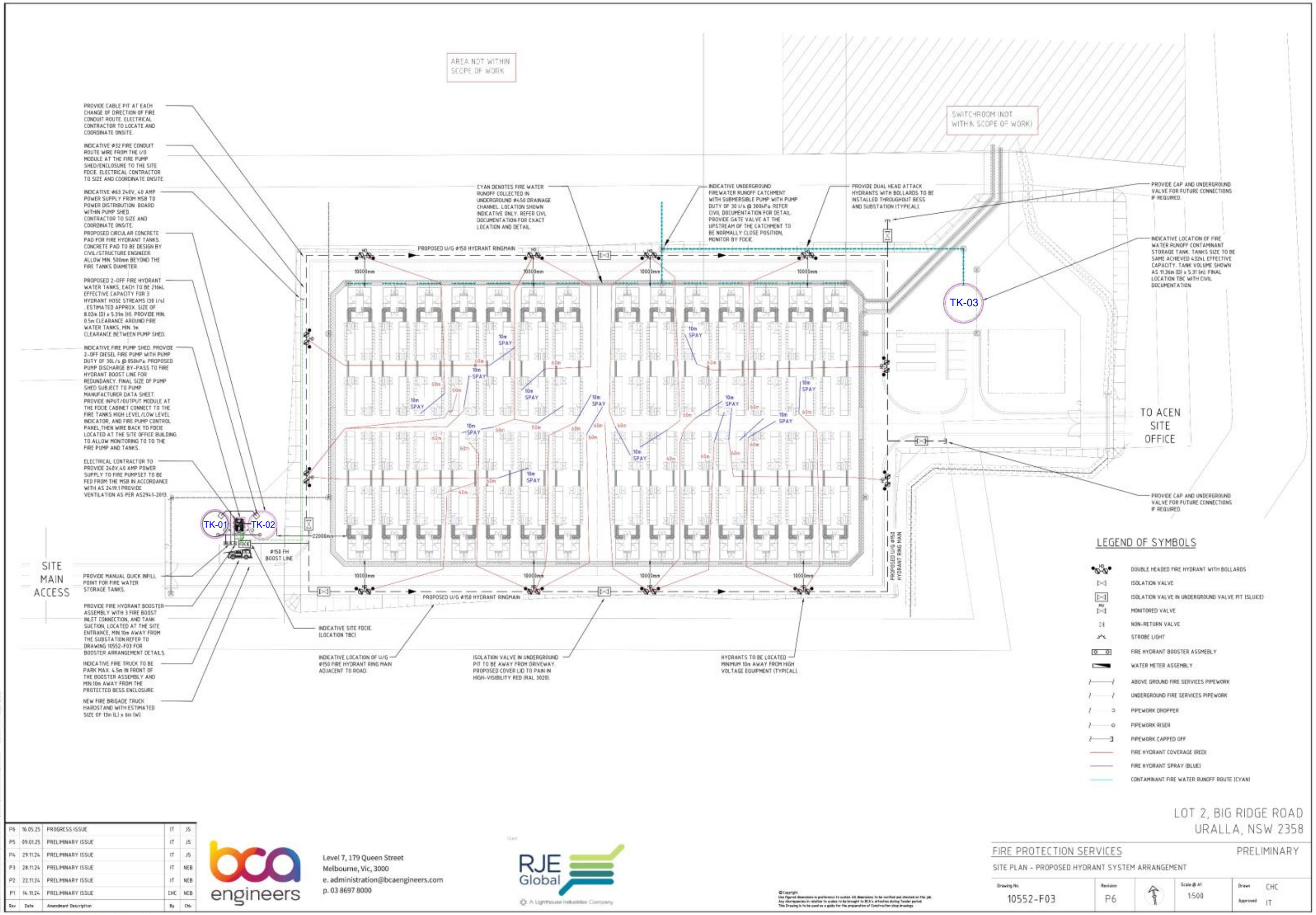
> *The quantity of static fire water storage is to be calculated from the number of hydrants required to flow from AS 2419.1-2021: Fire hydrants installations, Table 2.2.5(D). For example, for battery installations with an aggregate area of over 27,000 m^2, 4 (four) hydrants outlets are required to operate at 10 L/s for four hours, which equates to a minimum static fire water supply of 576 kL.*

For the Stage 3 BESS compound (9000 m^2 < footprint area ≤ 27,000 m^2), the required static fire supply was determined to be 432 kL based on the requirement to have 3 hydrant outlets with flow of 10 L/s for 4 hours. This meets the minimum requirement for 90 minutes supply specified in HIPAP No. 2, Ref [10]. To meet the required demand, two 216 kL water tanks and two diesel pumps (duty and standby) will be provided. The water supply options (including the sources and available supplies) are detailed in the NES Water Supply Strategy document, Ref [38].

The locations of the cooling water tanks (TK01-02), pump module, ring main and fire hydrants are shown in Figure 7-1.Hydraulic modelling of the supply of water to the hydrants is provided in APPENDIX D. The hydraulic calculation models the hydrants at the most hydraulically challenged location (furthest from the pump and tanks) to confirm the required duty at the pump discharge end. The result indicates that the proposed pump and tanks system can supply sufficient flow and pressure (30 L/s @ 700kPa) at the hydrant outlets to the most hydraulically challenged location (i.e. eastern side of the BESS array).

Recommendation 7: Energy Vault (O&M Contractor) to ensure that the firewater/cooling water system including the hydrants are tested in accordance with the relevant standards and/or regulatory requirement.

Figure 7-1 Layout – Fire protection services (cooling water tanks and hydrants)



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7.2 Spent cooling water containment

The spent cooling water run-off and containment system is purpose built and comprise the following:

- Drainage catchpit with penstock valve and submersible pump (capable of 30 L/s at 30 m head). The pit/capture basin is located at the low end of the culvert, denoted as J1 pit in Figure 7.2.
- Spent cooling water tank, denoted as TK-03 in Figure 7.2.

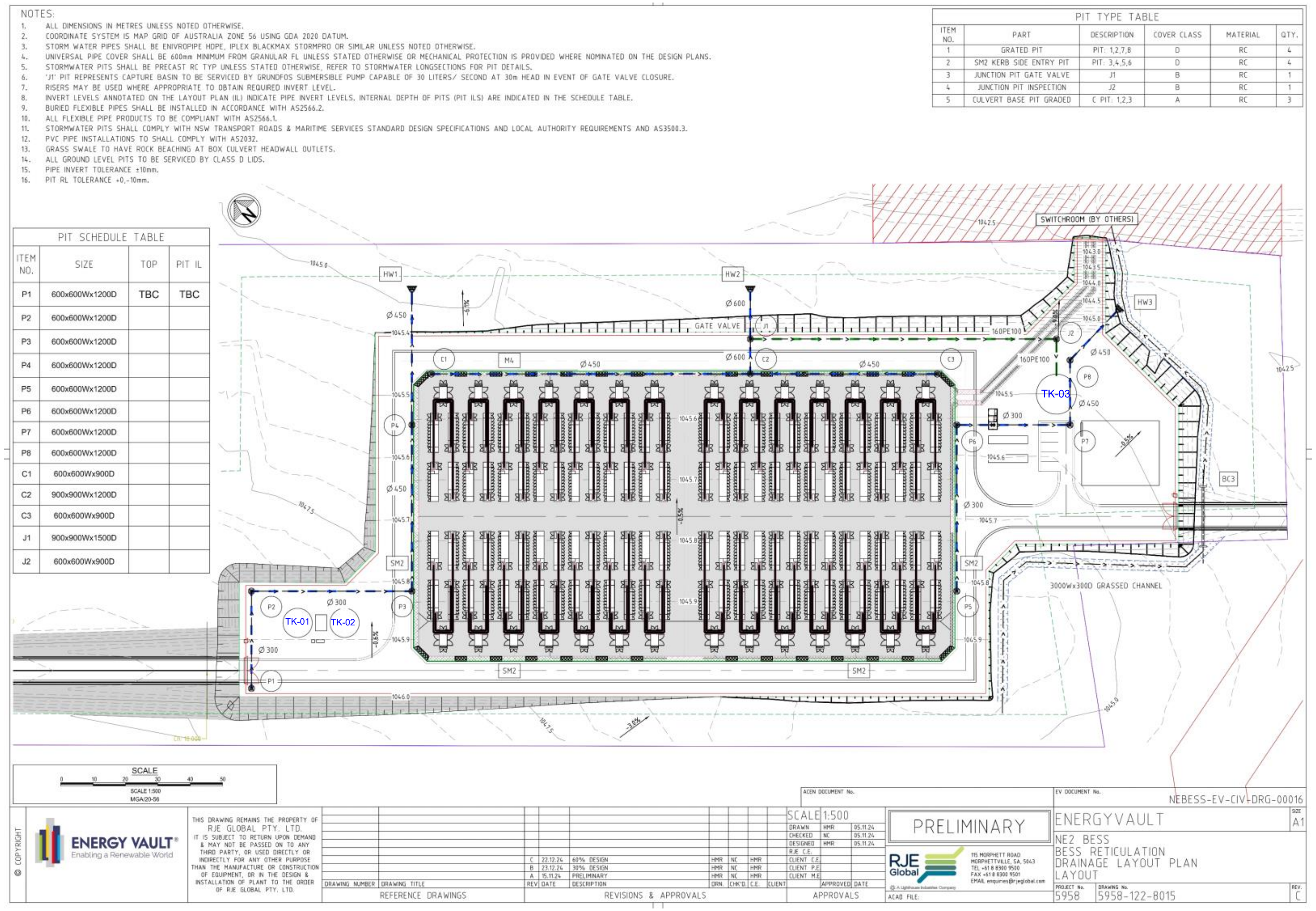
Spent cooling water will flow into the designated drainage into the capture basin. All stormwater pits will be designed with the relevant standards and codes and comply with the authority requirements. During a fire event requiring application of cooling water, the penstock valve will be in closed position to prevent spent cooling water discharge to the stormwater drain. From the catchpit, the water is pumped into the spent cooling water tank (TK-03). The effective volume of TK-03 (432 kL) equals the volume of the cooling water supply tanks (2 x 216 kL).

