Fire Safety Study

Sapphire Solar Farm

Prepared by Arup for CWP Renewables

Final | 2 March 2021

Job number 264556-00

Arup Australia Pty Ltd ABN 76 625 912 665

Arup
Sky Park
One Melbourne Quarter
699 Collins Street
Docklands Vic 3008
Australia
www.arup.com

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		Name	Jas Calder-Lowndes		
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Contents

Executive Summary

Background

The Proponent (Sapphire Solar Farm Pty Ltd) has obtained development approval for the Project (Sapphire Solar Farm (SSF); planned infrastructure map depicted in Figure 1). The Project involves the construction, operation and decommissioning of a utility-scale photovoltaic (PV) solar farm and battery energy storage system (BESS) on an approved development footprint of 458.5 ha in the Kings Plains region of the Inverell Shire Local Government Area (LGA) 30 km east of Inverell in northern NSW. Construction and operation will occur in stages, with the battery component to be constructed in Stage 1 (commencing in early 2021), and the solar PV component of the project comprising later stage(s). The Project was granted development consent by the NSW Department of Planning, Industry and Environment (DPE) under the *Environmental Planning and Assessment Act* (EP&A Act) on 16 August 2018. It was granted consent by the Minister for the Environment (in accordance with the *Environment Protection and Biodiversity Conservation Act* (EPBC Act)) on 15 October 2018.

The development approval is therefore subject to the consent conditions:

- NSW EP&A Act Development Consent SSD8643; and
- Commonwealth EPBC Act Approval 2017/8121.

This document is the Fire Safety Study (FSS) required by Condition 23 in Schedule 3 of SSD8643. It builds on the preliminary hazard assessment (PHA), completed as part of the SSF Environmental Impact Statement (EIS), which formed part of the project Development Application in January 2018 and has been prepared considering the relevant State Environmental Planning Policy 33 (SEPP 33) guidelines:

- *Applying SEPP 33: Hazardous and Offensive Development Application Guidelines (NSW DPIE 2011a);*
- *Hazardous Industry Planning Advisory Paper No 2 (HIPAP 2): Fire Safety Study Guidelines* (NSW DPIE 2011b);
- *Hazardous Industry Planning Advisory Paper No 4 (HIPAP 4): Risk Criteria for Land Use Safety Planning* (NSW DPIE 2011c); and
- *Hazardous Industry Planning Advisory Paper No 6 (HIPAP 6): Hazard Analysis* (NSW DPIE 2011d).

Findings

A summary of the findings and recommendations of this FSS are:

- All vegetation within 20 m of the BESS is cleared, and a material such as gravel used to ensure clearance is maintained.

- Vegetation in the area around the BESS is maintained at a level that will prevent any external fire from reaching an intensity which would adversely impact on the BESS across the 20 m separation distance.
- Each container is to be provided with an automatic gas suppression system (Novec 1230) designed by a suitably qualified fire services engineer.
- The aspirating smoke detector (ASD) system design be reviewed by a suitably qualified fire services engineer.
- ASDs and local Fire Indicator Panels (FIPs) within each BESS are to link back to a main GEMS panel which serves as a proxy-FIP, with an appropriate site map and block plan to be provided.
- The HVAC system shall be capable of operating at a maximum ambient temperature of 50°C and in direct sunlight.
- Battery procurement should consider those certified to UN38.3 and/or IEC 62281 for transport, and UL 1973, IEC 61427-2 and/or IEC62619 to ensure appropriate thermal management and short-circuit protection is present.
- Installation should be certified to all relevant Australian Standards (e.g. AS 4777, AS 3000 series), and consider complying with draft standard AS 5139:2017 where possible as a precautionary measure.
- BESS containers should be appropriately IP rated for the environment and certified to AS 60529.
- The modelling and analysis performed for this study was based on the assumption that firewater was not available. Therefore, the conclusions reached do not rely on the availability of firewater. Firewater for the BESS may be provided if deemed necessary during the safety in design process or the detailed design phase.

Key Terms and Definitions

Term	Definition
AS	Australian Standards
BMS	Battery Management System
DG	Dangerous Good
EIS	Environmental Impact Statement
FHA	Final Hazards Analysis
FRNSW	Fire and Rescue New South Wales
FIP	Fire Indicator Panel (often called Fire Detection Indicating and Control Panel)
FSS	Fire Safety Study
HAZID	Hazard Identification
HAZOP	Hazard and Operability Study
HIPAP	Hazardous Industry Planning Advisory Paper
HV	High Voltage
HVAC	Heating, ventilation, and air conditioning
IEC	International Electrotechnical Commission
LV	Low Voltage
MW	Megawatt, a unit of power
MWh	Megawatt hour, a unit of energy
NEM	National Electricity Market
NSW	New South Wales
NFPA	National Fire Protection Association (USA)
NSW RFS	New South Wales Rural Fire Service
PHA	Potential Hazards Analysis, as defined in the SEPP 33 Guidelines
Phast	An engineering software package used for consequence modelling
PCU	Power Control Unit
PV	Photovoltaic
SEPP 33	State Environmental Planning Policy 33
SSF	Sapphire Solar Farm
SWF	Sapphire Wind Farm
UL	Underwriter Laboratories, a battery testing for certification organisation
UN	United Nations

List of Standards

AS 1530.1	*Methods for fire tests on building materials, components and structures. Part 1: Combustibility test for materials*
AS 1530.4	*Methods for fire tests on building materials, components and structures. Part 4: Fire-resistance tests for elements of construction*
AS 1670.1	*Fire detection, warning, control and intercom systems – System design, installation and commissioning. Part 1: Fire*
AS 1670.5	*Fire detection, warning, control and intercom systems – System design, installation and commissioning. Part 5: Special hazards systems*
AS 1940	*The storage and handling of flammable and combustible liquids*
AS 2419.1	*Fire hydrant installations Part 1: System design, installation and commissioning*
AS ISO 14520	*Gaseous fire-extinguishing systems – Physical properties and system design*
AS 60529	*Degrees of protection provided by enclosures (IP Code)*
AS 3000	*Electricity Wiring Rules*
DR AS 5139	*Electrical installations - Safety of battery systems for use with power conversion equipment (DRAFT Standard)*
IEC 61427-2	*Secondary cells and batteries for renewable energy storage - general requirements and methods of test - part 2: on-grid applications*
IEC 62619	*Secondary cells and batteries containing alkaline or other non-acid electrolytes - safety requirements for secondary lithium cells and batteries, for use in industrial applications*
UL 1973	*Standard for Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications*

1 Introduction

1.1 Background

The Proponent has obtained development approval for SSF (planned infrastructure map depicted in Figure 1). The project involves the construction, operation and decommissioning of a utility-scale PV solar farm and BESS on an approved development footprint of 458.5 ha at Kings Plains, within the Inverell Shire LGA 30 km east of Inverell in northern NSW. The Project was granted development consent by the DPE under the EP&A Act on 16 August 2018. It was granted consent by the Minister for the Environment (according to the EPBC Act) on 15 October 2018.

The development approval is therefore conditional on the consent conditions:

- NSW EP&A Act Development Consent SSD8643; and
- Commonwealth EPBC Act Approval 2017/8121.

1.1.1 Project Staging

It is intended that SSF will be constructed and operated in stages.

Stage 1 will involve construction and operation of the battery storage component of the solar farm. This Stage will include establishment of electrical cables between the battery and existing Transgrid substation, construction of a site compound. Access to the site will be via Western Feeder Road and the existing internal roads of Sapphire Wind Farm will be used.

Construction is planned to commence in early 2021 and will take approximately 10 months. Once operational, the battery may be upgraded, added to and/or replaced.

Subsequent stage(s) of the SSF will be the construction and operation of the solar photovoltaic (PV) component of the project.

Stage 1 will have a considerably reduced footprint and will not impact on any vegetation communities that require retirement of biodiversity credits.

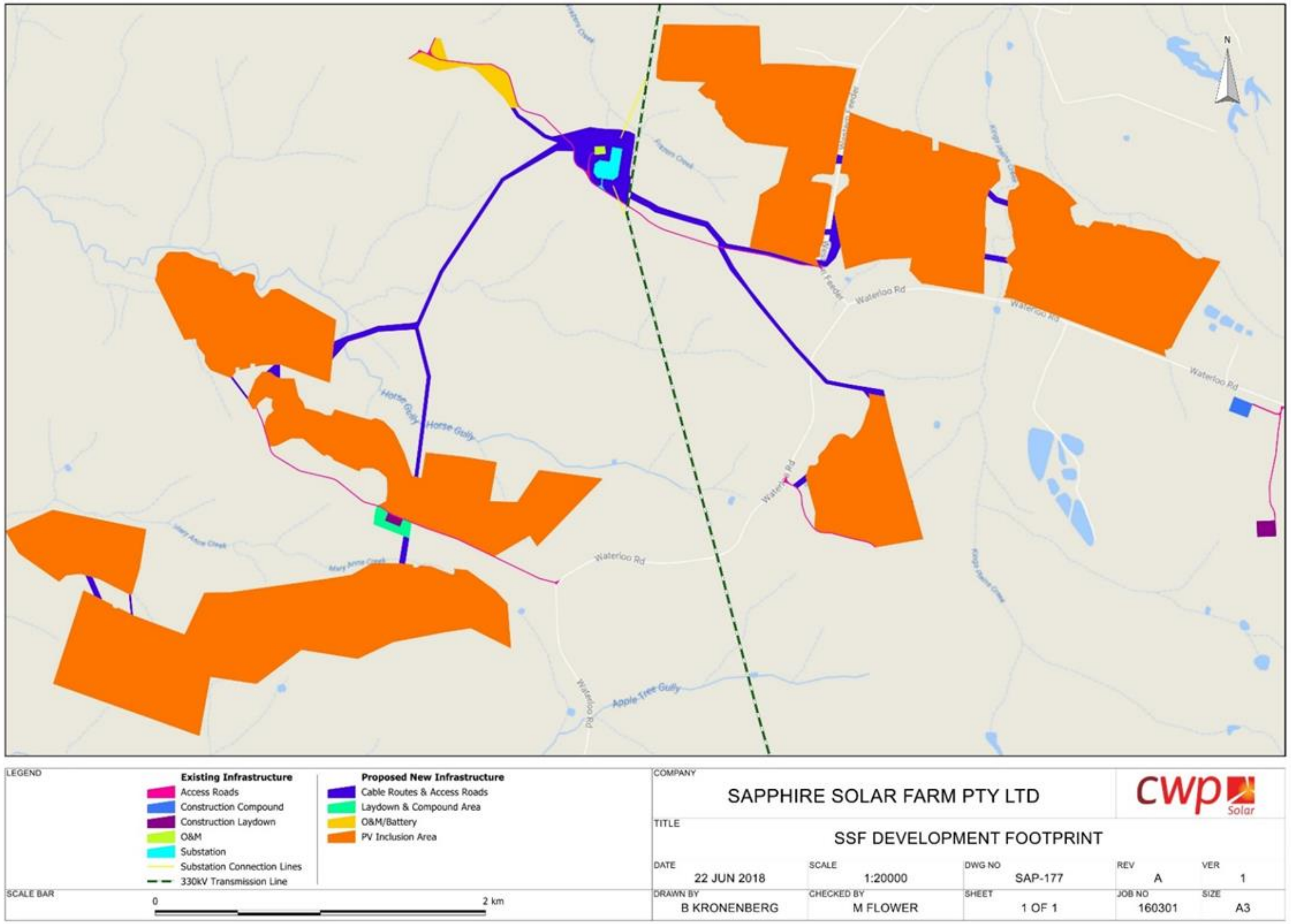

Figure 1: Project layout showing development footprint

Figure 2: Area layout (with Bess location at coordinates C3)

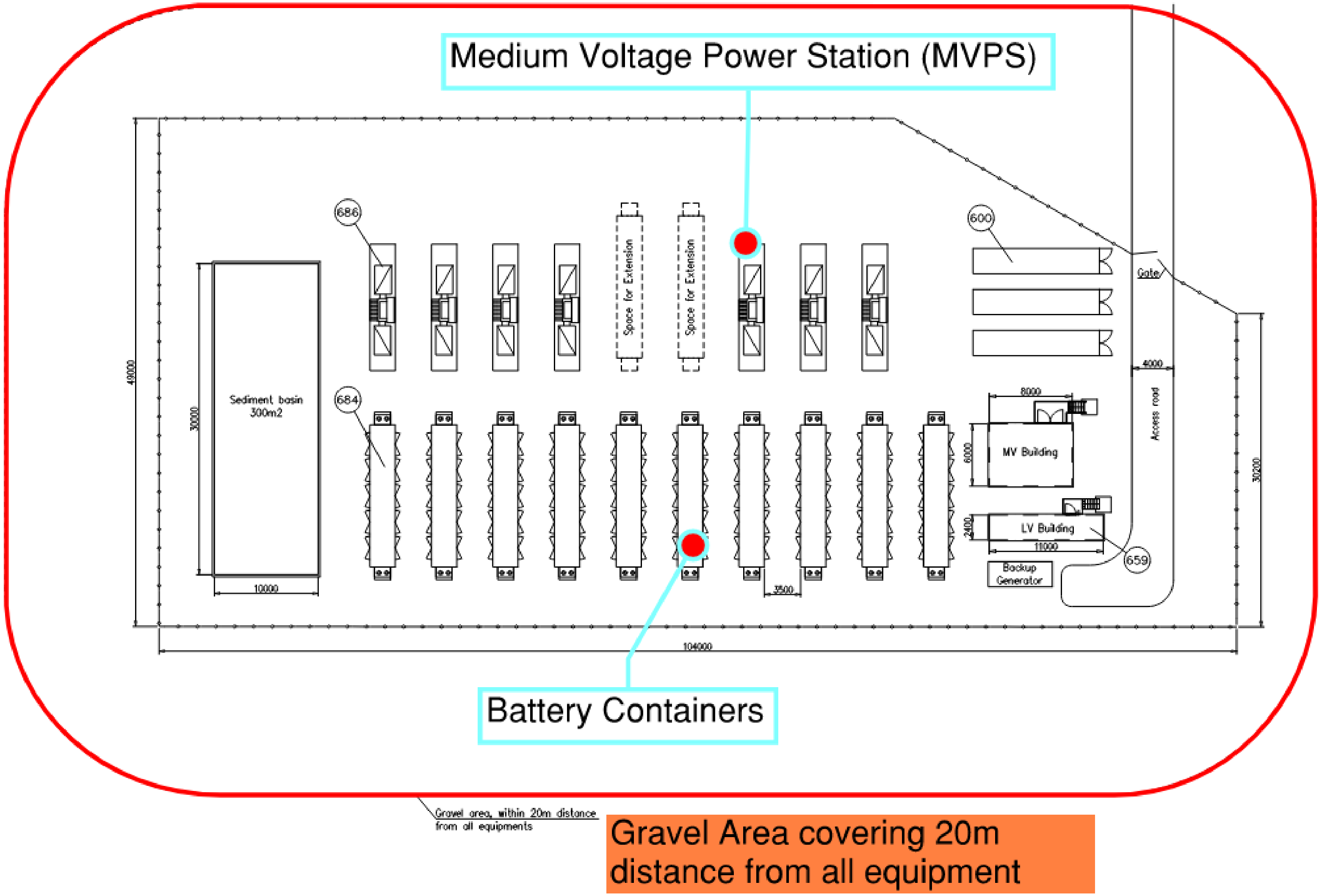

Figure 3: Indicative BESS Site layout

1.2 Scope and Purpose of this Report

This report is the FSS on the proposed SSF to satisfy Condition 23 in Schedule 3 of the Development Consent (SSD8643) which states:

