APPENDIX 4

Outline Battery Safety Management Plan

ARC-1264-001-R1

Sunny Oaks Renewable Energy Park and Battery Energy Storage System – Outline Battery Safety Management Plan

Issue 1 – August 2024

Prepared for:

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Executive Summary

This Outline Battery Safety Management Plan (OBSMP) has been prepared in relation to the Sunny Oaks Renewable Energy Park, Isle of Wight (IoW) consisting of a Solar Farm (SF), and Battery Energy Storage System (BESS) and associated infrastructure at land north and south of Whiterails Road, near Wootton Common, IoW. The SF is to the north of Whiterails Road and the BESS compound to the south of Whiterails Road and east of the existing Scottish and Southern Electricity Networks Electrical Substation. The installation in totality is henceforth referred to in this report as the Sunny Oaks site. The Sunny Oaks BESS units will most likely use Lithium Ferrous Phosphate (LFP) chemistry cells.

This OBSMP provides details of the safety management processes and procedures to be implemented to satisfy the prevailing safety requirements for the Sunny Oaks site and BESS system specifically. The safety management approach to be adopted follows:

- The ethos of ‘So Far As Is Reasonably Practicable’ (SFAIRP).
- The Health and Safety Executive (HSE) ’Reducing Risk, Protecting People’ Guidance document.
- The National Fire Chiefs Council (NFCC) Guidance for BESS installations and the associated FM Global Datasheet 5-33.
- The Department for Energy Security and Net Zero Health and Safety Guidance for Electrical Energy Storage Systems.

Whilst the make and model of the BESS units to be employed at the Sunny Oak site has yet to be determined, the selection of the BESS units will require that the design, development, and manufacture by the Original Equipment Manufacturer (OEM), demonstrates that the development and maintenance of high standards, in respect of safety and operational sustainability, can be evidenced. This will be achieved through adherence to internationally acknowledged codes of practice for Lithium-Ion BESS including IEC 62619:2022, UN38.3, UL1973 and UL9540A.

Consultation with the Fire and Rescue Services (FRS) at similar BESS installations has concluded that “*the developer should produce a risk reduction strategy*” incorporating safety measures and risk mitigation in collaboration with the associated Regional FRS and covering the construction, operational and decommissioning phases of the project. This has been conducted for this installation and is detailed in Section 6.0 of this OBSMP. The developer must ensure that the risk of fire is minimised, this may be by way of any or all the following measures:

1. Procuring components and using construction techniques which comply with all relevant legislation.
2. Including automatic fire detection systems in the development design.
3. Including automatic fire suppressions systems in the development design.
4. Including redundancy in the design to provide multiple layers of protection.
5. Designing the development to contain and restrict the spread of fire using fire-resistant materials and adequate separation between elements of the BESS.
6. Developing an emergency response plan with FRS engagement to minimise the impact of an incident during construction, operation, and decommissioning of the facility.

7. Ensuring that the BESS is located away from residential areas. Prevailing wind directions should be factored into the location of the BESS to minimise the impact of a fire involving Lithium-Ion batteries due to the toxic fumes produced.

Abbreviations

ARC	Abbott Risk Consulting Ltd
BESS	Battery Energy Storage System
BMS	Battery Management System
CHG	Charge
DSG	Discharge
ECU	Environmental Conditioning Unit
EM	Electromagnetic
EMC	Electromagnetic Compatibility
ERP	Emergency Response Plan
FDSS	Fire Detection and Suppression System
fph	failures per hour
FRS	Fire and Rescue Service
HF	Hydrogen Fluoride
HIoWFRS	Hampshire and Isle of Wight Fire and Rescue Service
HL	Hazard Log
HSAWA	Health and Safety at Work Act
HSE	Health and Safety Executive
IoW	Isle of Wight
LFP	Lithium Ferrous Phosphate
MW	Mega Watt
NFCC	National Fire Chiefs Council
NMC	Nickel Manganese Cobalt
OBSMP	Outline Battery Safety Management Plan
OEM	Original Equipment Manufacturer
R2P2	Reducing Risk, Protecting People
SF	Solar Farm
SFAIRP	So Far As Is Reasonably Practicable
SOREP	Sunny Oaks Renewable Energy Park Ltd
TR	Thermal Runaway
UK	United Kingdom
US	United States

Contents

1.0 Introduction

This OBSMP has been developed by Abbott Risk Consulting Ltd (ARC) in the role of the Safety Subject Matter Expert. The OBSMP has been prepared on behalf of Sunny Oaks Renewable Energy Park Ltd (SOREP) in relation to the BESS facility at land north and south of Whiterails Road, near Wotton Common, IoW.