Recommendation 8: ACEN to ensure that the updated FERP has identified local catchment areas and drainage pathways such that appropriate measures may be implemented in the event that the capacity of the provided containment system is exceeded (Ref: Clause 5.8.6 FRNSW BESS FSS Guideline).

Recommendation 9: ACEN and Energy Vault (O&M Contractor) to ensure that the supporting management and procedures documentation for the BESS facility provide the following details on post incident cleanup and disposal (Ref: Clause 5.9.1 FRNSW BESS FSS Guideline):

- Following an incident, how the affected BESS units will be handled and removed (including transportation) from site.
- A procedure for testing of the spent cooling water and disposal options in accordance with the test result (i.e. if irrigation is acceptable). As it is not used to suppress fire for the affected BESS unit, the spent water may be only lightly contaminated. Water that is tested and found to be not contaminated should be able to be disposed by on-site irrigation if possible, or to off-site stormwater drains.

Figure 7-2 Drainage layout plan



8 Codes and standards

The codes and standards used in the design and operation of the Stage 3 BESS facility are listed in Table 8-1.

Table 8-1 Codes and standards

Components	Codes and standards
BESS	• AS/NZS 3000:2018 Australian Wiring Rules • BS EN1364-1 Fire resistance tests for non-loadbearing elements - Walls • EN ISO 13849-1 Safety of machinery — Safety-related parts of control systems • EN 60146-1-1 Semiconductor converters - General requirements and line commutated converters - Part 1-1: Specification of basic requirements • EN 60204-1 Safety of machinery - Electrical equipment of machines - Part 1: General requirements • IEC 63056 Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries for use in electrical energy storage systems • IEC 60730-1 Automatic electrical controls - Part 1: General requirements • IEC 62619 Safety requirements for secondary lithium cells and batteries, for use in industrial applications • NFPA 69 Standard on Explosion Prevention Systems • NFPA 72 National Fire Alarm and Signaling Code • NFPA 855 Standard for the Installation of Stationary Energy Storage Systems • UL 1642 Lithium batteries • UL 1973 Batteries for Use in Stationary and Motive Auxiliary Power Application • UL 9540 Standard for Energy Storage Systems and Equipment • UL 9540A Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems • UN 38.3 Testing for lithium batteries • UN 3536 Lithium batteries installed in cargo transport unit - lithium ion batteries or lithium metal batteries
Substation and transformers	• AS 2067:2016 Substations and high voltage installations exceeding 1 kV a.c • AS/NZS 1768:2007 Lightning protection
Hydrant system	• AS 2419.1:2021 Fire hydrant installations - System design, installation and commissioning to provide a working space for firefighters • AS 1074:1989 Steel tubes and tubulars for ordinary service • AS/NZS 1477:2017 PVC pipes and fittings for pressure applications • AS/NZS 3500.1:2021 Plumbing and drainage – Part 1: Water services
Cooling water pump room/shed	• AS 2941:2013 Fixed fire protection installations - Pumpset systems • AS/NZS 2293.1:2018 Emergency lighting and exit signs for buildings – Part 1: System design, installation and operation

Components	Codes and standards
	• AS 2444:2001 Portable fire extinguishers and fire blankets - Selection and location
O&M Building and Warehouse	• National Construction Code (NCC) 2022 • AS/NZS 1850:2009 Portable fire extinguishers - Classification, rating and performance testing • AS 2444:2001 Portable fire extinguishers and fire blankets - Selection and location

9 Conclusions and recommendations

9.1 Conclusions

The FSS has identified fire events associated with the proposed BESS and other fire scenarios that could impact/escalate to the BESS facility. For the scenarios that were carried forward for further analysis, consequence modelling and review of the fire strategies and the supporting measures (fire prevention, detection and protection) were completed.

The study findings are as follows:

- Based on the separation distances, fires from existing infrastructure from NES Stages 1 and 2 are not expected to escalate to the Stage 3 BESS compound. Bushfire is also not expected to impact the BESS compound accounting for the APZ provided for the overall NES site and the BESS compound.
- A credible fire scenario for the proposed BESS is a battery compartment fire which was analysed to understand the consequences of a BESS unit on fire. The analysis found that:

  <u>Heat radiation impact</u>

  - The 3 kW/m^2 heat radiation (emergency responder endangerment) does not impact the cooling water tanks and pump but may affect accessibility to some fire hydrants depending on the location of the BESS unit on fire. If a BESS unit on fire is impeding access to the closest hydrant, the next two closest hydrants will be accessible to provide cooling to nearby units (i.e. coverage redundancy included).
  - The 4.7 kW/m^2 heat radiation (personnel injury) does not impact the buildings within the BESS compound and remains within the BESS compound boundary (i.e. no offsite impact resulting in injury/fatality).
  - The 23 kW/m^2 heat radiation (propagation to non-combustible material) extends 5 m from the BESS unit on fire and propagation to the front adjacent BESS unit is theoretically possible in absence of any fire protection measures to prevent the fire spread. Protection measures on the adjacent BESS unit to minimise risk of fire propagation includes (1) 2-hour fire rated battery compartment walls, (2) liquid cooling on the battery modules and (3) cooling using fire hydrants.

  <u>Dispersion of toxic combustion products</u>

  - Distances to AEGL-1 (irritation), AEGL-2 (injury) and AEGL03 (fatality) remain within BESS compound boundary (i.e. no offsite impact resulting in injury/fatality).
- A CFD analysis was carried out to assess the thermal runaway or fire propagation potential to adjacent units in the event of a single battery unit burning. The CFD models reflect the project specific battery system and configuration (i.e. spaced 3 m apart on all sides) and did not account for the effects of any fire suppression systems or first responders (no intervention assumed). The findings are as follows:
  - Predicted air temperatures in the battery compartment of adjacent units do not approach the cell venting temperature in any wind conditions modelled. Therefore, propagation of a fire to thermal runaway in an adjacent unit is not expected.
  - Modelling results indicate that maximum heat fluxes on or near the surface of adjacent units may cause damage to components such as gaskets or rubber seals resulting in

a path for flames or hot gases to be drawn into an adjacent unit leading to temperature rise and thermal runaway. To address this, the B-Vault AC system design includes a layer of steel covering the door gaskets/seals designed to reduce heat exposure. The exhaust fans on the outside of the enclosure are also protected with a steel damper when not in use. These additional barriers are designed to provide protection to the major vulnerable areas on the exterior of the enclosure.

  - Modelling results indicate that maximum temperatures on the outside of adjacent units could melt the door seals, creating new openings for hot gases to enter the enclosures. To address this, the B-Vault AC system design includes a layer of steel covering the door gaskets/seals to protect the door seals. If the door seals are damaged, the steel is intended to block hot gases from entering the enclosure.

- In the event of a BESS unit on fire, a defensive fire response strategy will be adopted (i.e. allow the affected unit to burn in a controlled fashion until all fuel sources are depleted), where:
  - There will be no requirement to apply water directly to the BESS unit on fire.
  - Cooling water may be applied to nearby equipment or structures for cooling as necessary using dedicated fire hydrants provided around the perimeter of the BESS array. Decision to provide cooling will be made in coordination between:
    - ACEN (facility owner)
    - Energy Vault (O&M Contractor and the OEM Subject Matter Expert)
    - FRNSW (emergency responder).
- The fire safety strategy and the supporting design features and/or control measures (fire prevention, detection and protection) are appropriate for the specific fire hazard and adequate to meet the extent of the potential fires.
- The combined volume of the cooling water supply (TK01-02) meets the demand which was based on the requirement to have 3 hydrant outlets with flow of 10 L/s for 4 hours (i.e. 432 kL).
- During a fire event requiring application of cooling water, the penstock valve at the drainage catchpit will be in closed position to prevent spent cooling water discharge to the stormwater drain. From the catchpit, the water is pumped into the spent cooling water tank (TK-03). The volume of the spent cooling water tank (432 kL) equals the volume of the cooling water supply tanks.

9.2 Recommendations

The study recommendations including those accepted for implementation or further assessment are presented in Table 9-1.