> *Prior to the commencement of construction of the development, or unless otherwise agreed by the Secretary, the Applicant must prepare a Fire Safety Study for the development, in consultation with Fire & Rescue NSW, and to the satisfaction of the Secretary.*
>
> *The study must:*
>
> *(a) be consistent with the Department's Hazardous Industry Planning Advisory Paper No. 2, 'Fire Safety Study Guidelines'; and*
>
> *(b) report on the implementation status of the relevant mitigation measures listed in the EIS.*
>
> *Following the Secretary's approval, the Applicant must implement the measures described in the Fire Safety Study.*

It builds on the preliminary hazard assessment (PHA) completed as part of the SSF EIS which formed part of the project Development Application in January 2018 and has been prepared considering the relevant SEPP 33 guidelines:

- *Applying SEPP 33: Hazardous and Offensive Development Application Guidelines* (NSW DPIE 2011a);
- *Hazardous Industry Planning Advisory Paper No 2 (HIPAP 2): Fire Safety Study Guidelines* (NSW DPIE 2011b); and
- *Hazardous Industry Planning Advisory Paper No 2 (HIPAP 4): Risk Criteria for Land Use Safety Planning* (NSW DPIE 2011c).

The purpose of this FSS is to ensure that existing or proposed fire prevention, detection, protection and fighting measures are appropriate for the site-specific fire hazards at the SSF and to report on the application of the mitigation measures presented in the EIS. Figure 4 presents the context of this FSS in relation to other documents outlined in HIPAP 2 (NSW DPIE 2011b).

In accordance with HIPAP 2 (NSW DPIE 2011b):

- This FSS encompasses the entire SSF site and all fire-related potential hazards;
- The fire protection and strategies presented are based on the worst-case scenario;
- The study considers both the aspects of a fire system: the physical components, and the operational and strategic planning aspects; and
- The study considers all effects of fire at SSF. This includes flame, radiant heat and explosion effects, as well as toxic materials, gases and contaminated fluids

The structure of this FSS is:

- Section 2: describes the project setting and components

- Section 3: identifies the fire hazards presented by SSF
- Section 4: presents the fire event modelling and consequences
- Section 5: presents the fire prevention and mitigation strategies

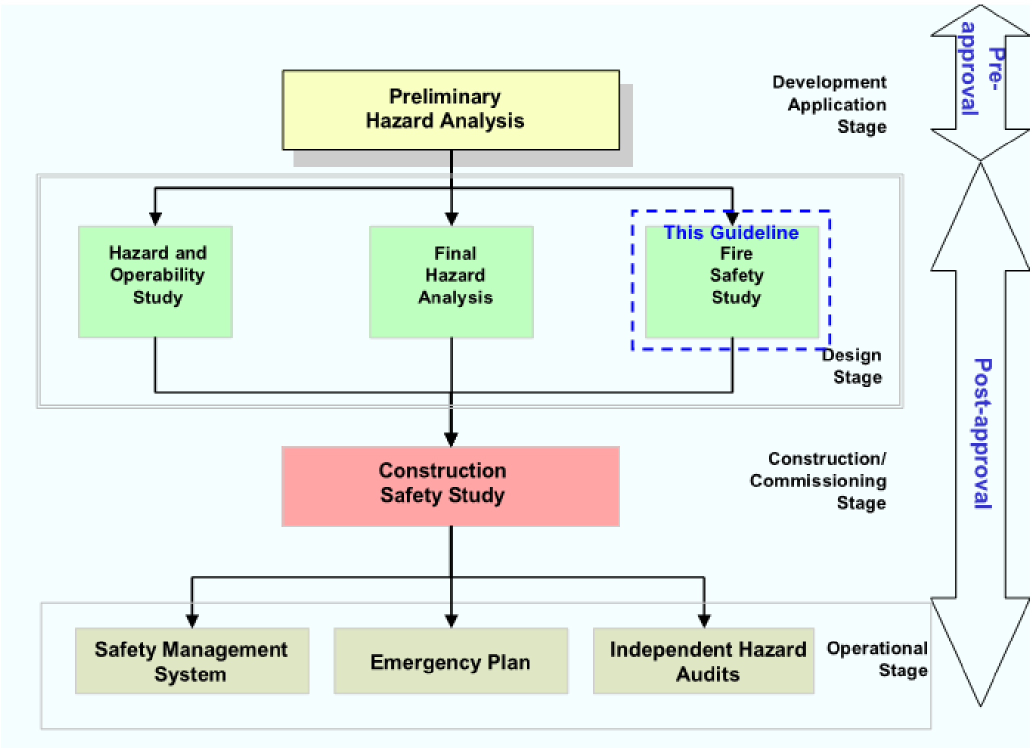

Figure 4: The Hazards-Related Assessment Process outlined in HIPAP 2 (NSW DPIE 2011b)

1.2.1 Details of February 2021 Update

This report has been updated in February 2021 in order to reflect changes to the project. These changes include the staging of the project and technological and design modifications. None of the proposed changes increase the relevant risk levels or alter any of the conclusions of previous versions of this report. Therefore, this version of the report is substantially similar to previous versions, although references may be made to the project changes.

2 Project Setting and Component Description

The layout of the SSF development footprint is shown in Figure 1 and consists of areas for solar PV panels, a BESS, an operations and maintenance (O&M) facility, construction laydown areas, and construction compounds all linked by cable routes and access roads (both new and existing).

The project will be connected to the electricity network via the TransGrid Substation that provides the network connection point for the Sapphire Wind Farm (SWF).

2.1 Project Setting

The SSF site ('the Site') is located on land 30 km east of Inverell, in the Inverell Shire LGA, in northern New South Wales. The Site can generally be accessed from Gwydir Highway via Waterloo Road, or from Kings Plains Road via the Western Feeder and Waterloo Road (although the consent conditions identify the project haulage route being from the east via Gwydir Highway and Waterloo Road) (refer to Figure 5). The Site encompasses some land also utilised by the SWF. The Site comprises predominantly cleared agricultural land used for grazing and cultivation with some scattered trees. Some areas having previously been the site of open-cut sapphire mining and quarrying have since been returned to agricultural grasslands.

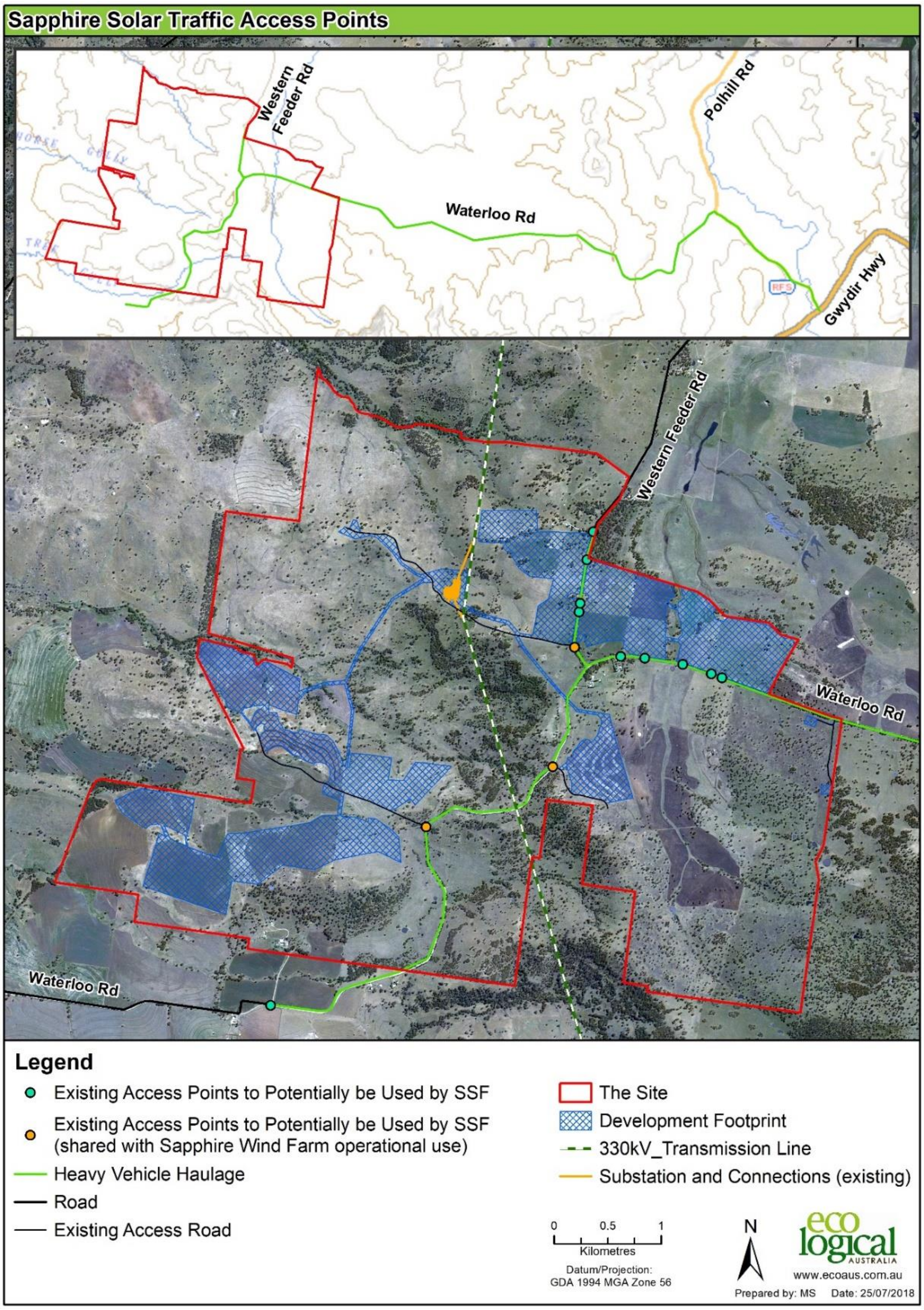

Figure 5: SSF location showing the haulage access route and traffic access points (as per Appendix 3 of the Development Consent SSD8643)

Surrounding Land Use

The development footprint and surrounding land is agricultural land zoned RU1 Primary Production under the *Inverell Shire Local Environmental Plan 2012* and has a very low population density. There are 12 residences within 2 km of the site. Five are associated with SSF by their owner's hosting infrastructure and seven residences are non-associated.

Site Layout

The SSF site layout is shown in Figure 1, which also shows the distribution of the PV panel areas and the single footprint area for the BESS. Further descriptions of the physical characteristics of the proposed locations for PV panels and the BESS are provided in the relevant subsections of Section 2.2.

The area layout is shown in Figure 2 and the site layout for the BESS is shown in Figure 3.

2.2 Project Components

This section describes the project components that would require firefighting intervention in the event that control measures fail, specifically the PV panel arrays and the BESS. Further, the operations and maintenance (O&M) facility and the workforce are discussed. The existing TransGrid substation is outside the scope of this analysis as it operated by TransGrid and subject to its own fire prevention and mitigation regime.

2.2.1 PV Panel Arrays

The PV panel areas are generally proposed on flat land or low-gradient land sloped facing north. The land is currently agricultural grassland used for grazing and cultivation in a varied pattern throughout the year and from year to year. The PV panel array is proposed to be a single-axis tracking system with rows aligned in a north-south orientation, with tracker to tracker east-west spacing of 4 m to 9 m. The ground below the PV panel array will be a grassland which will be maintained with a high percentage of ground cover, but with a low height above the ground (via mechanical slashing or grazing). The physical components of the PV panel array will be designed to allow grazing. East-west gravel access roads will be located throughout the PV panel rows where rows are separated by breaks and between the panel rows at intervals every 150 m to 250 m. The PV panels and racking generally consist of steel piers with panels composed of glass, silicon and polymer films connected with plastic-insulated electrical cables.

As shown in Figure 1 the development footprint is comprised of a series of discontinuous PV panel areas. As part of the EIS process and consistent with Condition 23 in Schedule 3 of the Development Consent (SSD8643), PV panel areas will be surrounded by a defendable space.

2.2.2 BESS

The BESS location is adjacent to an existing gravel access road constructed for the SWF. This access road is located along an approximately 350 m wide ridge with the land descending to the north-east and south-west (refer to Figure 2). The proposed BESS area is relatively flat, with good road access and significant distances from major off-site infrastructure as shown in Table 1. These distances form a critical layer of protection for off-site populations in the event of a major incident at the SSF.

Table 1: The distance from the eastern end of the BESS to the nearest major infrastructure and residences

Location	Distance from Battery Storage Location
Site Boundary SSF[1]	280 m
Site Boundary SWF[2]	1,500 m
Nearest Residence	1,540 m
Nearest Road	1,600 m
Nearest non-involved landholding	1,600 m

The proposed BESS is a lithium-ion, solid state battery system with lithium iron phosphate ($LiFePO_4$) cells housed in ISO-standard 40-foot containers. It will comprise 11 battery storage containers[3], each storing 2 to 5 MWh of electrical energy. Each container houses many battery packs that are stacked vertically into racks and placed in rows throughout the container (see Figure 6), with external doors such that maintenance staff can access the batteries and auxiliary equipment without entering the BESS container. Within each battery, many battery cells are connected in both series and parallel to obtain the desired output voltage and current. Cells and racks are designed according to IEC 62619.