This OBSMP has been developed to outline the potential risks presented by the BESS and its operation / maintenance. This OBSMP provides a robust safety strategy, supported by evidence to support full commissioning. The final design and equipment detail is yet to be fully defined and is based on the intended site layout plan and associated details currently available and provided by SOREP at this juncture.

2.0 Background

ARC have conducted the Hazard Identification of the Sunny Oaks site. This analysis has provided the necessary foundation for the identification of hazards and the development of a preliminary Hazard Log [Ref. 1], which contains:

1. Consolidated list of hazards and hazard descriptions.
2. Associated causes driving the hazards with linkage to the relevant hazard(s).
3. Design controls implemented to ameliorate / mitigate the causes.
4. Identification of the potential outcomes or consequence from the hazards.
5. Identification and linkage to mitigating factors that could ameliorate the severity or frequency of occurrence of the outcomes (consequences).
6. Identification of any mitigation that will further ameliorate the probability of hazard or consequence frequencies and be contained in the Emergency Response Plan (ERP).

3.0 Aim

The overall safety aim is that the levels of risk of accident, death or injury to personnel or other parties, and risks to the environment due to the construction, operation and decommissioning are to be broadly acceptable or tolerable and SFAIRP in accordance with the HSE Reducing Risk, Protecting People (R2P2) [Ref. 2]. For the OBSMP specifically, the document presents an initial appraisal of the safety risks including:

- An overview of the main characteristics and the associated design guidelines and legislative and compliance requirements.
- The identification of safety risks (with consideration to proximity and pathways to sensitive receptors).
- The identification of inherent safety features and additional safety recommendations (e.g. emergency response planning) to be secured through the OBSMP at the detailed design stage and ensured by planning condition).
- Determination of the identified safety risks and their significance.

4.0 Scope

The scope of the OBSMP for the Sunny Oaks site and capability covers the physical and functional aspects of the equipment. The safety management covers design, validation, and operation. It also includes any remote monitoring and control, maintenance, storage / transportation, and calibration.

The site is not in an area of flood risk from rivers or the sea or from surface water flooding as identified on the Environment Agencies long term flood risk map[1]. The nearest dwellings to the BESS installation are:

- Benham is c. 270m north of the BESS units.
- Doggy Paddles Retreat is c. 230m northwest.
- Briddlesford Lodge is c. 330m east of the BESS.
- Little Brook Farm is c. 200m southwest of the BESS.

There are no public rights of way affecting the site and the land is a mixture of agricultural Grade 3 and 4.

4.1 Site Access

Access to the SF is from Whiterails Road and access to the BESS facility is from Briddlesford Road. The primary access track to the BESS facility is 4.5m in width, initially running west from Briddleford Road and then north into the BESS compound. The primary access track is constructed using a crushed / compacted stone and capable of withstanding 20 tonne payloads.

[1] A limited proportion of the solar panel area falls within the flood zone 3 (approx. 3% of solar panels).