In line with Condition 23 of Schedule 3 of the Development Consent, following the Secretary's approval of the Fire Safety Study, the Applicant is required to implement the recommendations described in the Fire Safety Study. Implementation of these recommendations will be audited for compliance through a number of mechanisms including:

- Design requirements through the Construction Certificate process.
- Confirming built infrastructure has been constructed in accordance with the design through the Occupation Certificate process.

- The Independent Audit process as nominated by Condition 11 of Schedule 4 of the Development Consent.

Additionally, any findings relating to fire and emergency response will be captured in the updated Fire and Emergency Response Plan as well as details of how the Battery Storage can be safely isolated in an emergency (Development Consent, Schedule 3, Condition 26).

Table 9-1 Study recommendations accepted for implementation or further assessment

No	Recommendations	Accepted for implementation / further assessment?	Remarks (ACEN and Energy Vault)
1	Energy Vault (O&M Contractor) to comply with the Certifier's requirements on provision of first aid fire protection for the BESS Compound buildings as part of the occupancy certification.	Yes	Accepted for implementation. First aid fire protection will be provided for the BESS compound buildings per the National Construction Code (NCC) requirements for each building. Energy Vault is finalising the design of the buildings. Once finalised and NCC requirements are known these will be provided to FRNSW.
2	ACEN and Energy Vault to investigate options to automate fire notification from the Stage 3 BESS facility to FRNSW. <u>Note</u>: In its feedback on the Rev 0 FSS submission, FRNSW recommends providing Alarm Signalling Equipment (ASE) or similar to ensure automatic notification.	Yes	Currently, the proposed design is based on manual notification by the Remote Monitoring Centre (RMC) operator in the event of an emergency. The BESS facility will be monitored 24/7 and remotely controlled from the RMC. The BESS control systems include notifications and alarms (audible and visual) to assist the RMC operator to troubleshoot and alert any abnormal events or an emergency. During an emergency, the RMC operator will notify: - Emergency Services (i.e. FRNSW) by calling 000 - The designated Emergency Response Coordinator (ERC) - Energy Vault's Support Engineer. The project has accepted the recommendation to provide automatic notification of a fire alarm to FRNSW. The engineering solution to provide automatic notification to FRNSW will be developed and implemented in consultation with FRNSW to ensure the specific requirements are met.

No	Recommendations	Accepted for implementation / further assessment?	Remarks (ACEN and Energy Vault)
3	ACEN to consider integrating all NES FDCIEs including Stage 3 BESS to a site wide FDCIE. This will provide a site wide alert improving the emergency response coordination between the different O&M contractors for the solar farm and BESS. Currently, there are separate FDCIEs established across the different areas or infrastructure with the NES (e.g. substation, solar farm O&M building and warehouse have separate FDCIEs).	No	The BESS FDCIE will be kept separate from (1) the BESS substation FDCIE and (2) the solar farm FDCIE, i.e. these will not be tied together.
4	ACEN to update the NES Fire and Emergency Response Plan (FERP) to include emergency response actions for fire scenarios at the BESS compound, including: - Scenarios included in Section 8 *Incident Scenarios and Procedures* of the B-Vault ERP, Ref [1]. - Safe stand-off distance of 30 m shall be maintained between individuals and the BESS unit on fire, per the B-Vault ERP. - Specification of the required PPE and resource for emergency response personnel, including Self-Contained Breathing Apparatus (SCBA), portable gas detectors and thermal imaging devices. - Contact numbers of the Energy Vault Remote Monitoring Centre and Support Engineer. - Fire strategy and measures outlined in Sections 6.2 to 6.4.	Yes	Accepted for implementation. Recommendation is aligned with the Energy Vault Platform 2 ERP.
5	ACEN and/or Energy Vault (O&M Contractor) to coordinate Pre-Incident Planning (PIP) with the local fire services once the BESS is operational (typically within the first year of operation) and subsequent exercises as agreed with fire services. The PIP and exercises will assist to familiarise fire services with the site and access, the available firefighting/fire response equipment and water supply, and test the response time from notification to arriving on site.	Yes	Accepted for implementation.

No	Recommendations	Accepted for implementation / further assessment?	Remarks (ACEN and Energy Vault)
6	ACEN and/or Energy Vault (O&M Contractor) to develop an Emergency Services Information Package (ESIP) for the Stage 3 BESS facility in accordance with FRNSW Fire Safety Guideline – *Emergency services information package and tactical fire plans*. Alternatively, update the existing ESIP to include the Stage 3 BESS facility. Once developed, a copy of ESIP should be made available at the designated site entry point and other locations as determined by the regulatory authority.	Yes	Accepted for implementation.
7	Energy Vault (O&M Contractor) to ensure that the firewater/ cooling water system including the hydrants are tested in accordance with the relevant standards and/or regulatory requirement.	Yes	Accepted in principle. Way forward for implementation to be agreed between ACEN and Energy Vault.
8	ACEN to ensure that the updated FERP has identified local catchment areas and drainage pathways such that appropriate measures may be implemented in the event that the capacity of the provided containment system is exceeded (Ref: Clause 5.8.6 FRNSW BESS FSS Guideline).	Yes	Accepted in principle. The flood study completed for the NES Stage 1 development found that, Ref [2]: - There are 3 major overland flow paths traversing the site - The northern overland flow path drains to Saumarez Creek, while the two southern flow paths directly discharge into the Saumarez Creek Dam. The Stage 3 BESS is located in the southern array. A flood study is being prepared for the Stage 3 BESS. <u>Note</u>: As the volume of the spent cooling water tank (432 kL) equals the volume of the cooling water supply tanks, exceedance of the containment system is not expected..

No	Recommendations	Accepted for implementation / further assessment?	Remarks (ACEN and Energy Vault)
9	ACEN and Energy Vault (O&M Contractor) to ensure that the supporting management and procedures documentation for the BESS facility provide the following details on post incident cleanup and disposal (Ref: Clause 5.9.1 FRNSW BESS FSS Guideline): - Following an incident, how the affected BESS units will be handled and removed (including transportation) from site. - A procedure for testing of the spent cooling water and disposal options in accordance with the test result (i.e. if irrigation is acceptable). Note: As it is not used to suppress fire for the affected BESS unit, the spent water may be only lightly contaminated. Water that is tested and found to be not contaminated should be able to be disposed by on-site irrigation if possible, or to off-site stormwater drains	Yes	Accepted for implementation
10	Energy Vault (O&M Contractor) to ensure that if the temporary storage of battery units onsite is required it meets the requirements specified in FRNSW's position statement for Open Yard Storage of BESS.	Yes	Accepted for implementation where temporary storage onsite is required. Once delivered to site, the intent is to place the battery units onto the dedicated concrete pads where they will be installed with no requirement for temporary storage. This eliminates double handling and reduces risk during construction.
11	ACEN and/or Energy Vault (O&M Contractor) to provide signage at the entrance gate to ensure FRNSW personnel does not enter until a site representative is present	Yes	Accepted for implementation (per FRNSW recommendation).

No	Recommendations	Accepted for implementation / further assessment?	Remarks (ACEN and Energy Vault)
12	Energy Vault (O&M Contractor) to provide further details on the proposed buildings including all relevant NCC requirements. This includes the general storage container (BLD +07). <u>Note</u>: This recommendation was requested by FRNSW in its feedback on the Rev 0 FSS submission.	Yes	Accepted. Energy Vault is finalising the design of the BESS compound buildings. Once finalised and NCC requirements are known these will be provided to FRNSW. Current design are as follows: - All buildings will comply with the NCC requirements and be certified by an independent building certifier. - The fire alarms from each building will be wired back to the SCADA system providing visibility to the operators at the Energy Vault's Remote Monitoring Centre and alert emergency services if needed.
13	ACEN and Energy Vault to provide automated fire notification for the general storage container (BLD +07). <u>Note</u>: In its feedback on the Rev 0 FSS submission, FRNSW recommends ensuring that automatic notification of a fire to the nearest fire station is established for the containers with spare batteries.	Yes	The project notes FRNSW's recommendation to provide automatic notification of a fire to the nearest fire station for containers with spare batteries. The project views that the requirement for automatic notification for the building type and size will be determined by the NCC and Building Certifier's requirements. If automatic notification is required, an engineering solution to provide automatic notification to FRNSW will be developed and implemented in consultation with FRNSW.
14	ACEN and/or Energy Vault (O&M Contractor) to provide signages at appropriate locations (including but not limited to all entrances and the control room) warning the potential electrical and chemical hazards present at the BESS compound, taking into consideration guidance provided in Section 7 of AS 5139 *Electrical installations - Safety of battery systems for use with power conversion equipment*.	Yes	Accepted for implementation.