During charging, electricity flows from the existing TransGrid substation through underground cabling to each container. The electricity flow is controlled by the battery management system (BMS). During discharge, this process is reversed: electricity flows from the battery cells, back to the substation. The output of the BESS is reticulated through unit transformers to 33 kV and then through the SWF HV transformers to connect to the NEM's 330 kV Queensland and New South Wales interconnector.

[1] Noting the BESS is within the SSF site boundary.
[2] Noting the BESS is within the SWF site boundary.
[3] The previous version of the report refenced 25-75 containers; there is an allowance for a second stage development beyond the 11 containers referenced here, which could bring the total number closer to the 25-75 range.

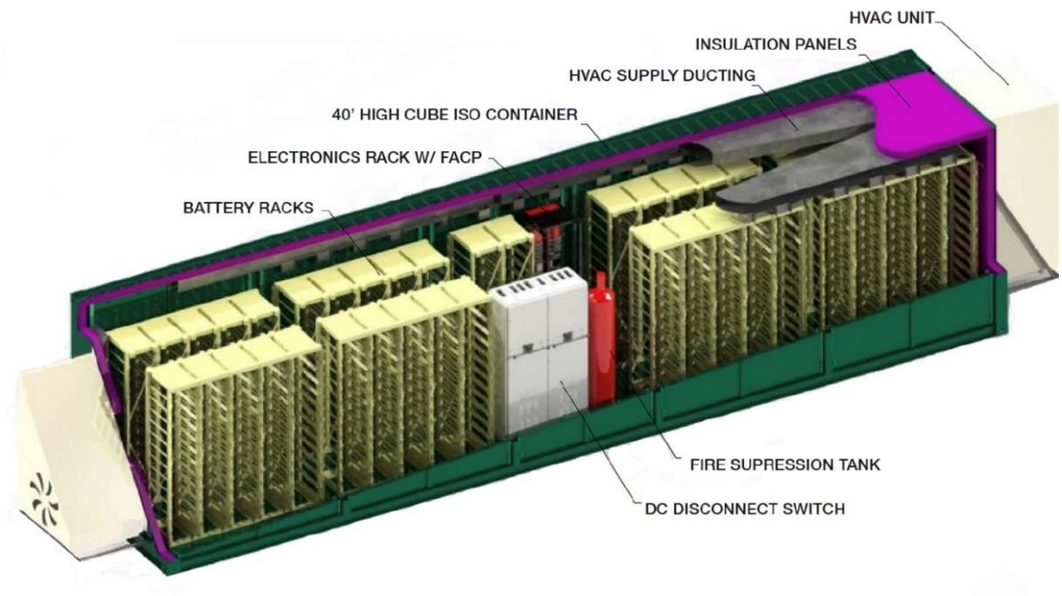

Figure 6: An indicative containerised BESS © Greensmith

The stacked batteries are connected to the BMS, which provides a range of safety measures including preventing overcharging and current surges, maintaining voltage levels and ensuring the systems cut out in the event of electrical shorts, overheating or other unplanned events. An HVAC system is included with all battery systems, maintaining the batteries in the container within safe and optimal operational temperature limits (between 18°C and 25°C). The HVAC system can operate between -17°C and 55°C ambient temperature (unshaded). The limiting factor in the HVAC's operability is the inlet air temperature, so while radiation from direct sunlight may increase the surface temperature of the HVAC unit beyond 55°C, if the inlet air temperature is below that level, the system can continue to operate (albeit with a higher power demand due to decreased efficiency with increased inlet air temperature). The HVAC units and the GridSolv Battery Containers are painted/powder coated using minimally reflective texture and coating in order to mitigate against the potential for surface temperatures to exceed 55°C.

Further, the BMS is designed to control battery cells in the event of abnormal operating conditions, including temperature. There are three levels to the BMS:

- Level 1: Module BMS (MBMS) – cell level monitoring;
- Level 2: Rack BMS (RBMS) – each rack consists of 15 modules connected in series; and
- Level 3: System BMS (SBMS) – racks connected in parallel.

The MBMS monitors battery conditions including cell voltage and temperature, and communicates this to the RBMS. Based on this information, the RBMS controls cell operation (such as cooling and balancing). In abnormal temperature conditions, the RBMS manages whether the rack remains engaged on the DC bus or isolates itself from the DC bus by opening its DC contactors. The RBMS also communicates with the SBMS, which uses the information to determine the power which can be exercised from the battery system. The GEMS controller communicates with the SBMS and uses the data obtained to decide how to operate the battery system.

The BESS fire detection system is an ASD. An ASD is a sensor system enclosed within the air flow piping of the battery enclosure that takes rapid air quality samples for hazard (smoke) detection. The design of the ASD is to generally comply with AS 1670.1, noting that not all aspects of AS 1670.1 may be relevant to the design, as the BESS is not a true building structure. A suitably qualified services engineer will review the ASD design and provide advice on the final design. Specifications for the ASD models qualified for GridSolv containers are attached in Appendix B.

Carbon monoxide and hydrogen gas detectors are fitted to monitor for gases which are typically released during thermal runaway.

The BESS fire suppression system utilises Novec 1230 fluid, a gaseous suppression system. This is to be designed to appropriate standards (AS ISO 14520) and manufacturer recommendations. The system controls and activation will be in accordance with AS1670.5.

Each container within the BESS has metal external walls and is provided with insulation. The insulation is to be a 100mm rockwool sandwich panel with steel on both sides, which is non-combustible when tested in accordance with AS1530.1. In addition, there will be approximately a 200mm air gap between the wall and the battery modules. As the containers are single-storey free standing structures which are spatially separated, a fire resistance level is not required.

While a fire rating is not required, Greensmith, the provider of the containers, has indicated that each container is provide with a fire rating of EI-60 under ISO 834. This is comparable to a fire rating of -/60/60 under AS1530.4.

Each container is bonded to site level earth/grounding at four locations.

2.2.3 Operations and Maintenance Facility

The SSF Operations and Maintenance (O&M) Facility and compound is to be constructed in the vicinity of the BESS. The facility will consist of an office and a workshop, either in the same building or separately. SSF operations and maintenance activities will be coordinated from this facility. The number of operational staff working from this building each day may vary and is yet to be determined, but is expected to be up to 10 personnel.

2.2.4 Workforce

Staff numbers on site will be approximately 200 during construction and up to 10 maintenance staff during the operational phase of the project. Staff will typically be on site during daylight hours, with 24-hour remote monitoring of system integrity and security.

2.2.5 Dangerous Goods and Hazardous Chemicals

The dangerous goods (DGs) and hazardous chemicals present at the SSF Site include:

- Transformer oil (class 3);
- HVAC coolant (class 2.2); and

None of the DGs or hazardous chemicals are “stored” in the conventional sense. The transformer oil and coolant are in circulation in their respective pieces of equipment while the batteries themselves are fundamentally a piece of operational equipment.

There is no off-site risk due to DGs being on site, therefore further analysis of DG-related incidents was not required.

3 Fire Hazard Identification

3.1 Materials and Quantities

A list of specified dangerous goods and hazardous materials at the SSF is presented in Table 2. The table shows the quantity and location of the materials present as well as their classification according to the ADGC and Hazardous Chemical (HAZCHEM) Codes.

HIPAP 2 (NSW DPIE 2011b) calls for average and maximum quantities to be shown. As the materials will be stored in small quantities if at all, the average and maximum figures would be materially the same value. Therefore, only a single value is shown for all materials.

The materials listed in Table 2 are constantly in use either as coolants (in the batteries, transformers or HVAC systems) or the batteries themselves.

The critical hazards on the site, and those that would require firefighting intervention should control measures fail, are not related to the storage of DGs or other hazardous materials but rather to the PV panel arrays, BESS and the substation. As described in Section 2.2, the substation is outside of the scope of this FSS and is not discussed here.

Table 2: List of potentially hazardous materials at SSF

Chemical Name	Class	UN No.	HAZCHEM Code	Inventory Average	Storage Type	Location Reference
Lithium-ion batteries	9	3480	4W	1700 tonnes	In use	BESS
Kerosene	3	1223	3Y	45 m^3	In use	Transformer oil
1,1,1,2-tetrafluoroethane (R134a)	2.2	3159	2TE	*unknown*	In use (coolant)	HVAC

3.2 Hazardous Incident Scenarios

Hazardous Incident Scenarios were identified using a variety of methods, including:

- a hazard identification (HAZID) process;
- a site visit to the SSF, including a site inspection of the BESS location;
- information received from the preferred battery original equipment manufacturer (OEM) suppliers identified in the procurement process;
- prior battery fire studies in the literature and from industry;
- liaison with relevant NSW Government Agencies including:
  - Department of Planning, Industry and Environment;
  - Fire and Rescue NSW (FRNSW);
  - New South Wales Rural Fire Service (NSW RFS); and
- the PHA previously completed for the SSF as part of the EIS process.

The SSF PHA identified the following types of potential hazards (not all fire related) at the facility:

- Fire (flammable liquid);
- Explosion (flammable gas);
- Toxic liquid leak;
- Toxic gas leak;
- Electrocution; and
- Crushing.

Not all of the potential hazards listed above are related to fire and detailed analyses were included in the PHA. This FSS is concerned only with fire and explosion consequences. HIPAP 2 (NSW DPIE 2011b) advises that a word diagram should be used as part of the reporting of hazard identification. The word diagram produced for the PHA (reproduced and refined in Table 3 in accordance with HIPAP 6 (NSW DPIE 2011d)) outlines some possible causes, consequences and mitigation measures for specific hazard events. This analysis does not address likelihood; however, most of the hazards are appropriately controlled by the mitigation measures already in place.

A critical hazard in lithium-ion batteries is thermal runaway. Triggered by a fault (for example an electrical short-circuit or battery cell electrical shunt) which can induce high-current flows inducing high temperatures and potentially an exothermic reaction perpetuating thermal runaway, which may result in a fire. The heating and fire can then heat neighbouring cells, propagating the effect. If a fire results, it can cascade from battery to battery, rack to rack and in extreme cases, container to container.

The thermal runaway hazard is mitigated by a series of safety measures, occurring at the cell, battery, BMS, rack and container levels of the battery system. Standards for lithium-ion batteries include thermal runaway testing at the cell level and battery level; and install standards in some international jurisdictions assess the system or container level, although these standards do not yet exist in Australia. Regardless, this is the most significant hazard identified and is thus the basis for the fire modelling performed in this study. The BMS continuously monitors peak cell voltage and in the event of a potential overcharge will immediately isolate a cell from the DC bus by opening its contactors.

The selection of $LiFePO_4$ cells instead of $LiNiMnCoO_2$ is, in part, intended to reduce the overall risk of thermal runaway.

Furthermore, the possibility of the battery releasing gaseous emissions, due to an overcharge or thermal event, presents an explosion and toxicity hazard for maintenance and fire-fighting staff. Whilst the likelihood of this event is minimal, the consequences are significant and as such this hazard and the two resulting potential consequences were considered in further detail in the PHA. Results are therefore presented in this report.

Table 3: Hazard identification word diagram

Event	Cause	Consequence	Mitigation Measures
Thermal Runaway in battery cell	• Electrical fault (e.g. short circuit) • External heat source (e.g. bushfire, arson) • High ambient temperature • Mechanical failure allowing rapid chemical mixing in cell (e.g. crush, penetration, fall, internal structure failure) • Excessive charge/discharge current • Excessive voltage during charging • Frequent temperature excursions in cells • Charge imbalance across cells connected in series • Over-discharge, inducing very low voltage • BMS/safety mechanism failure • HVAC failure • Battery aging/degradation cause by the above	• Fire engulfing single cell, which can then spread to whole battery • Fire, spreading to other batteries in the rack • Fire, spreading out of racking/cabinet to other battery racks/cabinets • Fire, spreading out of container to other containers	• BMS, particularly for voltage balancing, charge/discharge rate limiting and safety shutoff mechanisms • Pre-charge charging circuitry, initiated by BMS, to limit charge rates at low battery voltage • HVAC/backup power supply for HVAC system • Passive cooling devices integrated in battery pack • Charge interrupt devices (CID's) • Specific battery design to minimise thermal runaway risk (e.g. electrolyte additives, LFP rather than LCO chemistry) • Integrated protective circuitry to provide safety in case of internal short circuit failure, as part of certification procedure for Lithium Ion cell testing • Containerised system to prevent escalation • Fire suppression system • Integrated container level, rack level and battery level BMS. • Air aspirating fire and smoke detection system will detect gases, the status of which can be monitored by the EMS • System sizing and battery capacity take into account degradation over time • Selection of $LiFePO_4$ battery chemistry

Event	Cause	Consequence	Mitigation Measures
Electrical connection failure/short	• Improper installation • Faulty equipment/untested to industry standards • Failure of safety devices	• Excess heat leading to fire • Electrocution of maintenance staff • Damage to BMS, with potential to disrupt larger system	• BMS detection and cut-off of faulty cell
BMS failure	• Improper installation • Faulty equipment/untested to industry standards • Operation beyond supplier specified parameters • Software failure • Incoming electrical surge •	• Thermal Runaway and fire • Electrocution	• Robust BMS with back safety measures installed in accordance with appropriate regulation • Integrated container level, rack level and battery level BMS. • Routine inspection and maintenance
Release of battery cell liquid electrolyte	• Puncture, crush or fall event for battery or stack • Onsite explosion and resulting projectile ruptures battery pack • Battery penetrated by gunshot fired from surrounding farmland • Car collision with container/s	• Potential for electrolyte to form a pool fire • Potential for electrolyte to gasify, build up in container and explode	• Protected by shipping container against most small arms • No shooting signs at site boundary as deterrent • Bollards installed between road access and battery systems
Fall of battery racking/stack	• Improper installation of batteries, both in container and placement of containers • Faulty equipment/untested to industry standards • Improper operational procedures	• Crush operational stuff • Potential for toxic material leakage	• Install in line with appropriate standards and manufacturer's instructions
Flammable gas release from battery	• Overcharging/discharging • Damage to cell • Heat exposure	• Potential for explosion if gas is allowed to build up and ignition source is present • Potential for explosion to send small projectiles flying, presenting a hazard to maintenance staff • Toxic gases presenting risk to maintenance staff/fire-fighting staff (specifically carbon monoxide, hydrogen fluoride)	• BMS to control overcharge/discharge and overvoltage • Charge interrupt devices (CID's) • Positive temperature coefficient (PTC) devices to physically limit current flow in overcharge case were BMS fails • Integrated protective circuitry to provide safety in case of internal short