APPENDIX A FRNSW BESS FSS GUIDELINE CONSIDERATIONS

No	FRNSW BESS FSS Guideline Considerations	Considered?	Remarks
	The development of a FSS for a facility containing the large-scale LiBESS should be undertaken in accordance with the Hazardous Industry Planning Advisory Paper No 2 (HIPAP No. 2) Fire Safety Study Guidelines (Department of Planning, Industry and Environment 2011). This guideline assists persons developing the FSS in undertaking a case-specific hazard-based approach to the design to ensure that the fire safety system is adequate to meet the extent of potential fires for the site and effective in minimising the potential for propagation and escalation of an incident. It is noted that there are many different battery chemistries. The FSS should be based on the particular batteries proposed to be used on the site.	Yes	This FSS was completed following the methodology specified in the HIPAP No. 2 and FRNSW BESS FSS guideline, as outlined in Section 3 (Methodology). Details on the battery system including chemistry are provided in Section 2.2.2 (Battery System).
Section 5.1 – Assessment of potential consequences of credible incidents			
5.1.1	A fundamental objective of a FSS is that the hazard potential of a plant and/or operation is defined by a process of hazard identification and subsequent estimation of the potential consequences of credible incidents. Underestimation of the potential consequence of a credible incident is likely to result in failure of the fire safety system and subsequent propagation and escalation of an incident.	Yes	Hazard identification including scenarios carried forward for further analysis is presented in Section 4. Consequence analysis is provided in Section 5.
5.1.2	A failure event involving LiBESS may eventuate from a number of internal and external mechanisms including mechanical-, thermal- and electrical abuse or failure, and may result in the expulsion of chemical components, propagation of chemical vapours and/or a thermal runaway event and fire and/or explosion.	Yes	Included in Section 4 (Hazard identification).
5.1.3	FRNSW consider a credible incident to be one in which a fire propagates within a LiBESS system or unit, with active fire safety systems disabled, and involves the full BESS unit / container.	Yes	Consequence analysis for a battery unit on fire assessing impacts from radiant heat, toxic products of combustion and propagation potential is included in Section 5 (Consequence Analysis). Assessment of the fire propagation potential to adjacent battery units did not account for the effects of any fire suppression systems.

No	FRNSW BESS FSS Guideline Considerations	Considered?	Remarks
5.1.4	When undertaking consequence analysis of an incident, both the direct impacts of an incident and the potential for propagation and secondary incidents should be addressed. This includes management of chemical components or by-products released during an incident and the environmental impacts of toxic water-run off that may be used to mitigate an incident.	Yes	Consequence analysis of toxic products of combustion is included in Section 5 (Consequence Analysis). Information on the containment of spent cooling water is included in Section 7.2 (Spent cooling water containment).
5.1.5	Where a hazard analysis study (i.e., preliminary hazard analysis, final hazard analysis, or a hazard and operability study) has been undertaken for the site in question, this should be used to inform the FSS.	Yes	The Preliminary Hazard Analysis (PHA) for the site forms an input to the HAZID and consequences in this study.
5.1.6	Whilst the emphasis of this section is the assessment of consequences of a failure event involving LiBESS and the potential for propagation and secondary incidents, the FSS must still consider the broader potential for all credible incident scenarios at the facility.	Yes	The broader potential for all credible scenarios at the facility is included in Section 4 (Hazard identification).
Section 5.2 – Defining the fire safety strategy			
5.2.1	Within the context of a FSS, the fire safety strategy relates to the strategy and approach that will be adopted to achieve the required level of safety and performance. An effective fire safety strategy aims to minimise the likelihood, severity, and extent of an incident.	Yes	Included in Section 6 (Fire strategy and control measures).
5.2.2	Special consideration should be given to developing a fire safety strategy that is effective in minimising potential for propagation and escalation of an incident with reference to the credible incidents outlined in Section 5.1 Assessment of potential consequences of credible incidents. An example of an element of a fire safety strategy that may be adopted is the separation of BESS containers or racks by way of either appropriately fire-rated physical barriers or distance. Where possible, preference should be given to the implementation of strategies that are supported by higher-order risk controls (i.e., elimination and/or engineering controls, etc.).	Yes	Included in Section 6 (Fire strategy and control measures). For example, a clearance of 3 m is provided on all sides of each battery unit and the battery compartment is equipped with firewalls with 2-hour rating to minimise the likelihood of fire propagation to adjacent battery units.

No	FRNSW BESS FSS Guideline Considerations	Considered?	Remarks
5.2.3	Supporting analysis and/or evidence should be provided within the FSS to justify the selection, appropriateness, and efficacy of the selected fire safety strategy. This should include all calculations and analyses and contain justification of all inputs and methods used. Where testing is relied upon, detailed test reports need to be provided which detail who undertook the tests, the test methodology and results obtained. Testing should be witnessed and verified by parties who are independent from the battery manufacturer / supplier.	Yes	References and supporting information are listed in APPENDIX E and have been provided to FRNSW.
5.2.4	The fire safety strategy should consider the likelihood of occupants being present within the BESS unit / container.	Yes	Not applicable (non-walk-in battery unit/enclosure is used).
5.2.5	FRNSW does not support the adoption of fire safety strategies that are either partially or wholly reliant on fire brigade intervention to achieve an acceptable level of safety, given that: - Intervention of a fire brigade at an incident is considered to constitute application of a low-order administrative type risk control and is not in line with the so far as is reasonably practicable principle in managing risk, given higher-order controls are available and may be implemented in a reasonably practicable manner - Large-scale LiBESS including supporting infrastructure may constitute a chemical or electrical hazard such that intervention activities and/or firefighting operations may pose unacceptable risks to the safety of attending firefighters - The rapid intervention of a permanent full-time fire brigade cannot be relied upon as it is subject to resource availability and proximity to the incident. - Potential for significant variation in the weight of response, capability, equipment, and level or training of attending fire brigade resources.	Yes	Refer to Section 6.2. In the event of a battery unit on fire, a defensive fire response strategy will be adopted (i.e. allow the affected unit to burn in a controlled fashion until all fuel sources are depleted). There is no requirement to apply water directly to the battery unit on fire. Whilst not required by the firefighting strategy, water may be applied to nearby equipment or structures for cooling as necessary using dedicated fire hydrants provided around the perimeter of the BESS array. Decision to provide cooling will be made in coordination between: • ACEN (facility owner) • Energy Vault (O&M Contractor and the OEM Subject Matter Expert) • FRNSW (emergency responder).

No	FRNSW BESS FSS Guideline Considerations	Considered?	Remarks
Section 5.3 – Electrical hazards posed to firefighters			
5.3.1	Large-scale LiBESS including supporting infrastructure are considered to constitute an electrical hazard when involved in an incident, given that: - It may not be possible to determine the state of charge of an affected unit. - High voltages may still be present, even at low states of charge. - There is potential for energy to be stranded within an affected unit. - FRNSW currently does not have the equipment or capability to be able to detect live direct current (DC) power. - It may not be possible to isolate the input to- or output from an affected unit, particularly where isolation controls (automated or otherwise) have been adversely affected by exposure to radiant heat. - The affected and surrounding units may experience a degradation of the ingress protection (IP) rating as a result of exposure to radiant heat.	Yes	Informative clause within the FRNSW guideline. In the event of a battery unit on fire, a defensive fire response strategy will be adopted (i.e. allow the affected unit to burn in a controlled fashion until all fuel sources are depleted).
5.3.2	A FRNSW incident commander may determine that no intervention activities or firefighting operations will be undertaken where it is considered that there is unacceptable risk posed to the safety of firefighters.	Yes	Refer to remarks on Clause 5.2.5 above.
5.3.3	Signage should be provided at appropriate locations (based upon a site assessment), including but not limited to all entrances to the facility and the main control room, warning of the potential electrical and chemical hazards present. Whilst the scope of AS 5139 is limited to a battery with a maximum capacity of 200 kWh, Section 7 of the standard contains useful guidance that can be used for labels and safety signage.	Yes	Appropriate signages of hazard onsite will be provided. **Recommendation 14**: ACEN and/or Energy Vault (O&M Contractor) to provide signages at appropriate locations (including but not limited to all entrances and the control room) warning the potential electrical and chemical hazards present at the BESS compound, taking into consideration guidance provided in Section 7 of AS 5139 *Electrical installations - Safety of battery systems for use with power conversion equipment.*

No	FRNSW BESS FSS Guideline Considerations	Considered?	Remarks
Section 5.4 – Fire Brigade Intervention			
5.4.1	Section 5A General functions of Commissioner of the Fire and Rescue NSW Act 1989 imposes specific statutory functions on the Commissioner of FRNSW, specifically that: 1) It is the duty of the Commissioner to take all practicable measures for preventing and extinguishing fires and protecting and saving life and property in case of fire in any fire district. (and) 2) It is the duty of the Commissioner to take all practicable measures— a) for protecting and saving life and property endangered by hazardous material incidents, and b) for confining or ending such an incident, and c) for rendering the site of such an incident safe. In the event of a fire or hazardous material incident involving large-scale LiBESS, FRNSW may be required to undertake intervention activities and firefighting operations in order to fulfil statutory obligations, as such, consideration to the safety of first responders conducting intervention activities must be considered.	Yes	Noted - informative clause within the FRNSW guideline. Refer to remarks on Clause 5.2.5 above.
5.4.2	A potential incident at a BESS facility may be deemed a “hazardous material incident” in accordance with Section 3 of the Fire and Rescue NSW Act 1989. Substantial Hazardous Material response resources may be required to determine an appropriate intervention and mitigation strategy in the event of an incident.	Yes	Noted - informative clause within the FRNSW guideline.

No	FRNSW BESS FSS Guideline Considerations	Considered?	Remarks
5.4.3	Intervention activities and firefighting operations at an incident involving large-scale LiBESS will be undertaken in a manner similar to that for large-scale electrical infrastructure (e.g., substations, electrical switchyards, etc.). FRNSW personnel may not enter the affected BESS compound or compartment until an electrical company representative is in attendance on site and has confirmed power is isolated. The electrical company representative may also be required to provide safety and technical advice to a FRNSW incident commander to assist in determining what intervention activities and firefighting operations can be safely undertaken.	Yes	Noted that when the site in unattended, FRNSW personnel will standby at the site entrance for a representative to arrive (i.e. will not enter an unattended site). A study recommendation is included in line with this clause to "provide signage at the entrance gate to ensure FRNSW personnel does not enter until a site representative is present" and also per FRNSW feedback on the previous FSS submission (Rev0).
5.4.4	As previously noted, a FRNSW incident commander may determine that no intervention activities or firefighting operations will be undertaken where it is considered that there is unacceptable risk posed to the safety of firefighters.	Yes	Noted - informative clause within the FRNSW guideline.
5.4.5	An Emergency Plan is to be developed for the site in accordance with Hazardous Industry Planning Advisory Paper No 1 (HIPAP No. 1) Emergency Planning. The findings of the FSS should inform the development and content of the Emergency Plan. This should include, but not be limited to: a) Details on how the owner / operator is alerted to abnormal operation, fault or hazard in a BESS. b) Details on how fire services are notified of an incident. This should be described as part of the fire safety strategy. Upon detection of a fire in a BESS or on the site via an automatic detection system, notification of the fire services should be automatic. c) Detail effective communication strategy with remote operator representative for incident duration. d) Suitable arrangements for attendance on site by an appropriately qualified representative during any incident. e) Details on how battery status and information is relayed to emergency services, including items such as deployment of deflagration panels, etc..	Yes	A study recommendation is included in line with this clause to update the NES Fire and Emergency Response Plan (FERP) to include emergency response actions for fire scenarios at the BESS compound, including: • Scenarios included in Section 8 Incident Scenarios and Procedures of the B-Vault ERP. • Safe stand-off distance of 30 m shall be maintained between individuals and the BESS unit on fire, per the B-Vault ERP. • Specification of the required PPE and resource for emergency response personnel, including Self-Contained Breathing Apparatus (SCBA), portable gas detectors and thermal imaging devices. • Contact numbers of the Energy Vault Remote Monitoring Centre and Support Engineer. • Fire strategy and measures are outlined in Sections 6.2 to 6.4.

No	FRNSW BESS FSS Guideline Considerations	Considered?	Remarks
5.4.6	Detail the required level of personal protective equipment (PPE) including any breathing apparatus (BA) requirements for emergency services.	Yes	Per remarks on Clause 5.4.5, a study recommendation is included to update the NES FERP to include emergency response actions for fire scenarios at the BESS compound, including specification of the required PPE and resource for emergency response personnel (e.g. SCBA, portable gas detectors and thermal imaging devices).
5.4.7	The following FRNSW guidelines should also be utilised as part of the fire safety strategy and documentation requirements for the site: a) FRNSW Fire safety guideline – Hazardous chemicals manifest b) FRNSW Fire safety guideline – Emergency services information package and tactical fire plans The most recent versions can be found on the FRNSW website.	Yes	Hazardous chemicals to be stored, handled or used at the BESS compound are not expected to exceed the manifest quantities prescribed in Schedule 11 of the Work Health and Safety Regulation 2017. A list of hazardous chemicals to be stored, used or handled at the BESS Compound is provided in Section 2.3. A study recommendation is included to develop an Emergency Services Information Package (ESIP) for the Stage 3 BESS facility in accordance with FRNSW *Fire Safety Guideline – Emergency services information package and tactical fire plans*.
Section 5.5 – Implemented fire safety systems			
5.5.1	The implementation of fire detection and protection measures may be required to ensure that the necessary level of safety and performance has been achieved for a site.	Yes	Noted - informative clause within the FRNSW guideline. Refer to remarks on Clauses 5.5.3 to 5.5.7 below.
5.5.2	The analysis of requirements for fire detection and protection measures should be informed by the assessment of potential consequences of credible incidents for the site. This should also align with the objectives of the fire safety strategy for the site, particularly those relating to the management and mitigation of the severity of an incident, and prevention of propagation and escalation of an incident, including the potential off-site and environmental impacts.	Yes	Noted - informative clause within the FRNSW guideline. Refer to remarks on Clauses 5.5.3 to 5.5.7 below.

No	FRNSW BESS FSS Guideline Considerations	Considered?	Remarks
5.5.3	Supporting analysis and evidence is required to be provided within the FSS to justify the suitability and efficacy of proposed fire detection and protection measures for the site. This evidence is required to demonstrate that the specified performance of individual measures and the collective system is adequate to satisfy the objectives of the fire safety strategy.	Yes	The fire strategy and supporting measures are provided in Section 6. For a battery unit on fire scenario, these are provided in Section 6.2. Information and/or references to (1) clearances between battery units, (2) efficacy test for the aerosol suppression device, (3) battery compartment firewalls are included. A reference and summary of the CFD analysis findings which assessed the potential for fire propagation to adjacent battery units (reflecting the adopted clearances between battery units) is provided in Section 5.5.
5.5.4	All fire detection and protection measures that are relied upon to satisfy the objectives of the fire safety strategy should be automatic in nature (i.e., not require manual operation by an operator or attending emergency service). Supporting evidence is required to be provided within the FSS to demonstrate that individual measures and the collective system have sufficient capacity to operate at the required level of performance for the full duration of an incident.	Yes	The fire strategy and supporting measures are provided in Section 6. For a battery unit on fire scenario, these are provided in Section 6.2. These include active and passive systems. The project has accepted the recommendation to provide automatic notification of a fire alarm to FRNSW. The engineering solution to provide automatic notification to FRNSW will be developed and implemented in consultation with FRNSW to ensure the specific requirements are met. Once implemented, no system that are relied upon for the fire strategy require manual operation. As part of a defensive firefighting strategy, application of cooling water using dedicated fire hydrants may be used as necessary based on the decision made between ACEN (facility owner), Energy Vault (O&M Contractor and SME) and FRNSW (emergency responder).
5.5.5	Adequate redundancy should be provided to all fire detection and protection measures that are relied upon to satisfy the objectives of the fire safety strategy. Emergency power supply to essential systems is one key consideration.	Yes	Each B-Vault battery compartment is equipped with 2 heat detectors, 2 smoke detectors and 2 hydrogen gas detectors. Additionally, each battery unit is equipped with backup power supplies located at the BOP compartment.

No	FRNSW BESS FSS Guideline Considerations	Considered?	Remarks
5.5.6	Where the fire safety strategy does not rely on direct fire attack on a LiBESS system or unit, a fire hydrant system should still be provided for the purpose of addressing other credible fire scenarios (e.g. within auxiliary buildings and infrastructure) and protection of LiBESS units from all potential fire sources. The specific requirements of the fire hydrant system, in terms of locations of hydrants, water supply, etc., should be based on the level of risk of the facility. Coverage by street hydrants is not considered adequate for such a facility.	Yes	Design basis and layout of the hydrant system are provided in Section 7 (Cooling water). In addition to provide cooling to nearby equipment or structure in the event of a battery unit fire and protecting the battery units from potential fire sources, the hydrant system can also be used to address other credible fire scenarios within the BESS compound (e.g. BESS MV transformer fire, auxiliary transformer fire).
5.5.7	Provision should be made for monitoring of the Alarm Signalling Equipment (ASE) where a fire detection system is provided as part of the fire safety system for a site and a readily available response from a permanent fire brigade is available.	Yes	A study recommendation is included in line with this clause to investigate options to automate fire notification from the Stage 3 BESS facility to FRNSW. In its feedback on the Rev 0 FSS submission, FRNSW recommends providing ASE or similar to ensure automatic notification. The project has accepted the recommendation to provide automatic notification of a fire alarm to FRNSW. The engineering solution to provide automatic notification to FRNSW will be developed and implemented in consultation with FRNSW to ensure the specific requirements are met.
Section 5.6 – BESS unit separation			
5.6.1	As identified in Section 5.2 Defining the fire safety strategy, the separation of large-scale LiBESS containers or racks by way of either appropriately fire-rated physical barriers or distance may be adopted as a fire safety strategy for a site.	Yes	Noted - informative clause within the FRNSW guideline. Refer to remarks under Clause 5.6.2.