Event	Cause	Consequence	Mitigation Measures
			circuit failure, as part of certification procedure for Lithium Ion cell testing • Pressure release in battery cell, casing, cabinet and container in case of gas build up • No access to inside of container.
External impact	• Car collision with container/s • Potential wind turbine failure	• Crush and penetration of multiple cells, overheating, leading to fire	• Bollards installed between road access and battery systems • In terms of the wind turbine falling, a geotechnical report has been undertaken to warrant the safety of the foundations.
Vandalism and/or ingress (animals, people, insects)	• Access and/or damage by unauthorised personnel • Access and/or damage by animals or insects	• Damage to BMS, batteries, auxiliary electronics or safety systems • Potential hazard to vandals/animals • Potential for damage to battery system to create fire/toxic materials hazards	• Batteries enclosed in locked shipping container • Area fenced off to prevent access • Site boundary fenced to prevent accidental ingress • On site security protocols (monitored by 24 hour monitoring system with incident response protocols)
External fire engulfs battery containers	• Bushfire • Substation/transmission line/PV/Wind infrastructure failure and subsequent fire initiation, spreading through surrounding grassland to Battery System	• Large amount of chemical energy in battery system engulfed by external fire is released, exacerbating fire • The Battery Container carries an EI rating of EI60. If the battery container is engulfed in flames it will cause the HVAC system to most likely shut down. Shut down of the HVAC system will lead to increase in battery cell temperature and as previously identified, this condition will lead to enforcing the battery protection due to abnormal temperature.	• Containers sealed • Cleared 20m exclusion zone around battery system • Bushfire management plan includes management of surrounding grasslands • Fire suppression system in containers with backup power supply • Separation distance between battery system and other flammable material,

Event	Cause	Consequence	Mitigation Measures
			including materials stores and O&M facility • Separation between containers to limit heat transfer to be 2m or to the manufacturer's specifications • Site-wide isolation through GEMS
Sustained heatwave	• Sustained environmental radiative heat output	• Cell overheating and thermal runaway if HVAC not operational or sufficient	• HVAC system, with backup power source • Temperature monitoring and shutoff with BMS control
Water ingress	• Leaks in container during rain events	• Short circuit, leading to electrocution or fire	• Container certified to relevant standards • Container checked for leaks as part of maintenance regime • Container to be IP54 rated
High levels of humidity	• Weather events • HVAC system does not de-humidify, or even adds moisture content over time (condensing type)	• Short circuit, leading to electrocution or fire	• HVAC to not contribute to humidity levels • HVAC to have dehumidify option, and container software management systems to measure humidity levels inside container
Electrical fire from PV panels	• Improper installation • Wiring fault	• Fire within PV array • Potential for grassfire	• Defendable space around the PV panels • Wiring and installation standards

4 Consequences of Incidents

The consequences of the hazard scenarios identified during the HAZID process were assessed in the PHA. The results of the fire event assessments are provided below.

4.1 PV Panel Array

4.1.1 PV Panel Array Fire Scenarios

The fire risk associated with PV panel arrays is no different to any other electrical installation. Research commissioned by the Department for Communities and Local Government (DCLG) in the UK and carried out by BRE Global indicates that "there is no reason to believe that the fire risks associated with PVs are any greater than those associated with any other electrical equipment" (Shipp *et al.*, 2013). Fire incidents associated with PV arrays were generally related to installation faults.

4.1.2 PV Panel Array Fire Spread

The PV panel array causes no additional risk of a fire spreading to the rest of site and potentially having off site consequences. The panels are constructed almost exclusively from non-combustible materials (such as glass, steel and concrete). Fire spread is appropriately mitigated by the separation provided by the surrounding roadways.

4.2 BESS

4.2.1 BESS Fire Modelling

A fire event in a battery container was modelled. In order to assess the worst credible case off-site risk, it was assumed that all fire prevention measures had failed, and a container had caught fire. Two fire configurations were considered: a single door being open and the more credible scenario in which all doors are closed.

The radiative heat flux emitted was calculated using the Stefan-Boltzmann Law:

$$j^*_{emitter} = \varepsilon\sigma T^4$$

where j^* is the radiant emittance, ε is the emissivity of the container, σ is the Stefan-Boltzmann constant and T is the surface temperature. The heat flux received was calculated using the view factor method. Further description of this methodology and all equations used are presented in Appendix A.

The following assumptions formed the basis for the modelling:

- The temperature of the open door was set at 840°C (flame temperature). This is representative of an emitting heat flux of 84kW/m² which is used for fire spread design between buildings such as offices (Approved Document B) (HMCLG, 2010). While the units do contain batteries, which would have combustible contents and some plastic materials, the overall structure of the container and insulation is to be non-combustible and the majority of racking within the space is constructed of non-combustible metal. This results in a comparable fuel load. 840°C is also within the flame temperature range recommended for use for fires based on the Fire Engineering Design Guide. While adiabatic flame temperature is based on the chemistry of a flame, within a compartment the overall compartment dynamics and air ratio influence the temperature of a flame.
- The temperature of the closed doors and container walls was set at 600°C, which is generally the temperature at which flashover begins in a compartment as per the SFPE Handbook and CIBSE Guide E. This represents a severe fully developed fire throughout the container. While a flashover fire may reach higher temperatures than 600°C, given that the container has been confirmed by Greensmith to have a 60 minute integrity and insulation (EI) rating when subject to a furnace curve, it is unlikely that the external surface temperatures would teach 600°C or beyond.
- The emissivity of the container was taken to be 0.9. This represents a conservative emissivity for a severe fire and a good radiator;
- The open door was assumed to be the full height of the container, 2.4 m wide (based on OEM plans) and located in the middle of the long side;
- The heat flux from the emitting surface was assumed to be uniform; and
- No heat loss was assumed to intermediate media (i.e. to air or smoke).
- The basis of the fire modelling is to consider the worst-case conditions. It is a consequence-based assessment. In this context historical wind data does not affect the consequence assessment. Further as detailed above the fire modelling ignores that integrity and insulation rating of the containers, providing further conservativeness

The two scenarios are represented pictorially in Figure 7.

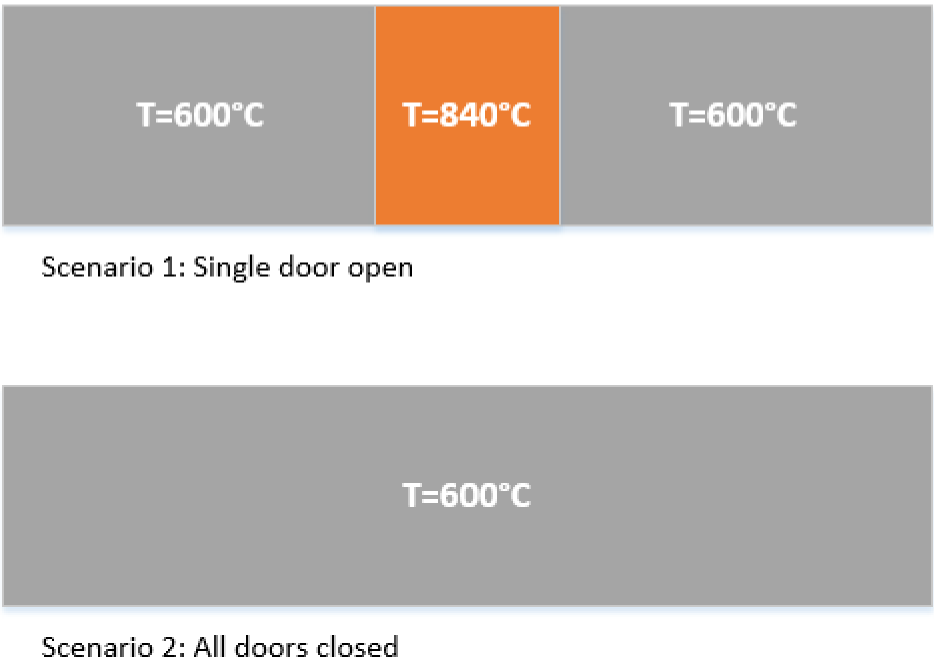

Figure 7: Pictorial representation of the two fire modelling scenarios.

The results of the modelling are presented in Figure 8. The red line shows 12.6 kW/m^2 which, according to HIPAP 4 (NSW DPIE 2011c), has the following effects:

- Significant chance of fatality for extended exposure. High chance of injury
- Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure
- Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure

The risk of a fatality as a direct result of a battery container fire is limited to people within 3 m (door closed) or 5 m (door open).

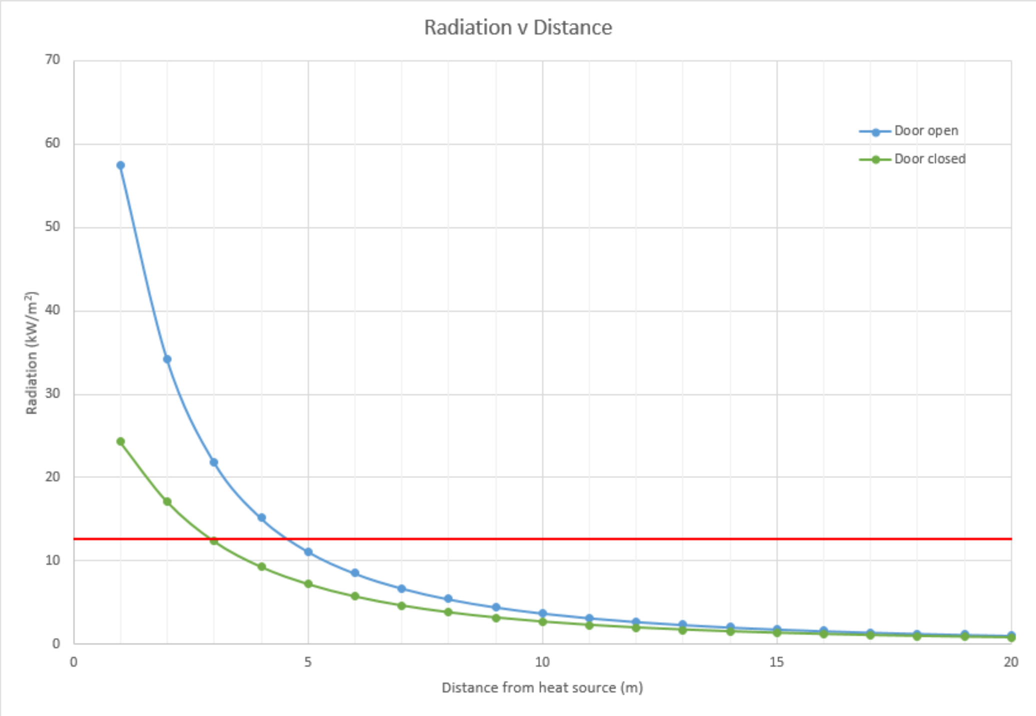

Figure 8: The results of the fire modelling, showing heat flux radiation plotted against distance. The red line is set at 12.6 kW/m^2

4.2.2 Fire Spread

In order to mitigate against the risk of fire spread from the BESS to the rest of the site and potentially off-site, a 20 m clear zone is to be installed around the BESS, with all vegetation cleared and gravel or a similar material placed on the ground.

The results of the analysis above suggest that in the event of an entire container catching fire, the 12.6 kW/m^2 radiation contour would extend approximately 3 m (door closed) to 4 m (door open) and at 20 m, the heat radiation would be below 1 kW/m^2, which is comparable to the effect of direct sunlight, and insufficient to cause ignition.

The fire modelling demonstrates that the 20 m separation zone is sufficient to prevent fire spread from the BESS to the remainder of the site and to off-site receptors.

Greensmith, the manufacturer of the BESS has indicated that the containers and insulation system have a fire rating of EI 60 when tested to ISO 834. This test standard is a furnace fire standard which while not an exact match for, is comparable to AS1530.4. An EI rating of 60 corresponds to a 60-minute rating for integrity and insulation under ISO 834.

The ISO 834 testing regime consists of exposure to a furnace fire curtain similar to that used in AS1530.4, which represents a fully developed fire which quickly reached 600°C and continues to heat gradually throughout the exposure period. The acceptance criteria for the insulation rating of the test is that on the unexposed side of container, the average temperature of five thermocouples may not increase by more than 140°C, which would not be expected to cause fire spread between containers. It is considered that the operational spacing required around the container (3.5m) would be sufficient to limit fire spread via radiative heat.

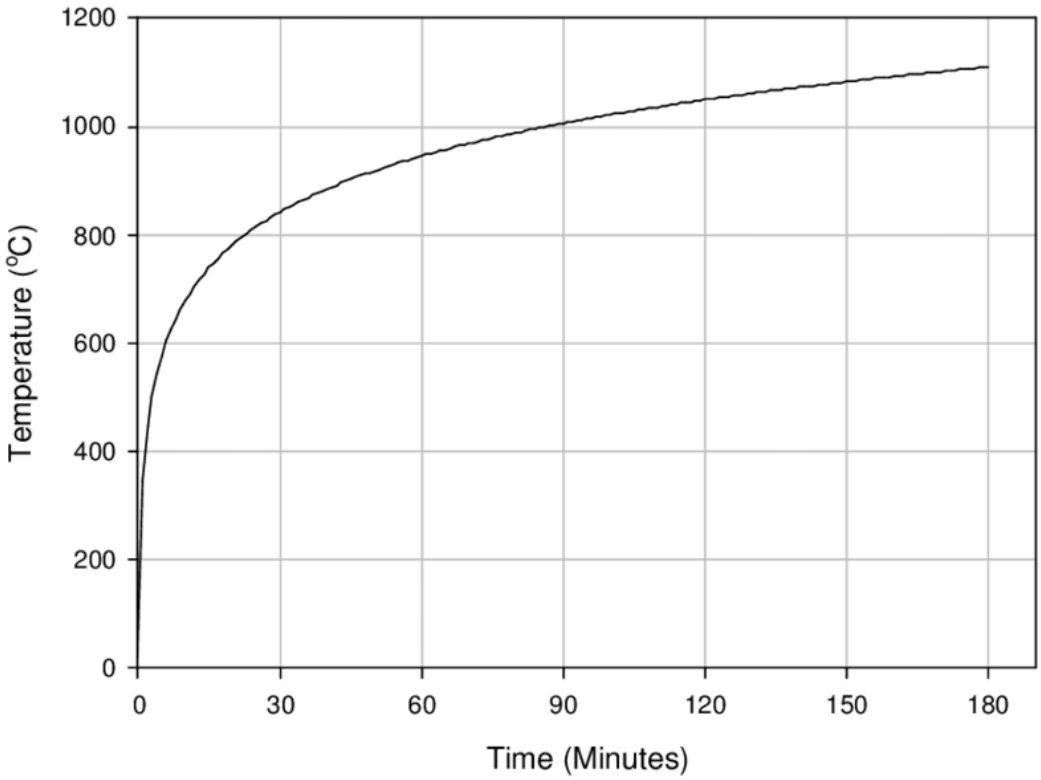

Figure 9 ISO 834 furnace fire curve

4.2.3 Gas Explosion

A confined vapour cloud explosion was modelled for a vapour release scenario inside a battery container. Battery system supplier information suggests that, at high temperatures (100°C or more), cells are designed to vent to release internal gas pressure. The amount of gas vented by cells in a single container was assumed to be 800 L (US DOT FAA, 2016). Teng et al. (2015) give the compositions of gas generated by different electrolyte combinations at different charge levels. For 1:2 mixture of ethylene carbonate (EC) and diethyl carbonate (DEC), the mass composition was derived based on the data shown in Table 4. At 100°C, 800 L of the above mixture has a mass of 764 g. Assuming that the batteries and other equipment inside the container take up 50% of the available space, 42.5 m^3 was available for the hot gas mixture to accumulate.