No	FRNSW BESS FSS Guideline Considerations	Considered?	Remarks
5.6.2	Where such a strategy is adopted, the FSS is required to contain supporting analyses or evidence to demonstrate that the objectives of the fire safety strategy have been satisfied, namely that the provided separation is adequate to prevent propagation and escalation of an incident. Where active and/or passive measures are provided to support the implementation of this strategy, evidence is required to be provided in the FSS that demonstrates their ability to maintain the required level of performance for the full duration of an incident.	Yes	The fire strategy and supporting control measures are provided in Section 6. For a battery unit on fire: • A clearance of 3 m is provided on all sides of each battery unit (as shown in Figure 6-1) to minimise the risk of fire propagation to adjacent battery units and infrastructure. • The battery compartment walls are fire rated for 2 hours to reduce the propagation potential to adjacent battery units. The battery enclosure firewall test report/certificate to EN 1364-1 *Fire resistance tests for non-loadbearing elements - Part 1: Walls* have been provided to FRNSW as part of response to comments on the previous FSS submission (Rev0) and references included in Section 6.2.7. Also refer to Section 5.5 (BESS unit fire propagation potential) which provides a summary on the CFD analysis completed to assess the thermal runaway or fire propagation potential to adjacent units in the event of a single battery unit burning. The CFD models reflect the project specific battery system and configuration (i.e. spaced 3 m apart on all sides) and did not account for the effects of any fire suppression systems. A copy of the CFD analysis report is provided to FRNSW as part of the FSS Rev 1 submission.

No	FRNSW BESS FSS Guideline Considerations	Considered?	Remarks
5.6.3	Where separation is provided by way of a physical barrier that is constructed of a material with a fire resistance level as determined in accordance with AS 1530.4:2014 Methods for fire tests on building materials, components and structures - Fire-resistance tests for elements of construction, an assessment is required to be undertaken to demonstrate that the fire severity associated with the design fire of the worst credible incident (i.e., the design fire severity) does not exceed that associated with the 'standard time versus temperature curve' as prescribed within Section 2.11 of AS 1530.4:2014. Failure to accurately quantify the design fire severity such that it is underestimated or exceeds that associated with the standard fire curve may result in the fire resistance performance of materials relied upon for separation being exceeded and subsequent failure of the fire safety system.	Yes	Refer to remarks on Clause 5.6.2 above.
5.6.4	Where separation is provided by way of distance, an assessment is required to be undertaken to demonstrate that propagation of the incident will not occur to adjacent and surrounding racks, containers, and/or associated infrastructure. The assessment is required to consider the combined effects of exposure to convective and radiant heat on a receiving body from the worst credible fire for the full duration of an incident.	Yes	Refer to remarks on Clause 5.6.2 above.
5.6.5	The impacts of environmental conditions (e.g., wind effects) must also be assessed. This should include assessment of flame tilt, etc.	Yes	The CFD analysis completed to assess the thermal runaway or fire propagation potential to adjacent units (in the event of a single battery unit burning) simulated (1) no wind and (2) the 99th percentile wind speed for Uralla, i.e. 30 miles per hour (mph) equivalent to 13.4 m/s.

No	FRNSW BESS FSS Guideline Considerations	Considered?	Remarks
Section 5.7 – BESS unit ventilation and flammable and toxic gases			
5.7.1	A LiBESS may produce large volumes of flammable, corrosive and toxic vapours and gases when involved in a thermal event as a result of: thermal decomposition of battery components and electrolytes, pyrolysis of combustible materials, and incomplete combustion of volatiles within smoke. Flammable vapours and gases when confined within a compartment or a container are deemed to have the potential to result in a hazardous atmosphere. Any person exposed to these vapours or gases is considered to be at risk of harm.	Yes	Noted - informative clause within the FRNSW guideline. Refer to remarks on Clauses 5.7.3 and 5.7.4 below.
5.7.2	Ignition of the flammable gases produced during a thermal runaway event may result in a deflagration or explosion. This is noted to have caused or contributed to injury and death to attending emergency services at past incidents.	Yes	Noted - informative clause within the FRNSW guideline. Refer to remarks on Clause 5.7.4 below.
5.7.3	The design of the fire safety system for any facility containing large-scale LiBESS is required to demonstrate that consideration has been given to the management of flammable, corrosive and toxic vapours and gases that may be produced during a thermal runaway event.	Yes	Refer to remarks on Clause 5.7.4 below on management of flammable gases vented following battery thermal runaway. Consequence analysis for toxic products of combustion was carried out – refer to Section 5.4. For LFP batteries, during a BESS fire event there is a potential for hydrogen fluoride (HF) to be generated following decomposition of lithium hexafluorophosphate in the battery electrolyte. In the absence of a full-scale burn test, a conservative approach was adopted, and dispersion of HF gas was modelled to assess potential impact to receptors. In this study, HF was considered to be the most toxic decomposition product based on the concentration (ppm) required to cause harm (i.e. irritation, injury and fatality) when compared to other potential products such as carbon monoxide (CO) and benzene. The modelling results indicate that at receptor height of 1.5 m the distance to AEGL-1 concentration (irritation threshold) is within the 30 m safe distance specified in the B-Vault AC Emergency Response Plan.

No	FRNSW BESS FSS Guideline Considerations	Considered?	Remarks
5.7.4	Where a large-scale LiBESS is proposed to be located within an enclosing container or compartment, a FSS must assume that there is potential for a hazardous atmosphere to be generated unless suitable evidence is provided that demonstrates otherwise. A subsequent analysis of potential consequences is required to be undertaken to inform the analysis of requirements for detection and protection such that suitable measures can be selected for implementation.	Yes	This FSS notes that vented gas from a thermal runaway event may accumulate in the battery compartment and lead to an explosion. It was assumed that this 'early explosion' would result in a fully developed battery compartment fire and hence was not modelled separately. The B-Vault explosion prevention system is described in Section 6.2.4, comprising a continuous gas detection system which automatically activates the mechanical ventilation system to exhaust the flammable off-gas formed due to battery thermal runaway, The system is designed to maintain flammable gases below 25% LFL per NFPA 69 and NFPA 855.
5.7.5	Where a large-scale LiBESS is proposed to be located within an enclosing container or compartment and it is determined that there is potential for a flammable atmosphere to be generated from a thermal runaway incident, the consequence assessment is required to consider how an ignition of the atmosphere resulting in a deflagration or explosion will impact on surrounding racks or units, supporting infrastructure, and any other surrounding elements or structures.	Yes	Refer to remarks on Clause 5.7.4 above.
5.7.6	Where a large-scale LiBESS is proposed to be located within an enclosing container or compartment that is occupiable by a person, signage should be provided at appropriate locations including but not limited to the entrance to the respective compartment or container, warning that in the event of an incident involving the LiBESS there is potential for a hazardous atmosphere to be present.	Yes	Not applicable (non-walk-in battery unit/enclosure is used).
5.7.7	Where a large-scale LiBESS is proposed to be located within an enclosing container or compartment that is occupiable by a person, a visual warning device should be provided at the entrance to the compartment or container that is to activate upon the activation of any provided detection or protection measures, with associated signage provided stating that a fire safety measure has activated and warning that there is potential for a hazardous atmosphere to be present.	Yes	Not applicable (non-walk-in battery unit/enclosure is used).
Section 5.8 – Environmental impacts			

No	FRNSW BESS FSS Guideline Considerations	Considered?	Remarks
5.8.1	A LiBESS involved in a thermal runaway incident may produce by-products that are hazardous to the environment.	Yes	Noted - informative clause within the FRNSW guideline. Details are covered in the remarks for clauses below.
5.8.2	When undertaking any consequence assessment relating to a thermal runaway incident, consideration must be given to the potential for the generation of a toxic smoke plume and its subsequent impact on the surrounding environment and communities. This should include demonstrating that toxic gas emissions during such a fire will not impact neighbours, first responders or passers-by, under worst-case weather conditions specific to the site.	Yes	Consequence analysis incudes dispersion of toxic products of combustion following a battery unit on fire (Section 5.4, dispersion of HF was modelled). The modelling results indicate that at receptor height of 1.5 m the: • The distance to AEGL-1 concentration (irritation threshold) is within the 30 m safe distance specified in the B-Vault AC Emergency Response Plan. • The distance to AEGL-2 (injury) and AEGL-3 (fatality) concentrations remains within the BESS compound boundary (i.e. no offsite impact resulting in injury/fatality).
5.8.3	Any Emergency Plan for the site should detail the required level of personal protective equipment (PPE) including any breathing apparatus (BA) requirements for emergency services.	Yes	Per remarks on Clause 5.4.5, a study recommendation is included to update the NES FERP to include emergency response actions for fire scenarios at the BESS compound, including specification of the required PPE and resource for emergency response personnel.
5.8.4	Where a fire safety strategy is adopted that relies on the application of water (or water- based agents) to suppress a fire, provision must be made for the containment of all contaminated firefighting water for the entire expected duration of the incident. Any provided containment system must ensure that contaminated firefighting water is not able to enter local waterways or groundwater.	Yes	As part of the defensive firefighting strategy, application of cooling water using dedicated fire hydrants will be as necessary based on the decision made between ACEN (facility owner), Energy Vault (O&M Contractor and SME) and FRNSW (emergency responder). During a fire event requiring application of cooling water, the penstock valve in the drainage catchpit will be in closed position to prevent spent cooling water discharge to the stormwater drain. Refer to Section 7.2 for more details on the spent cooling water run-off and containment system.
5.8.5	Where a containment system is proposed to be connected to a reticulated stormwater system, provision must be made for the isolation of the system by way of automatically operated valves that close upon activation of an associated fire safety measure.	Yes	Per remarks on Clause 5.8.4, during a fire event requiring application of cooling water, the penstock valve in the drainage catchpit will be in closed position to prevent spent cooling water discharge to the stormwater drain.