Table 4: Gas composition for a release from a representative $LiPF_6$-EC-DEC electrolyte during a high temperature event (Teng et al., 2015)

Material	Gas composition by mass (%)
Carbon Monoxide	34.8
Carbon Dioxide	0.2

Methane	0.3
Ethane	0.7
Ethylene	63.9

A confined vapour cloud explosion (VCE) was modelled in DNV GL's Phast v8.0 software. The results are presented in Figure 10. The results of the consequence modelling show that the more severe contours (14 kPa, 21 kPa and 35 kPa) are restricted to within around 14 m of the blast epicentre. HIPAP 4 (NSW DPIE 2011c) suggests that 7 kPa is an appropriate cut-off for significant injury or fatality to individuals. As such, the risk to human life in an explosion event is contained within a 24 m radius.

Anderson et al. showed that ISO shipping containers sustained "minor" damage at 2 psi overpressure (approx. 14 kPa) and "significant" damage at 5 psi overpressure (approx. 35 kPa). Therefore, in the unlikely event of a worst-case explosion occurring in a container, significant damage will be restricted to a 5 m radius, and only the immediately adjacent container. It is worth noting that an explosion event would not cause a cascade effect or lead to residual risk of further significant events.

The explosion consequence was assessed as being *very unlikely* in the PHA.

Any flammable gas vented by battery cells at very high temperatures is, in the worst case, likely to cause a confined vapour cloud explosion (VCE). In the unlikely event that a flash fire results instead of a VCE, the impact zone will be negligible, given the mass of flammable vapour is less than 800 g.

No off-site consequences are expected due to the release of vented flammable gases.

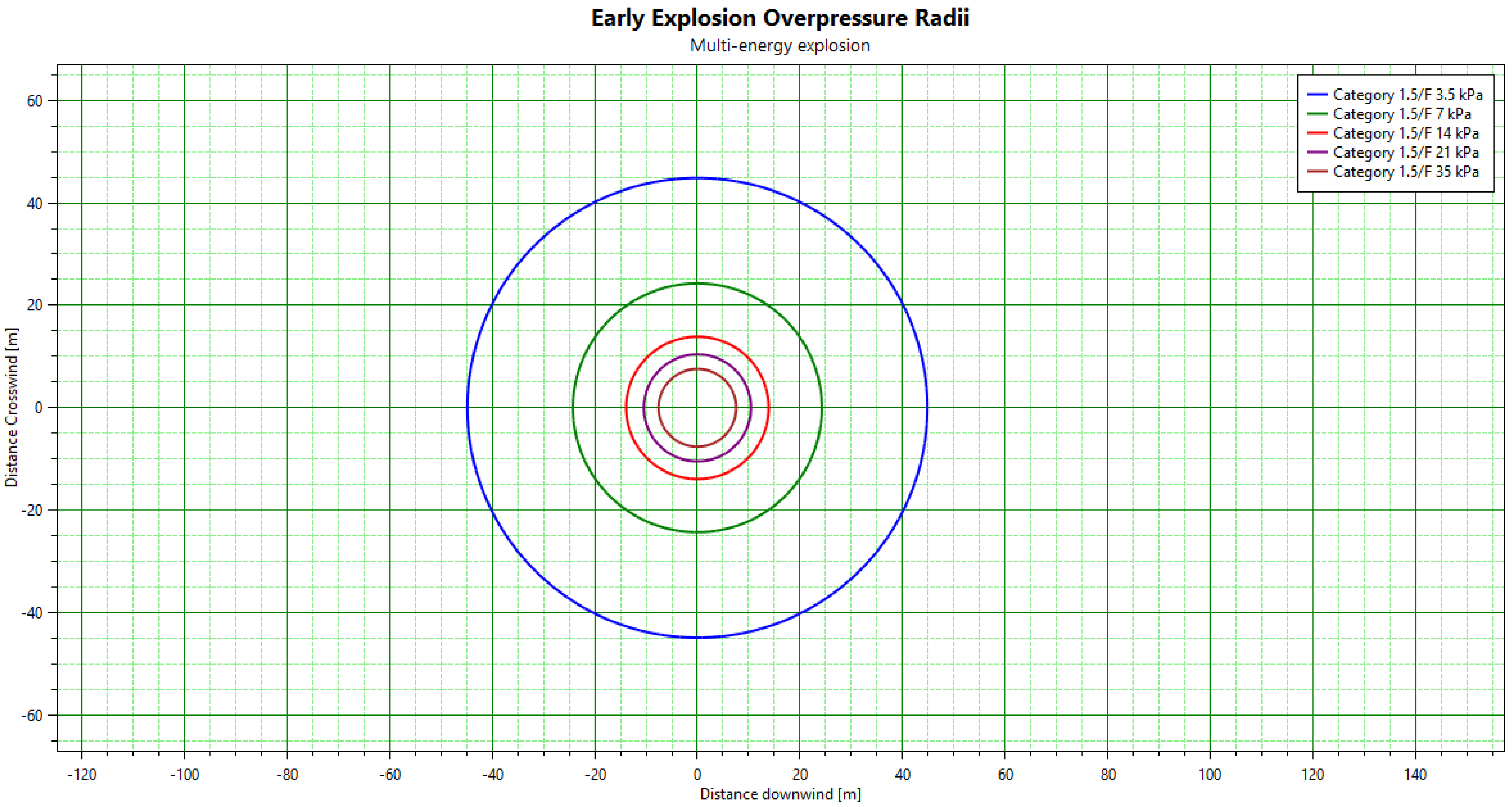

Figure 10: Overpressure contours resulting from a gas explosion in a battery container

5 Fire Prevention and Mitigation Measures

The fire prevention and mitigation strategy for the SSF contains multiple layers of fire control and fire defence, following a typical risk control hierarchy. They are described below against each of the two key parts of the project.

5.1 PV Panel Array

Grass will be managed beneath the panels to reduce the height of grasses. Vegetation clearing from the development will not result in cleared logs and branches remaining below the panels.

5.1.1 PV Panel Array Fire Spread Prevention

As described in Section 2.2.1, as part of the EIS process and consistent with Condition 23 in Schedule 3 of the Development Consent (SSD8643), the perimeter of each of the PV panel areas will be surrounded by a 20 m defendable space managed as a grassland.

5.2 BESS

The fire prevention and mitigation strategy for the BESS contains multiple layers of defence. The first control measure is the battery management system, which ensures the batteries are operating within normal conditions. If that should fail and a battery begins to operate outside defined parameters, controls are in place to detect and prevent, and then finally mitigate increases in temperature, and ultimately fire propagation. Firefighting options are also in place as a final resort.

5.2.1 Battery Management System (BMS)

The BMS works to ensure that the performance of each battery is within normal operating range. The flow of energy to different storage cells is determined by the BMS, which prevents any single cell from overcharging.

The BMS typically includes features such as:

- Overcharge protection;
- Surge protection;
- Voltage level maintenance; and
- Trip switching in the event of shorts, overheating, or unplanned electrical events.

5.2.2 Temperature Control

Each container is fitted with its own HVAC system, which maintains the temperature of the container and the batteries within it at a normal operating range of 18°C to 25°C. Each HVAC has a backup power supply (a common diesel backup system for the BESS).

Further, the BMS is able to detect elevated temperatures in any of the cells and cease directing current to that cell.

The HVAC systems in use on the battery containers must be rated for use in local weather conditions, including prolonged direct sunlight exposure; and will have a maximum operational temperature of 55°C. The record high temperature in Inverell is 41.9 °C and the record low temperature in Inverell is -9.5 °C. Climate change scenarios over the life of the plant have not been assessed due to inherent uncertainty; however, maximum high temperatures may be expected to increase in future under such projections.

5.2.3 Shutdown Mechanisms

The BESS system is equipped with both automatic and manual shutdown capabilities.

Automatic Shutdown

Protection units are built into the BESS at the battery level, PCS level and EMS level (monitoring), which are programmed such that if the BESS is operating outside permissible limits, the system will automatically shut down. For example, the BMS is continuously monitoring battery temperatures, voltages and currents, and if any of these parameters reaches an unsafe level, the BMS will exercise protection and shut down the batteries. Similarly, if the PCS detects voltage, current or frequency outside its permissible range, it will trip and protect the system.

Automatic shutdown is also triggered when the doors of the container are opened or the fire system goes into countdown mode.

Manual Shutdown

Each container is equipped with an e-Stop button at each end, mounted on the outside surface of the HVAC system. These emergency stop buttons can be used by emergency responders to drive a safety relay which will cease power exchange between the batteries and the grid, and to isolate the batteries from the DC Bus. The e-Stop button shuts down only the individual container. The entire system can be isolated through the GEMS panel.

5.2.4 Containerised Fire Detection and Suppression

Each BESS unit is to be provided with a self-contained automatic detection, alarm, and suppression system. The automatic fire suppression is to be provided by a Novec 1230 fire suppression system. Novec 1230 is a fluid with low boiling point of approximately 48°C and therefore gasifies immediately upon release from the suppression system injectors. Unlike other fire suppression measures, Novec 1230 systems extinguish fires by rapidly absorbing the heat source, rather than removing the presence of oxygen. Novec 1230 fire suppression systems are common in situations where electrical equipment is deployed, such as telecommunications, data centres and medical facilities.

The Novec 1230 system is to be connected to and activated by a series of detection systems provided within each container. Each container is to be provided with three separate fire detection devices:

- Heat detectors
- Smoke detectors
- An aspirating smoke detector (ASD) which is a VESDA (Very Early Smoke Detection Apparatus)[4]

The individual detectors are to be arranged into zones and the ASD is to be provided as a separate zone with a multi-stage alarm system on it to initiate outputs based on the detected fire phenomena.

The detection/alarm system shall be split into three stages:

1. Pre-alarm stage
2. Stage 1 alarm
3. Stage 2 alarm and discharge of Novec agent

Pre-Alarm Stage

This stage represents an early detection of smoke or dust by the VESDA system which is must more sensitive than the smoke or heat detectors. This mode triggers on a 30% value from the VESDA system which could be from actual smoke or from dust or other contaminants. At this level the VESDA is to shut down the HVAC systems, the fan, and shut the motorized dampers to seal the container. This is to prevent a delay of further activations in the case that smoke is vented out the HVAC, and to confirm if the sensor has actually identified smoke or dust. The GEMS (part of the battery management system) will keep the container in this mode for five minutes. If no further escalation of alarm occurs during this time period, then the panel will reset and the HVAC will resume typical operation.

Stage 1 Alarm

This stage is triggered if the VESDA reaches a 70% threshold, or Zone 1 or Zone 2 activate alone. In this case the HVAC is also shut off, and the BESS in alarm stops taking in power from the panels. This stage poses a more serious potential for actual fire and therefore has a 15-minute time out. If the alarm does not escalate to Stage 2 in 15-minutes, then the panel resets.

Stage 2 Alarm (Discharge)

In Stage 2, the Novec 1230 system discharges to suppress a fire. This stage requires that the VESDA reach a 70% threshold and Zone 1 or Zone 2 activates,

[4] Although the ASD does not directly detect thermal runaway, it will immediately detect any smoke generated by thermal runaway. The battery vendor has performed an Internal Fire Exposure Test based on the UL1973 thermal runaway testing procedure, and has certified their batteries to UL1973 and IEC 62619.

providing a double-knock to the detection before activation of the gas suppression system. The container in question is shut down under a Stage 2 alarm.

The responsible fire service is to be notified in the event of a Stage 2 alarm.

The systems are to be designed in general in accordance with the relevant Australian Standards and some overseas (NFPA) standards, noting that some portions of the standards relate to buildings and as such may not be applicable to the BESS containers. It is recommended that a suitably qualified fire services engineer be consulted for their design.

The fire panel in each BESS is to be connected back to the GEMS panel in the appropriate O&M building. The GEMS is to be provided with a map indicating the layout of the BESS systems across the land, and the responding device number for each fire control system. In this way if a fire panel senses smoke or goes into an early stage alarm the location of that container can be accurately determined quickly to allow for a response.

The O&M building containing the GEMS panel is to be located such that the brigade need not drive past a battery fire to reach it and its location is to be marked with signage to direct the fire brigade there in the first instance.

An external strobe is to be provided on each containerised to provide easy identification of containers. The status of discharge for Novec 1230 is provided through the GEMS portal.