No	FRNSW BESS FSS Guideline Considerations	Considered?	Remarks
5.8.6	Whilst not a requirement of a FSS, it is recommended that any Emergency Plan developed for the site identify local catchment areas and drainage pathways such that appropriate measures may be implemented in the event that the capacity of the provided containment system is exceeded.	Yes	A study recommendation is included in line with this clause to ensure that the updated FERP "identify local catchment areas and drainage pathways such that appropriate measures may be implemented in the event that the capacity of the provided containment system is exceeded".
5.8.7	Appropriate consideration should also be given to Planning for Bushfire Protection (2019).	Yes	Management of fuel load and APZs have been identified as strategies for bushfire protection (refer to Section 6.5).
Section 5.9 – Post-incident clean-up and disposal			
5.9.1	Whilst not a requirement of a FSS, it is recommended that supporting management and procedures documentation for the site provide details of the following: - Following an incident, how LiBESS will be handled and removed (including transportation) from site. It is noted that this is the responsibility of the facility owner and/or operator and that FRNSW is not responsible for aiding or facilitating such actions. - A procedure for the removal and disposal of contaminated firefighting water.	Yes	A study recommendation is included in line with this clause to ensure that the supporting management and procedures for the BESS facility provide the following details on post incident cleanup and disposal: • Following an incident, how the affected BESS units will be handled and removed (including transportation) from site. • A procedure for testing of the spent cooling water and disposal options in accordance with the test result (i.e. if irrigation is acceptable).
Section 5.10 – Reference standards and codes			
5.10.1	HIPAP No.2 states "The principle of a fire safety study is that the fire safety 'system' should be based on specific analysis of hazards and consequences and that the elements of the proposed or existing system should be tested against that analysis. This should always produce a better outcome than the application of generalised codes and standards alone" (DPIE 2011).	Yes	Noted - informative clause within the FRNSW guideline.
5.10.2	The provisions within applicable codes and standards may be adopted where it can be demonstrated that the requirements of HIPAP No.2 have been adequately satisfied.	Yes	Codes and standards are listed in Section 8.

APPENDIX B MANAGEMENT OF BATTERY UNIT ON FIRE AND PROPAGATION RISKS

The following response was included as part of response to FRNSW comments on the Rev 0 of the FSS report to justify the project's position on how the risk of a battery unit on fire and potential for propagation will be adequately managed, risk to firefighters is minimised (non-intervention strategy), and completion of a full-scale burn test is not required. The relevant supporting information (included as references below) have also been provided for FRNSW's review.

It is agreed that the UL9540A test is not representative of all failure mode that can lead to a battery fire. The intent of referencing the UL test is to show that some failure modes are managed by the design of the BESS.

Factors considered to demonstrate that the residual risk of a BESS unit fire propagating to an adjacent unit is managed to an acceptable level and justify full-scale burn test not being performed are outlined below:

1. UL 9540A Unit level test outcome found that the performance criteria of the Unit-level test have been met.
    - Flaming outside the initiating unit was not observed.
    - Surface temperatures of modules within the target units adjacent to the initiating unit did not exceed the temperature at which thermally initiated cell venting occurs.
    - For units intended for installation in locations with combustible constructions, surface temperature measurements on wall surfaces did not exceed 97°C (175°F) of temperature rise above ambient.
    - Explosion hazards were not observed, including deflagration or detonation.
2. To minimise the likelihood of multi-module arcing events such as coolant leakage, insulation faults and voltage fluctuations, the following design and safety features have been implemented:
    - Coolant leak management, Ref [39]
        - Coolant pipe system has self-sealing quick connectors.
        - Coolant pipe designed and manufactured per ASME B31.3 standard.
        - Coolant pipe has been leak pressure tested by Envicool as part of FAT.
        - The bottom plate of the battery pack are subjected to leak test thrice (after welding, before assembly of cells and at final assembly stage).
        - Air tightness test at the B-Vault integration factory after assembly of coolant pipe, battery pack and chiller together, before filling coolant.
        - Water sensor installed on battery enclosure floor to detect coolant leak.
    - The battery system incorporates an insulation monitoring device (Bender) capable of detecting real time insulation faults.

- The battery system is provided with a surge protection device that safeguards the system against voltage surges/fluctuations from the grid.

3. The BMS will monitor abnormal conditions that will be a precursor to thermal runaway and will disconnect the affected battery string from the system. Specifically, the REPT BMS safeguards the battery system by continuously monitoring, primarily, the cell voltage, module temperatures and current to ensure operational safety and prolong battery life. It acts as the first line of defence by enforcing protection limits and automatically disconnect battery strings with values outside the normal operating range. The key protective features include:

   - Over-voltage and under-voltage protection

     The BMS continuously monitors the voltage of every cell to prevent overvoltage/over-charging and undervoltage/over-discharging. It sends alert and automatically disconnects the affected battery string from the DC bus if the voltage of any cell within the string exceeds either the overvoltage or the undervoltage threshold.

   - Over-current protection

     The BMS has two types of overcurrent protection including:

     - Short-circuit protection via fast acting fuses located in the battery switchgear what will quickly melt in the event of a short-circuit on the DC bus.
     - The BMS continuously communicates the acceptable charge and discharge current limits to the control system. If the limits are exceeded, it will automatically disconnect the affected battery string from the DC bus.

   - Over-temperature and under-temperature protection

     The BMS continuously monitors temperatures within a battery module at 58 different points. If any temperature within a battery module:

     - exceeds the maximum operational temperature: the BMS will automatically disconnect the affected battery string from the DC bus.
     - falls below the operational temperature: the BMS will limit operation of the battery by reducing the current limits.

   - Cell imbalance detection and automatic balancing

     The BMS continuously monitors the cell voltages and compares the maximum and minimum cell voltages against the average cell voltage and automatically engages passive balancing resistors to maintain good cell balancing within the battery string.

4. Provision of heat, gas and smoke detectors and aerosol suppression system within the unit to slow cascading effects of thermal runaway and prevent propagation to a fully developed fire. The gas detection will initiate the exhaust ventilation system to remove flammable gas generated.

5. A clearance of 3 m is provided on all sides of each battery unit minimising the likelihood of fire propagation to adjacent units.

   - The spacing provided is beyond typical clearances specified by other battery OEMs where the side-to-side and back-to-back spacing can be as low as 0.1 m.
   - To further support the effects of the clearances, a CFD analysis was completed to assess the thermal runaway or fire propagation potential to adjacent units in the event of a single

battery unit burning. The results and findings are included in Section 5.5 in this revision of the FSS (Revision 1).

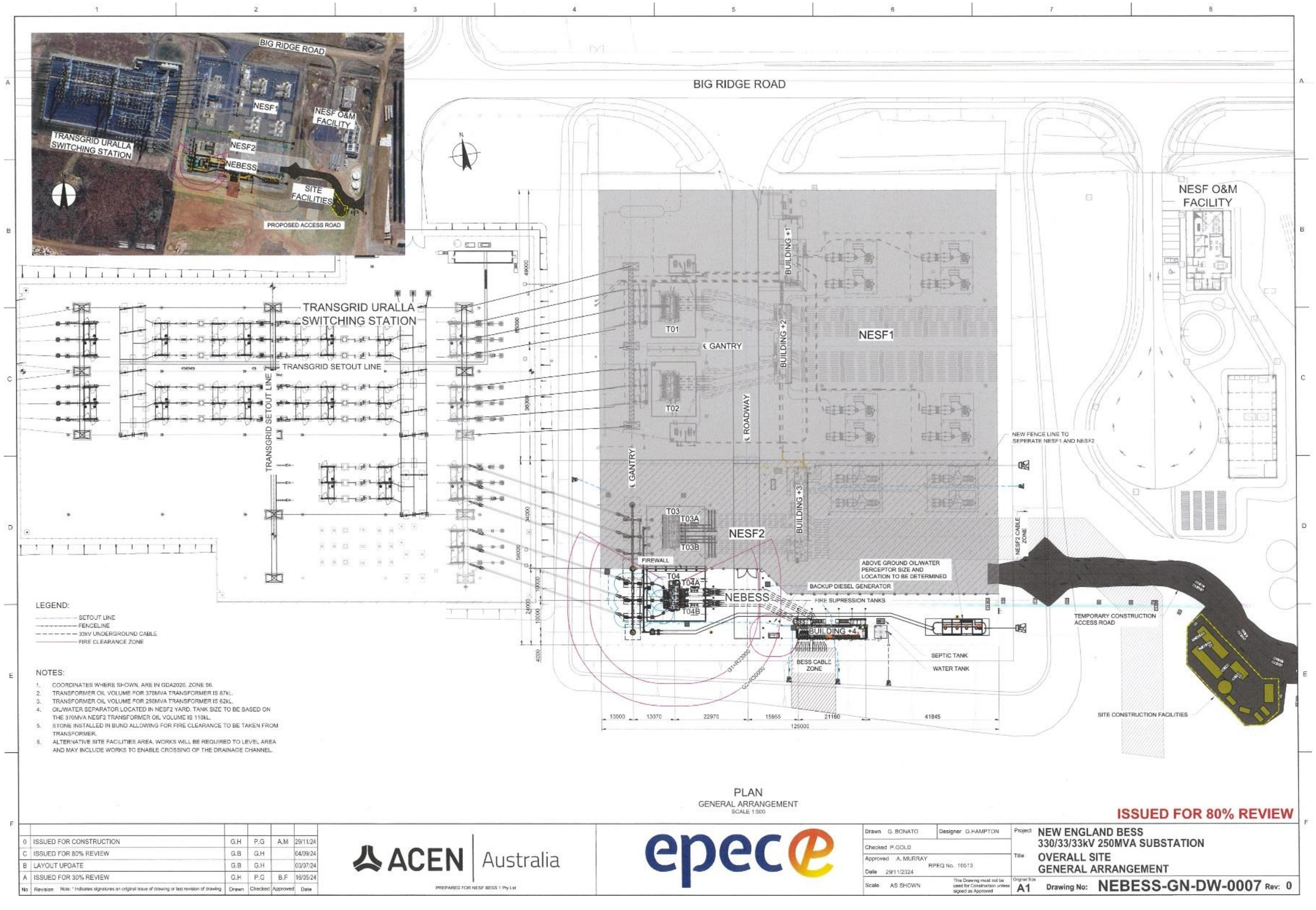
6. The battery enclosure external walls are fire rated for 2 hours (refer to test reports, Ref [34] and [35].
7. A fire hydrant system has been provided around the perimeter of the BESS array to provide cooling of nearby units and adjacent infrastructure, if determined required. The fire hydrant system design complies with requirements of AS 2419.1-2021.