Further, carbon monoxide and hydrogen gas detectors are fitted to monitor for gases which are typically released prior to thermal runaway (approximately six minutes before). The gas detectors will detect the off gas before thermal runaway commences, and mitigation measures such as release of Novec 1230 and emergency shutdown/isolation of the container can be implemented before thermal runaway begins. This is shown in Figure 11

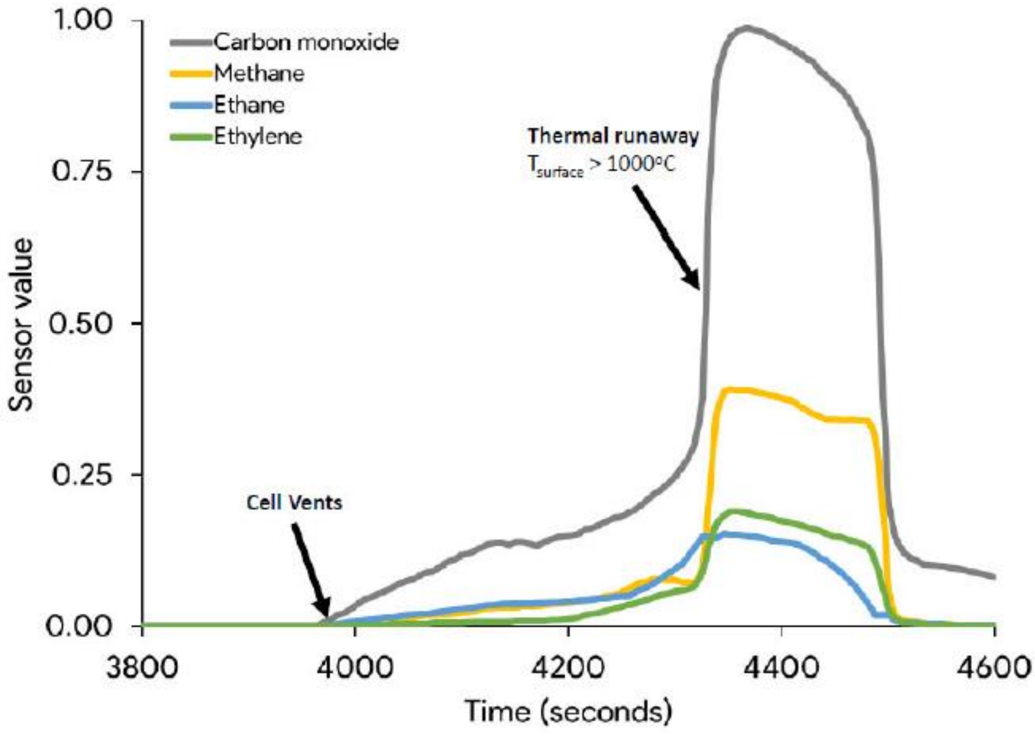

Figure 11 Cell Venting and Thermal Runaway from testing by DNV-GL

5.2.5 BESS Fire Spread Prevention

The following fire prevention strategies are recommended:

- All vegetation within at least 20 m of the BESS shall be cleared, with gravel or a similar material laid to prevent both an external fire impacting the BESS and a fire within the BESS spreading to the wider site and off site; and
- Vegetation shall be maintained across the remainder of the development footprint at a level that will prevent any external fire reach an intensity which would adversely impact on the BESS across the 20 m separation distance. Specifically, the slopes near the BESS should be well maintained.

5.3 Fire Brigade Provisions

The SSF will be serviced by the New South Wales Rural Fire Service (NSW RFS). RFS may call for assistance from Fire and Rescue NSW (FRNSW), who handle hazardous materials emergencies. Both the NSW RFS and FRNSW have stations in Inverell and Glen Innes, approximately 37 km from the SSF access point. The nearest fire stations are shown in Figure 12 and Table 5. Access to site is via Waterloo Road or Western Feeder, with the site entrance located at approximately 29°42'15.8"S, 151°25'26.5"E.

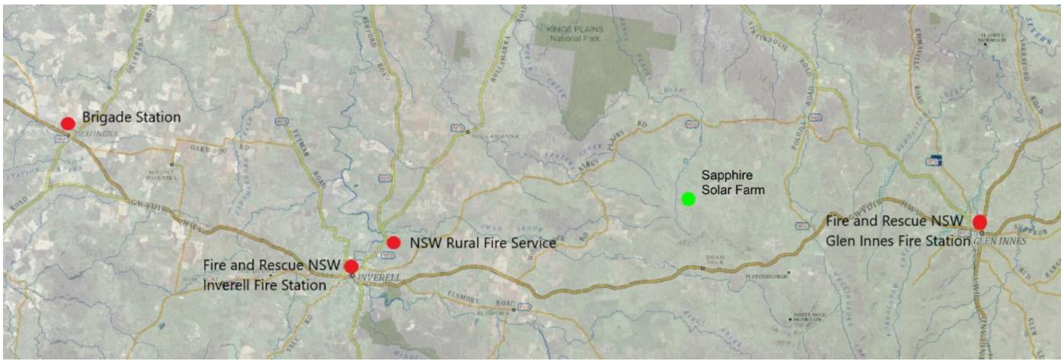

Figure 12: Location of nearby fire stations (image source: SIX Maps)

Table 5: Fire stations near SSF

Station Name	Address	Distance	Contact Details
NSW Rural Fire Service: Inverell	52 Burtenshaw Rd, Inverell NSW 2360, Australia	38 km	+61 2 6721 0446
Fire and Rescue NSW: Inverell	59 Evans St, Inverell NSW 2360, Australia	37 km	+61 2 6721 0015
NSW Rural Fire Service: Glen Innes	181 Bourke St, Glen Innes NSW 2370, Australia	37 km	+61 2 6732 7046
Fire and Rescue NSW: Glen Innes	202 Bourke St, Glen Innes NSW 2370, Australia	37 km	+61 2 6732 5379
Delungra Fire Brigade	Railway St, Delungra NSW 2403, Australia	74 km	+61 1800 679 737

5.3.1 Site Movement

The site contains solar arrays, wind turbines, the TransGrid 330 kV substation and the BESS, connected by roadways (both sealed and unsealed) trafficable by vehicles. The SWF O&M building is adjacent to the substation and located such that emergency services vehicles attending the site through the main access point on Waterloo Rd are not required to drive past the BESS to reach the O&M building.

The BESS O&M building will be located in the general area of the BESS, however at the eastern end of the BESS area to warrant safe emergency service access to the building in the event of a major incident at the BESS.

The GEMS, which serves as a proxy master FIP is to be provided in the O&M building. Signed directions to the appropriate O&M building shall be provided along the driving route in order to direct emergency services to the GEMS.

The perimeter of the solar array area must include a defendable space that permits unobstructed vehicle access as per Consent Condition 25.

5.3.2 Firefighting Water Considerations

The site is to be provided with a 20 kL potable fire water tank consistent with the consent conditions. This water tank is to be provided near the main access point to the Sapphire site, as the water may be used for grass fires and thus the brigade should have easy access to it direct from the main road.

The fire spread within the BESS has been considered in Section 4.2 without the use of cooling water and deemed to be unlikely to occur.

During the safety in design workshops and throughout detailed design the need for firewater for a BESS-related event shall be revisited in conjunction with a fire safety engineer including where alternative sources of water may be obtained. If required, an additional fire water storage or supply shall be introduced, and the volume shall be justified based on operational practices. If it is confirmed that fire water is not required, then additional analysis may be provided as justification.

5.4 Post-Fire Incident Actions

Due to the characteristics of thermal runaway, where the batteries may self-generate heat, there is a small potential for the batteries to re-heat themselves and reignite following a fire event.

In order to mitigate against this potential, the following actions are to be taken following a fire event in a BESS unit:

- If the unit was extinguished solely via the built in Novec 1230 system (no firefighting), the container is to be allowed to sit for a period of time based on the hold-time design of the Novec 1230 system.
- Following the above period, or if active firefighting was utilised, if it is safe to do so, the batteries/battery racks are to be removed from the container and isolated. The batteries may be isolated for inspection and checking. Batteries, especially damaged units are to be isolated outside in a clear area with no combustibles (e.g. on a hardstand or gravel pad). In this case they may be monitored and maintained in this clear are isolation for a few days to a week to warrant against reignition.
- If the batteries may not be removed immediately due to danger of fire, heat, electrification or other dangers or damage:
  - If possible reinstate a temporary detection system to the container, and/or
  - Provide on-site monitoring of the container for at least a week or until feasible to decant the battery packs from the container to an isolated area.
- Before any container or battery is reinstated and connected back to the energy grid, all fire safety systems within the container are to be fully reinstated including detection systems, automatic suppression systems, and connection back to the main GEMS system.

6 Conclusion

The risk of fire and explosion at the SSF has been assessed according to HIPAP 2 (NSW DIPE 2011b). The risk of off-site impacts as a result of fire or explosion at the site is appropriately controlled by the measures in place, subject to the following recommendations:

- All vegetation within 20 m of the BESS is cleared, and a material such as gravel used to ensure clearance is maintained.
- Vegetation in the area around the BESS is maintained at a level that will prevent any external fire from reaching an intensity which would adversely impact on the BESS across the 20 m separation distance.
- Each container is to be provided with an automatic gas suppression system (Novec 1230) designed by a suitably qualified fire services engineer.
- The aspirating smoke detector (ASD) system design be reviewed by a suitably qualified fire services engineer.
- ASDs and local FIPs within each BESS are to link back to a main GEMS panel which serves as a pseudo-FIP, with an appropriate site map and block plan to be provided.
- The HVAC system shall be capable of operating at a maximum ambient temperature of 50°C and in direct sunlight.
- Battery procurement should consider those certified to UN38.3 and/or IEC 62281 for transport, and UL 1973, IEC 61427-2 and/or IEC62619 to ensure appropriate thermal management and short-circuit protection is present.
- Installation should be certified to all relevant Australian Standards (e.g. AS 3000 series), and, although the project is not within its scope, consider complying with draft standard AS 5139:2019 where possible as a precautionary measure.
- BESS containers should be appropriately IP rated for the environment and certified to AS 60529.
- The modelling and analysis performed for this study was based on the assumption that firewater was not available. Therefore, the conclusions reached do not rely on the availability of firewater. Firewater for the BESS may be provided if deemed necessary during the safety in design process or the detailed design phase.

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Appendix A

Heat Radiation Calculations

Heat Radiation Calculations

A fire event in a battery container was modelled. In order to assess the worst credible case off-site risk, it was assumed that all fire prevention measures had failed and a container had caught fire. Two fire configurations were considered: a single door being open and the more credible scenario in which all doors are closed.

The radiative heat flux emitted was calculated using the Stefan-Boltzmann Law:

$$j^*_{emitter} = \varepsilon \sigma T^4$$

where j^* is the radiant emittance, ε is the emissivity of the container, σ is the Stefan-Boltzmann constant and T is the surface temperature. The heat flux received was calculated using the view factor method:

$$j^*_{receiver} = 4 \cdot \emptyset \cdot j^*_{emitter}$$

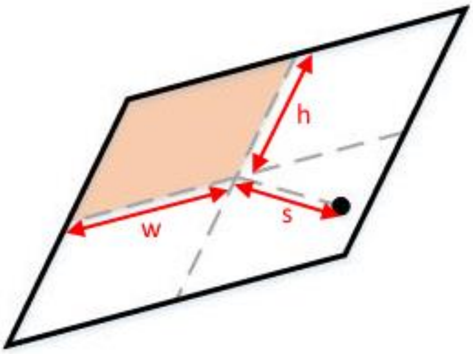
The view factor, $\emptyset$, is given by the equation

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

The parameters a and b are given by the following equations, where h is half the height of the surface, w is half the width of the surface and s is the perpendicular distance from the surface to the point of interest:

$$a = \frac{h}{s}\,; b = \frac{w}{s}$$

This is represented graphically as follows:



Appendix B

Aspirating Smoke Detector (ASD) Specification Sheet

B1 VESDA Specification Sheet

VESDA ECO™ Detector

Gas Detection for Use with Aspirated Smoke Detection

Xtralis the manufacturer of the market leading VESDA aspirating smoke detection (ASD) technology has developed the industries first multi-hole aspirated gas detector.

When used with the compatible range of ASD products; VESDA ECO provides the industries first combined aspirated smoke and gas detection system.

VESDA ECO provides early warning of toxic, oxygen and flammable gas hazards to protect personnel and property whilst ensuring business continuity.

Applications include:

- Battery charging rooms
- Boiler plant rooms
- Commercial kitchens
- Parking garages
- Utility / service tunnels
- Refrigerated stores and plant rooms
- Water treatment and sewerage plants
- Power generation plants
- Metal processing plants
- and more.

How It Works

VESDA ECO uses an existing or new aspirating pipe network to actively monitor for gas escapes and build-ups.

Each ECO gas detector can house up to two gas sensors, and additional detectors can be added easily to the pipe network to monitor more gases if required. Pre-calibrated sensor cartridges are easily replaced in the field and make converting to different gas sensors or replacing sensors a simple task.

The VESDA ECO detector is configured using Xtralis VSC configuration software and can be remotely monitored using Xtralis VSM4 monitoring software. Both VSC and VSM can be used to download data from the on-board memory card for data analysis and trending of historical data.

Integration with other building systems, including safety systems, PLCs, HVAC and building management systems, provides real-time situational awareness for intelligent response.

VESDA ECO by Xtralis provides significant installation and routine maintenance cost savings over conventional multi-point gas detection solutions, by reducing the number of detectors required to cover an area and by providing easy access for routine maintenance.

Hazardous area certified variants of VESDA ECO are available. For more information on VESDA ECO Ex, refer to document 19826.

Features

- Toxic, Oxygen or Flammable gas detection
- Single or dual gas versions
- Factory calibrated sensor cartridges
- Integral alarm status LEDs
- Integrates with PLCs/HVAC/BMS/FACP
- Configurable relays
- 4-20 mA analog outputs
- RS485 Modbus output
- On-board event logging
- On-board fault diagnostics
- Integral gas test port
- Remote reset

Compatibility

- VESDA ASD
- ICAM ASD
- FAAST ASD
- ECO is to be used only with large bore (3/4'' BSP or OD 25mm) systems, and not small bore (1/4'' BSP or OD 6mm) systems

Approvals

- CE
  Electrical safety
  - Conforms to ANSI/UL Std 61010-1
  - Certified to CAN/CSA Std C22.2 No. 61010-1
  - EN 61010-1
- EMC
  - FCC 47CFR Part 15B class B
  - ICES 003
  - EN 50270
- Others
  - LPCB, VdS, AFNOR compatible for use with EN54-20 approved ASD
  - LOM approved to UNE 23300 (CO & $CO+NO_2$)
  - AQISQ – CMC Pattern Approval
  - CCCF – CFE, GB:15322.1
  - VNIIPO
- SIL Rating
  - SIL 2 as per IEC 61508 (combustible gas and CO_2 versions)
  - SIL 1 as per IEC 61508 (toxic gas and oxygen versions)

Note: Consult with Xtralis if the application requires removal of interferent gases.