The project noted FRNSW's view that a fire propagating within a battery unit with active fire safety systems disabled involving a full battery unit is a credible incident and cannot be discounted. However, based on the UL9540A test results and measures included in the design and configuration of battery units the risk is expected to be low.

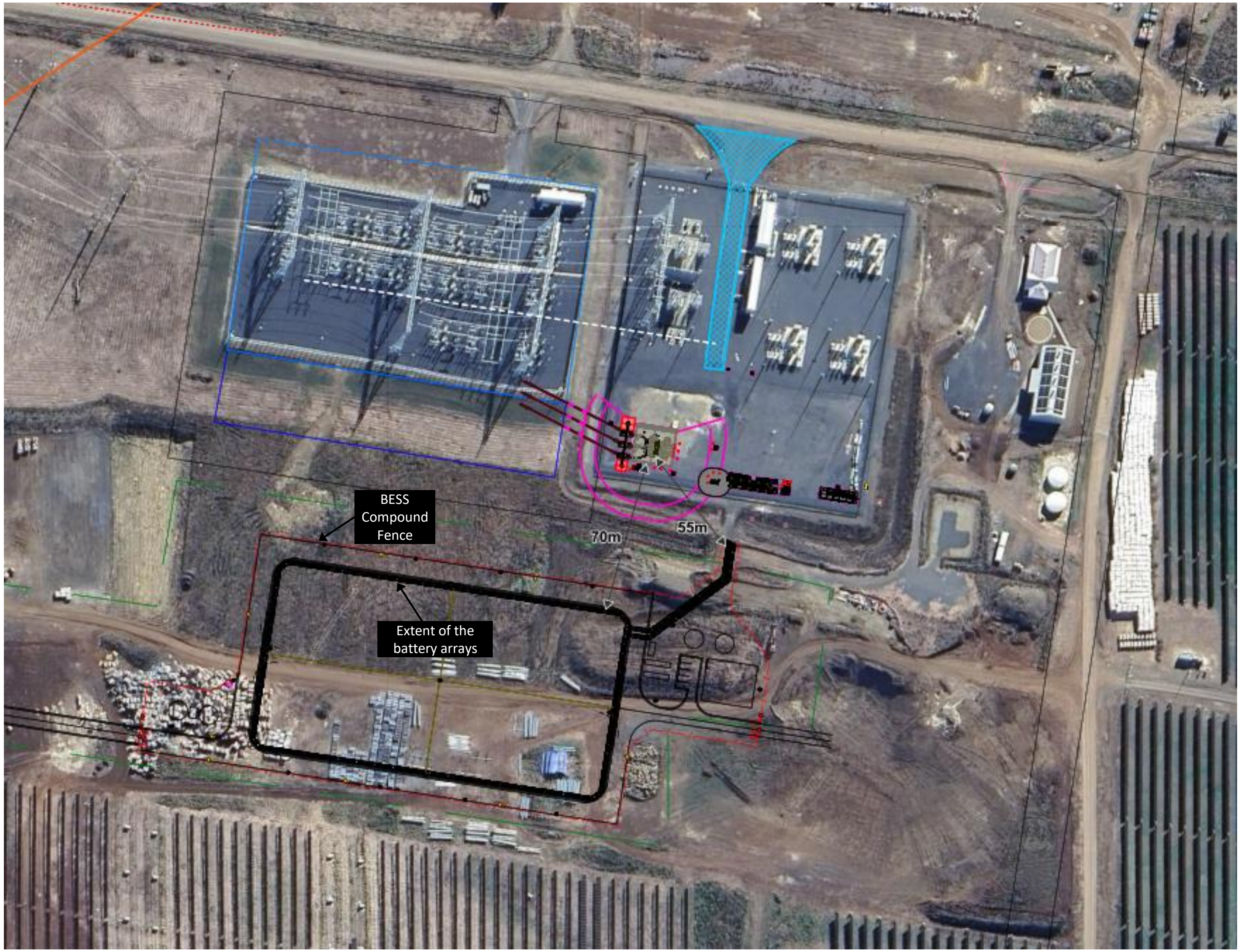
As a full-scale burn test would not cover every possible meteorological condition, it would not guarantee that propagation to adjacent units would not occur (i.e. residual risk still exists). Hence, regardless of engineering, modelling or a largescale fire test, an escalated fire event may result in fire involving a string of battery units. With the fire rated enclosures escalation is expected to take time (up to 2 hours) with sequential failure of batteries leading to events of a similar magnitude. This is not expected to result in a greater consequence footprint and increased risk to the fire brigade with the on-scene commander having time to withdraw from the fire front. Based on the project's location, impact of a BESS fire would be asset loss. Impact to surrounding residences is not expected based on the separation distance to these receptors.

APPENDIX C NES SUBSTATION TRANSFORMER CLEARANCES

Drawing: NEBESSHV-EPEC-ELE-DRG-00006 Overall Substation Layout



Drawing: NESF-P041 NE BESS Transformer Clearance to BESS Compound



APPENDIX D HYDRAULIC ANALYSIS (COOLING WATER TO HYDRANTS)

THE ACADS-BSG PROGRAM
HYENA
VERSION 7.0.0

ACADS BSG advises that the program HYENA is intended to be used only by persons who are proficient in its use and application, and that these results should be verified independently. The results must not be used without user acceptance of the ACADS-BSG's License Agreement for this program.

DESIGN PROGRAM FOR FIRE SPRINKLER, FIRE HYDRANT AND FIRE HOSE REEL SYSTEMS

Calculation build number 7.0.0AW

DESIGN DATA AND SUMMARY RESULTS

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 Page  1 of  1     -  Job No.
 -------------------------------------------------------------------------------------------------------------------
   DESIGNER :  IsaacTech@bcaengineers.com                                                       DATE :29 NOV 2024
   CLIENT   :  RJE                                                                              TIME :      18:19
   PROJECT  :  10552 - New BESS Fire Hydrant System
 -------------------------------------------------------------------------------------------------------------------
  Maximum unbalanced pressure is    =  0.00000 kPa
  Maximum node unbalanced flow is   =  0.00000 l/s and occurs at node 52
  Maximum loop unbalanced flow is   =  0.00005 l/s and occurs in Pipe Loop 1
      - No town main connection

  Fittings Specified as NFPA
  Calculate Input Flow and Pressure to achieve Minimum Discharge Flows

  Hazen-Williams formula used

  Number of Hydrants Operating    :   3
  Total water flow for Hydrants   :  30.0 l/s

  Balancing Devices

    The calculated size and/or pressure drop of orifice plates is based on data listed
    in the Australian Standard AS2118 Part 1 Automatic Fire Sprinkler Systems.

   Pipe No  Description                         Input                  Calculated
      1     (OD) Orifice Plate fixed P.Drop:  50.00 kPa         50.00 kPa drop   77.7 mm

  Required Flow & Pressure,            Input Node 1    : 30.0 l/s at 795 kPa

      Specified available pressure at input node  1    : 850 kPa
      Available pressure minus required pressure is    : 55.5 kPa

  Pressure at zero flow 0.00 kPa - Smallest elevation difference between discharges and input points

  Calculated Total Pipe Volume is : 10182 Litres

  Approving Authority            :
  Certification Number           :
```

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