VESDA ECO™ by xtralis

VESDA ECO Ordering information

VESDA ECO gas detectors come complete with the main housing, sensor cartridge, data storage card and USB interface cable. Two variants are available based on detector outputs:

Part number structure: ECO-D-B-AA-BB

Single Gas Units

Replace AA with the relevant gas type number below and remove BB:

11 Hydrogen (H_2) 0-100% LFL
12 Methane (CH_4) 0-100% LFL
13 Propane (C_3H_8) 0-100% LFL
14 Hydrogen (H_2) 0-2000 ppm
15 Gasoline Vapour 0-100% LFL
16 Pentane (C_5H_{12}) 0-100% LFL
20 Alcohols 0-100% LFL
31 Oxygen depletion only (O_2) 0-25% v/v
32 Oxygen depletion and enrichment (O_2) 0-25% v/v
41 Carbon Monoxide (CO) 0-500 ppm
43 Hydrogen Sulphide (H_2S) 0-100 ppm
44 Sulphur Dioxide (SO_2) 0-10 ppm
45 Nitrogen Dioxide (NO_2) 0-10 ppm
49 Carbon Dioxide (CO_2) 0-5% v/v

Dual Gas Units

Select one of the available combinations below. Replacing AA and BB with the preferred combination. Other combinations are available upon request:

12 – 31 Methane and Oxygen
12 – 41 Methane and Carbon Monoxide
12 – 43 Methane and Hydrogen Sulphide
13 – 31 Propane and Oxygen
31 – 41 Oxygen and Carbon Monoxide
41 – 43 Carbon Monoxide and Hydrogen Sulphide
41 – 45 Carbon Monoxide and Nitrogen Dioxide

Example: ECO-D-B-12-41

An ECO detector with relay, analogue and serial outputs for Methane and Carbon Monoxide.

Replacement sensor cartridge part number structure: ECO-SC-AA-BB

Where SC = Sensor Cartridge, AA-BB are 1st and 2nd gas types (see above).

Installation

VESDA ECO is designed to press fit on to the air sampling pipe. To fit VESDA ECO simply remove a 60 mm section of pipe when using 25 mm OD air-sampling pipe work or 4” for ¾” BSP pipe.

VESDA ECO provides total flexibility to install one or more detectors anywhere on the pipe network to enable monitoring of a specific point, zone or total area.

Specifications

Supply Voltage	18-30 VDC
Power Consumption @ 24 VDC	3.6 W (max)
Current Consumption	Typically 60 mA @ 24 V DC for a dual gas (flammable / toxic) quiescent. 85 mA when in alarm.
Dimensions (WHD)	34 mm x 125 mm x 110 mm (1.3” x 4.9” x 4.4”)
Weight	250 g (0.6 pounds)
IP/NEMA ratings	IP65 and NEMA 4
Operating Conditions	Temperature typically -20ºC to 50ºC (-4ºF to 122ºF) gas dependant. O_2 - 20ºC to 55ºC (-4ºF to 131ºF) Humidity: 10-95% RH, non-condensing
Pipe Size	External Diameter 25 mm (EU), ¾” (US/CAN)
Wire/Terminal size	1.5 mm² 16 AWG maximum
Cable Access and Termination	2 x PG9 cable glands, to suit 4.0 to 8.5 mm (0.157” to 0.335”) outer cable diameter
Accuracy	+/- 5%
Outputs	4 wire RS 485 Modbus RTU (2 wire data comms + 2 wire power) Four (4) programmable relays 30 VDC 1A One (1) 4-20 mA output per sensor
Onboard Memory Card	Micro SD card 2 GB - 8 GB (50,000+ events)

VESDA VLF for Rail Applications

The fundamental nature of train operation means that there is an inherent risk of fire. High power, high inertia systems, "as built" and introduced fuel loads combine to create fire risks. Trains are an evacuation challenge, often containing large numbers of occupants in a moving platform, complicating egress. High airflows and contaminants further challenge the longevity and performance of smoke detection systems in rolling stock. Robust and reliable operation and the earliest possible detection of smoke is key to the prevention of service interruption, threats to life safety, and loss of assets and business reputation.

The VESDA VLF-250 is a very early warning smoke detector designed to protect small, business-critical environments of less than 250 m^2 (2690 sq. ft.). It can detect smoke reliably at the very early stages of fire development and initiate appropriate response measures to prevent losses, damage and ensure business continuity. By providing reliable detection, and simple and cost-effective maintenance, VESDA VLF-250 provides optimal protection of railcars.

The detector works by continually drawing air into sampling holes in a pipe network. The air is filtered and passed into a detection chamber where light scattering technology detects the presence of very small amounts of smoke. Detector status information is communicated on the detector display and via relays or optional interface cards.

Out-of-the-box operation

The VLF can be installed and commissioned out-of-the-box without the need for a special interface or software programming tools.

In operation, the unique Smoke Dial™ display provides the user with an instant understanding of a smoke event, even from a distance. Should a fault occur, the user simply opens the field service door and activates the Instant Fault Finder feature to determine the specific fault condition. This information can then be passed onto their fire service company, ensuring that service technicians arrive onsite fully prepared.

Ultrasonic Flow Sensing

The patent-pending Ultrasonic Flow Sensing used in the VLF provides a direct reading of the sampling pipe flow rate. The system is immune to air temperature and pressure changes and is unaffected by contamination. The VLF is the first air sampling smoke detector to use ultrasonic flow sensing.

Features

- Out-of-the-Box Installation and Commissioning
- Ultrasonic Airflow Sensing
- Laser-Based Absolute Smoke Detection
- Pre-engineered pipe network designs
- Programmable Alarm Thresholds
- Clean air barrier optics protection
- Instant Recognition Display
- Instant Fault Finder™
- AutoLearn™ Smoke
- AutoLearn™ Flow
- Field Service Access Door
- Multiple Event Logging in separate logs
- Event log – up to 18000 events
- Offline/online configuration capability
- Up to 250 m^2 (2690 sq. ft.) coverage*

Listings/Approvals

- UL 94V0
- NF F16-101
- DIN 5510-2
- EN 50155
- SIL 2 as per IEC 61508 (2010)
- EN 54-20
  - Class A (12 holes / 0.12% obs/m)
  - Class B (12 holes / 0.35% obs/m)
  - Class C (12 holes / 0.80% obs/m)

  Classification of any configuration is determined using ASPIRE2.

Regional approvals listings and regulatory compliance vary between VESDA product models. Refer to www.xtralis.com for the latest product approvals matrix.

VESDA VLF for Rail Applications

VLF-250

Specifications

Input Power

Voltage:	24V DC Nominal (18-30 V DC)
Current @ 24 VDC:	220 mA nominal, 295 mA in alarm *Note: a DC/DC power converter shall be used to power-up the unit from the railcar power output.* *PSU filter (VSP-725) must be installed on each VLF-250 detector terminal block.*
Dimensions (W x H x D)	256 mm x 183 mm x 92 mm (10 1/16 in x 7 1/5 in x 3 2/3 in)
Weight	Approx. 2 kg (4.4 lbs)
IP Rating	IP30
Mounting	Upright, inverted or horizontal

Operating Conditions

Ambient:	Temperature Class T3 as per EN 50155
Tested to:	-25°C to 70°C (-13F to 158°F)
Sampled Air:	-20°C to 60°C (-4°F to 140°F)
Storage:	-40°C
Humidity:	5% to 95% RH, non-condensing

Sampling Network

Maximum pipe lengths:	1 x 25 m (80 ft) (Max. 12 holes) 2 x 15 m (50 ft) per branch (Max. 6 holes per branch)
Sampling Hole Options:	Pre-Engineered Option or Maximum Pipe length in accordance with Pipe Modelling Design Tool (ASPIRE2™)

Air Inlet Pipe
Accepts both metric and American standard pipe sizes
Metric: 25 mm (1.05 in.) American Pipe: IPS 21 mm (¾ in.). Flexible 21.6 mm (0.85 in.)

Area Coverage
Up to 250 m^2 (2690 sq. ft.) depending on local codes and standards

Relay Outputs
3 changeover relays (Fire 1, Action, Fault), Contacts rated 2A @ 30 VDC (max). NO/NC Contacts

Cable Access
3 x 25 mm (1.05 in.) cable entries (1 rear entry, 2 top entry)

Cable Termination
Screw Terminals 0.2-2.5 mm^2 (30-12 AWG)

Interfaces
Shown in Terminal Block Connections diagram, to right, plus an RS232 Programming Port. General Purpose Input (GPI) interface offers: Reset, Disable, Standby, Alarm set 1, Alarm set 2 and External Input functions.

Alarm Threshold Setting Range

Alert, Action	0.025 - 2.00% obs/m (0.008 - 0.625% obs/ft)
Fire 1, Fire 2	0.025 - 20.00% obs/m (0.008 - 6.25% obs/ft)
Individual Alarm Delays	0 – 60 seconds
Two Alarm Threshold Settings	Either time or GPI based

Display
- 4 Alarm State Indicators
- Smoke Level Indicator
- Reset, Disable and Test Controls
- Fault and Disabled Indicators
- Instant Fault Finder
- Smoke and Flow AutoLearn Controls

Event Log
Up to 18000 events, time and date stamped in separate, non-volatile, logs for:
Smoke Level, Flow Level, Detector Status and Faults

AutoLearn Smoke & Flow
- Automatically set acceptable alarm thresholds for both smoke and flow levels
- Minimum 15 minutes, maximum 15 days (default 14 days)
- During AutoLearn thresholds are NOT changed from pre-set values

Warranty Period
2 years

Ordering Information:

VLF-250-00	VESDA VLF. European language set. English display labels
VLF-250-01	VESDA VLF. European language set. International display labels
VLF-250-02	VESDA VLF. English + Asian language set. International display labels
VLF-250-04	VESDA VLF. English + Russian language set. International display labels
VLF-250-05	VESDA VLF. English + Eastern Euro language set. International display labels
VSP-725	VESDA PSU Filter
VSP-850-R (Red)	In-line Filter
VSP-850-M (Metal)	In-line Filter
VSP-855-20	In-line Filter Elements (pack of 20)
VIC-010	VESDAnet Interface Card
VIC-020	Multifunction Control Card (MCC)
VIC-030	Multifunction Control Card (MCC) with Monitored Powered Output (MPO)
VSP-005	Filter Cartridge, VSP-722 Aspirator for VESDA VLF-250

Display:

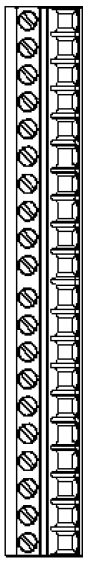
The display provided to the user includes a Smoke Dial™ and alarm and status indicators.

When the field service access door is open, the user has access to the RESET, DISABLE, Fire Test, AutoLearn and Instant Fault Finder functions.
When the Instant Fault Finder function is activated, the Smoke Dial™ converts to a fault indicator, with the dial segment numbers corresponding to the faults listed below.

Legend of fault indicators:

1 Filter	6 External Device/PSU
2 Aspirator	7 Interface card
3 High flow	8 Field wiring
4 Low flow	9 AutoLearn Fail
5 n/a	10 Detector failure

Terminal Block Connections



1	GPI	
2	GPI	
3	Display TX	
4	Display RX	
5	Display Common Ground	
6	Display Power -	
7	Display Power +	
8	Power Return 0 VDC	From power supply unit
9	Power In 24 VDC	
10	Power Return 0 VDC	To next detector (if more than 1 detector per Power Supply Unit)
11	Power Out 24 VDC	
12	NC	
13	Common	Fault relay
14	NO	
15	NC	
16	Common	Action relay
17	NO	
18	NC	
19	Common	Fire 1 relay
20	NO	

Approvals Compliance

Please refer to the Product Guide for details regarding compliant design, installation and commissioning.

UK and Europe +44 1442 242 330 **D-A-CH** +49 431 23284 1 **The Americas** +1 781 740 2223
Middle East +962 6 588 5622 **Australia and New Zealand** +61 3 9936 7000

Doc. no. 29873_02 Part: 30736

B2 Securiton Specification Sheet

Product information

Aspirating smoke detectors from Securiton are among the most reliable early warning systems for fires. The SecuriRAS ASD (aspirating smoke detector) range impresses with its unrivalled performance level. Developed in Switzerland and manufactured in Germany, the detectors are particularly reliable and robust.

SecuriRAS ASD 535/532/531

Aspirating smoke detectors (ASD)

Basic design and function of an aspirating smoke detector
An ASD consists of one or two independent sampling tubes with sampling apertures, and with a highly sensitive smoke sensor in each case. Airflow monitoring ensures that the sampling tubes are constantly checked for pipe breakage and the sampling apertures monitored for soiling. A high-performance fan sucks in air from the room or facility being monitored through the sampling tube into the evaluation unit. There the air is continuously evaluated by the smoke sensors. The display and control panel of the evaluation unit indicates the smoke concentration of the sampled air, as well as other alarm, fault and status messages. Any increase in smoke concentration levels is detected very early on. Pre-signals and one or two main alarms can be programmed, and signalled via potential-free relay contacts or directly to the SecuriLine loop.

Overview of range
The SecuriRAS ASD range consists of three types:

- The ASD 535 in 4 versions (1 or 2 channels, with/without smoke level indicator) is the universal device with outstanding performance characteristics for medium-sized and large monitoring areas. Its ambient temperature range reaches as low as –30°C, making it perfect for deep-freeze warehouses.
- The ASD 532 is the single-channel device for medium-sized monitoring areas. It has the same technical specifications as the ASD 535, but with just one sampling tube and a more compact fan. Configuration, programming, maintenance and networking of the system are the same as for the ASD 535 and just as simple.
- The ASD 531 detector is tailor-made for small monitoring areas and for customers who would like a device that is even easier to use but still want an extensive range of accessories.

Highly sensitive smoke sensor
The SSD 53x smoke sensor was specially developed for the SecuriRAS ASD and is the result of comprehensive research. A high-power LED combined with an LVSC (large-volume smoke chamber) sampling chamber results in unparalleled adjustable sensitivity with low aerodynamic resistance and the utmost resistance to soiling. These features ensure long system service life and durability. The patented lint filter helps suppress one-off disturbances.

PC tools for configuration and for calculating the sampling tube
Sampling tubes for all systems can be accurately calculated, optimised and documented with the VdS-tested ASD PipeFlow PC program. This offers the possibility of asymmetrical and therefore cheaper pipe layouts. ASD Config is the tool for commissioning and maintaining the ASD 535 and 532. The «Config over Line» function means this can be used without additional networking, including from the fire alarm control panel (FACP). And RS 485 networking allows an entire ASD array (ASD 535 and 532) to be be visualised and operated at the same time.

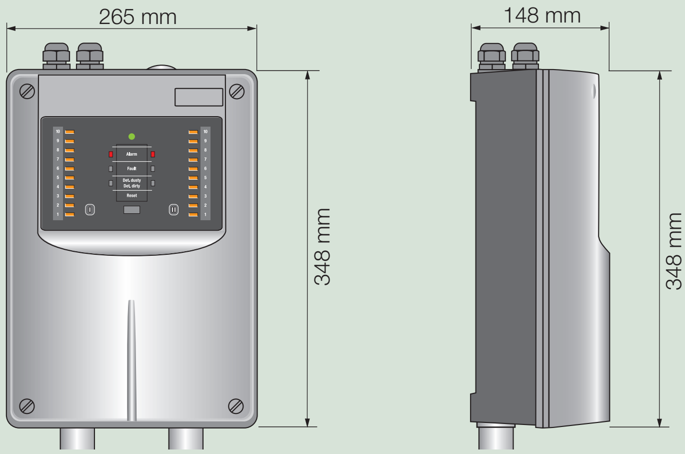
Commissioning
The ASD 535 and 532 can also be commissioned with «Easy Config» – so without a PC. With this method, practically the same functions are available as with the ASD Config PC tool. The ASD 531 also uses a simplified process known as «BasiConfig». This allows somebody to commission an ASD 531 with almost no training. All that is needed is the response grade required, and then it is a case of setting the number of sampling apertures and calibrating airflow measurement. Everything else is taken care of by the detector itself.

Bi-directional integration and Config over Line
All ASDs can be ideally integrated into the SecuriFire fire detection system with the optional SecuriLine XLM 35 interface. It is then no problem to display and operate the day/night sensitivity control, for example, from the fire alarm control panel. Thanks to «Config over Line», the ASD 535 and 532 can even be configured from the FACP.

- Approved according to EN 54-20 classes A, B and C, plus UL and FM
- VdS-tested calculation software ASD PipeFlow allows for an efficient asymmetrical pipe layout
- Sensitivity can be set from 0.002–10 %/m
- Highly sensitive yet robust smoke detection thanks to large-volume smoke chamber (LVSC) with measurement resolution < 0.001 %/m
- Complete integration into the SecuriLine loop including Config over Line
- Insensitive to dirt particles thanks to patented particle suppression
- Automatic soiling compensation and autolearning function
- Low noise level, compliant with ISO 11690-1
- Up to 5 alarm levels per detector (3 pre-signals and 1 or 2 alarms)

SECURITON

SecuriRAS ASD 535



Typical application	**ASD 535**	**ASD 532**	**ASD 531**
Area surveillance			
Warehouses, high-rack storage facilities	●●	●	○
Deep-freeze warehouses, explosion-hazard areas	●●	×	×
Explosion-hazard areas	●●	×	×
Lift shafts	○	●●	●●
Data centres	●●	●●	●
Clean rooms, laboratory and research centres	●●	●●	●●
Dropped ceilings and raised floors	●●	●	●
Cable and energy tunnels	●●	●	●
Transformer rooms	●	●●	○
Archive rooms	●●	●	●
Museums, galleries	●●	●	●
Theatres and cinemas	●●	●	●
Production facilities	●●	●●	○
Recycling plants	●●	●●	○
Rail wagons	●	●●	○
Airports, large halls, underground car parks	●●	●	○
Electronic measurement rooms	●●	●	●
Ventilation ducts	●	●	●●
Invisible applications			
Prisons	●	●●	●
Historical buildings	●●	●	○
Architectural considerations, flush-mounted sampling tubes	●●	●	○
Property surveillance			
EDP racks, telecomms facilities, CNC control systems	●	●●	●●
High- and low-voltage distribution cabinets	●	●●	●●
Display cases	●	●●	●●

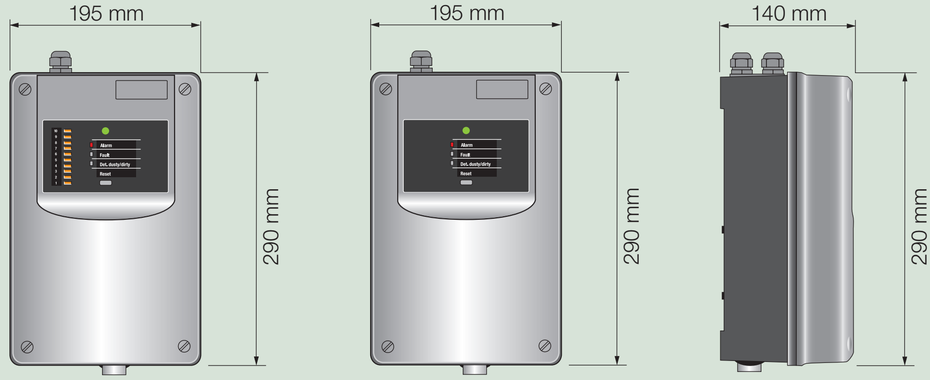
Accessory materials		**ASD 535**	**ASD 532**	**ASD 531**
Sampling tubes		Full range in PVC, ABS, stainless steel, copper with d = 25 mm or ¾" (27 mm)		
Filter box	Small, large	●	●	●
	Extra large	●	●	×
Dust trap box		●	●	●
Capillary sampling points	6/4 mm	●	●	×
Flexible tubes/ducts through ceilings, Water separator		●	●	●
Heated sampling fittings	Deep-freeze warehouses	●	×	×
Detonation flame arrester	For expl.-hazard zones	●	○	×
Connecting flange	For ventilation ducts	●	●	●

●● = very suitable, ● = suitable, ○ = fairly suitable, × = not suitable

ASD 535 aspirating smoke detector range	
ASD 535-1/2	Aspirating smoke detector for 1 or 2 SSD 535 smoke sensors without smoke level indicator
ASD 535-3/4	Aspirating smoke detector for 1 or 2 SSD 535 smoke sensors with smoke level indicator
SSD 535-3	Highly sensitive smoke sensor for ASD 535

ASD 532 aspirating smoke detector range	
ASD 532	Aspirating smoke detector for 1 SSD 532 smoke sensor with smoke level indicator
SSD 532-3	Highly sensitive smoke sensor for ASD 532

SecuriRAS ASD 532/531

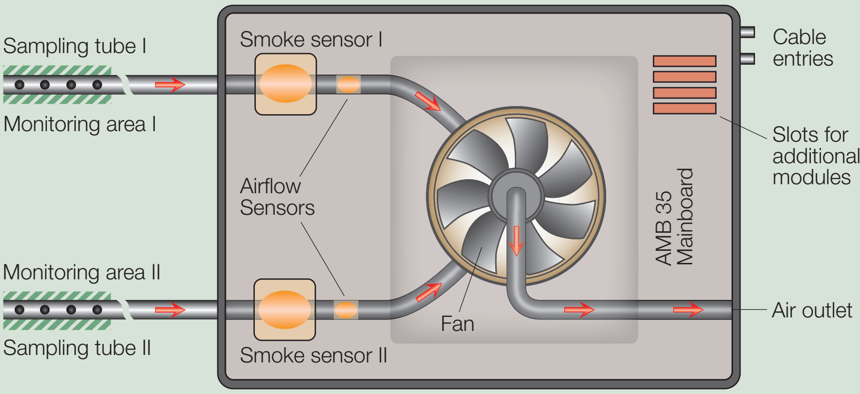


ASD 531 aspirating smoke detector range	
ASD 531	Aspirating smoke detector including 1 integrated highly sensitive smoke sensor SSD 31, without smoke level indicator

Optional modules range	
RIM 35	Optional module with 5 additional relays (ASD 535)
RIM 36	Optional module with 5 additional relays (ASD 531/532)
MCM 35	Optional SD memory card module connection, with card (ASD 535)
SD card	Industrial SD card (ASD 531/532)
XLM 35	Optional module for connection to SecuriLine eXtended
SIM 35/SMM 535	RS 485 networking module/RS 485 master module (ASD 532/535)
UMS 35	Universal module support for mounting line modules
ASD PipeFlow	PC tool for drawing and calculating the sampling pipe
ASD Config	PC tool for commissioning and maintenance (ASD 532/535)

Technical data		**ASD 535**	**ASD 532**	**ASD 531**
Supply voltage range	EN 54	10.5–30 VDC	14.0–30 VDC	14.0–30 VDC
	FM/UL	12.4–27 VDC	16.4–27 VDC	16.4–27 VDC
Power consumption	Typical for 24 VDC	260–290 mA	115 mA	75 mA
Sampling tubes/smoke sensors	Quantity	1 or 2	1	1
Alarm sensitivity	Alarm	0.02–10%/m (0.00087–0.457 dB/m)		0.02–10%/m
	Pre-signal	From 0.002%/m (0.0000869 dB/m)		From 0.006%/m
Alarm levels		5 (3 pre-signals, alarm, alarm 2) adjustable pre-signals 10–90%		4 (3 pre-signals fixed in adv. 30/50/70%)
Autolearning, day/night switching		Configurable	Configurable	Not available
Relays	Quantity 1-channel vers.	3 (1 alarm, 1 fault, 1 free)	2 (1 alarm, 1 fault)	2 (1 alarm, 1 fault)
	2-channel vers.	3 (al. I & al. II, 1 fault)	(use RIM 36 for pre-signals)	
	Contact load	50 VDC/1 A (UL 30 VDC)		
Interfaces	O.C. outputs	See relays	See relays	See relays
	PC tool	USB	Ethernet	–
	Network	RS 485	RS 485, Ethernet	–
	Inputs	Reset, day/night	Reset, day/night	Reset
Connection to SecuriFire FACP	Functions	Alarm, alarm 2, pre-signal 1–3, fault, reset		Alarm, pre-signal 1–3, fault, reset
	Optional module XLM 35	Config over Line, analogue values		
Optional modules	Quantity	4	2	2
	Types	2/1 RIM 35, SIM 35, SLM/XLM 35, MCM 35	2/1 RIM 36 (only RIM 36) XLM 35, SIM 35	RIM 36, XLM 35
Standards/approvals	EN 54-20	VdS G 208 154	VdS G 215 101	VdS G 215 100
	EN 54-27 (ventil. ducts)	Yes	Yes	Yes
	UL 268, FM 3230	Yes, Yes	Yes, Yes	Yes, Yes
	Other	ActivFire, CCCF, ISO 7240-20, GHOST	ActivFire, CCCF, ISO 7240-20, GHOST	ActivFire, CCCF, ISO 7240-20, GHOST
	Compliance	EMC, CPR, RoHS	EMC, CPR, RoHS	EMC, CPR, RoHS
Number of sampling apertures (with ASD PipeFlow)	EN 54-20 Class A	2 × 18	8	6
	EN 54-20 Class B	2 × 56	12	8
	EN 54-20 Class C	2 × 120	16	12
	NFPA 72 (UL/FM)	2 × 120	16	12

Operating principle of an ASD
(example based on ASD 535)



Technical data		**ASD 535**	**ASD 532**	**ASD 531**
Monitoring area	Max. area	5760 m²	1280 m²	720 m²
System limits as per EN 54-20 Class C	Max. quantity Sampling apertures	2 × 120	16	12
	Max. length to last sampling point	2 × 110 m	70 m	40 m
	Max. overall length for all sampling tubes	2 × 300 m	120 m	75 m
System limits without conformity to standards	Max. overall length for all sampling tubes	2 × 400 m	120 m	75 m
Configuration	Close operation PC tool	EasyConfig ASD Config	EasyConfig ASD Config	BasiConfig –
Calculation of sampling tubes for all three types of aspirating smoke detectors	ASD PipeFlow	• Full support for all product versions • Asymmetrical configurations • Genuine simulation, no table values		
Fan/sampling system	Suction pressure	> 400 Pa	> 100 Pa	> 30 Pa
	Service life (MTTF)	> 65,000 h (at 40 °C)	> 80,000 h (at 40 °C)	> 80,000 h (at 40 °C)
	Performance levels	5	3	1
	Noise level (1 m distance)	34 dB (A) (fan level 1)	25 dB (A) (fan level 1)	25 dB (A)
	Soundproof housing	< 20 dB (A)	< 20 dB (A)	< 20 dB (A)
Airflow monitoring	As per EN 54-20	1 air flow sensor p/ch. (therm. anemometer)	1 air flow sensor (therm. anemometer)	1 air flow sensor (therm. anemometer)
Housing	EN 60529 prot. category	IP 54	IP 54	IP 54
	Dimensions (W × H × D)	265 × 348 × 148 mm	195 × 290 × 140 mm	195 × 290 × 140 mm
	Cover, grey	RAL 280 70 05	RAL 280 70 05	RAL 280 70 05
	Base, anthracite violet	RAL 300 20 05	RAL 300 20 05	RAL 300 20 05
	Material	ABS blend, UL 94-V0	ABS blend, UL 94-V0	ABS blend, UL 94-V0
	Weight (approx.)	3850 g	1950 g	1950 g
	Cable entries	4 × M20, 1 × M25	3 × M20, 1 × M25	3 × M20, 1 × M25
Packaging	Cardboard (W × H × D)	437 × 281 × 182 mm	372 × 220 × 172 mm	372 × 220 × 172 mm
Operating temperature/humidity	Evaluation unit	–30 – +60°C/95% RH (amb. air max. +40 °C)	–20 – +60°C/95% RH (amb. air max. +40 °C)	–10 – +55°C/95% RH (amb. air max. 40 °C)
Display and operation	Generally, per channel	1 «power» LED green, 1 red «alarm» LED, 1 yellow «fault» LED, 1 yellow soiling LED, 1 reset key		
	Add. 10 LEDs (yellow) for smoke level indicator	ASD 535-3 and -4 (per channel)	Yes	Not available
Event memory/analogue values	On board	430 events	1000 events	1000 events
	With SD card	Up to 1 year (with MCM 35)	Up to 1 year on-board option	Up to 1 year on-board option
Related documents	Data sheet	T 131 193	T 140 422	T 140 417
	Tech. manual	T 131 192	T 140 421	T 140 416
	Sampling guide	T 131 194	T 131 194	T 131 194

Securiton AG
Alarm and Security Systems
Alpenstrasse 20, 3052 Zollikofen, Switzerland
Tel. +41 31 910 11 22, Fax +41 31 911 25 32
www.securiton.com, info@securiton.com

A company of the Swiss Securitas Group

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