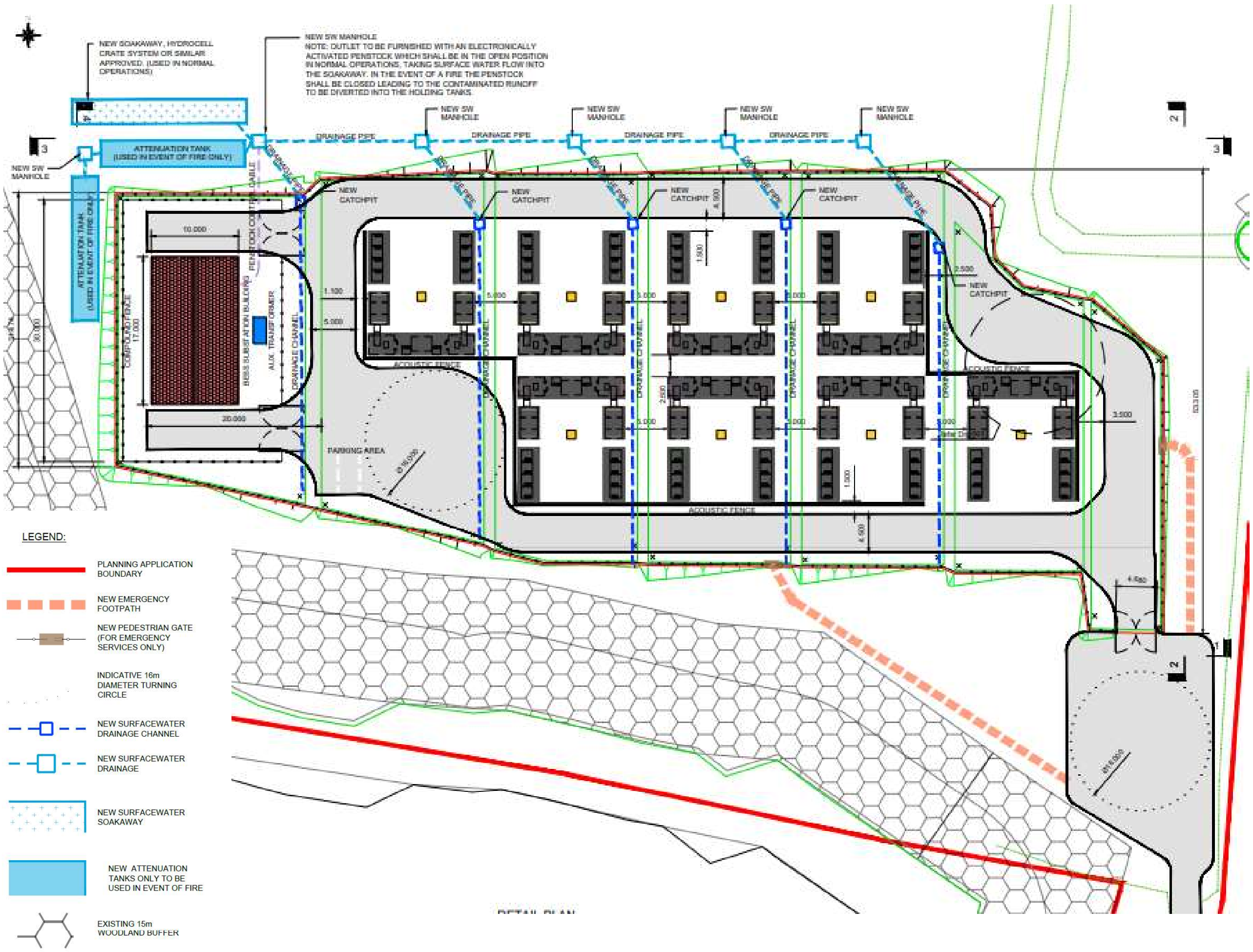


Figure 4-1 Sunny Oaks BESS facility layout

4.2 Frequently Asked Questions

Appendix A of this OBSMP contains frequently asked questions and is provided for assurance and a greater awareness of BESS and Lithium-Ion technologies in general.

5.0 Safety Requirements

5.1 High Level Safety Objective

The primary safety objective is to comply with applicable legal requirements and relevant good practice for large / grid scale BESS. Compliance with these requirements will be used as part of the safety evidence, to demonstrate that '***the risk posed to individuals, the environment and property has been reduced to a level that is SFAIRP'***. The Hazard Log (HL) produced for the Sunny Oaks site is to be used to ensure that all direct and indirect safety requirements are met, and the system remains safety compliant through the life of the installation.

5.2 Legislation and Compliance Requirements

Legislative compliance, specifically safety, will be demonstrated by compliance with the United Kingdom (UK) Health and Safety at Work Act (HSAWA) 1974 and the appropriate underlying legislation that is enacted through the HSAWA. The following legislation and industry guidance has been determined as applicable to this installation:

1. Legislation (England and Wales):
    a. Health and Safety at Work etc. Act 1974 – UKSI1974/0037.
    b. Control of Noise at Work Regulations 2005 – UKSI 2005/1643.
    c. Control of Substances Hazardous to Health Regulations 2002 – UKSI 2002/2677.
    d. Control of Vibration at Work Regulations 2005 – UKSI2005/1093.
    e. Electrical Equipment (Safety) Regulations SI 1994/3260.
    f. Electromagnetic Compatibility Regulations SI 2006/3418.
    g. Fire Safety (Employees' Capabilities) (England) Regulations SI 2010/471.
    h. Lifting Operations and Lifting Equipment Regulations 1998 – UKSI1998/2307.
    i. Management of Health and Safety at Work Regulations 1999 – UKSI1999/3242.
    j. Manual Handling Operations Regulations 1992 – UKSI1992/2793.
    k. Personal Protective Equipment Regulations 2002 – UKSI2002/1144.
    l. Provision and Use of Work Equipment Regulations 1998 – UKSI1998/2306.
    m. Reporting of Injuries, Diseases and Dangerous Occurrences Regulations SI2013/1471.
    n. Supply of Machinery (Safety) Regulations 2008 – UKSI2008/1597.
    o. Workplace (Health, Safety and Welfare) Regulations 1992 – UKSI1992/3004.
    p. Registration, Evaluation, Authorisation & Restriction of Chemicals Regulations – 1907/2006.
    q. Restriction of Hazardous Substances Directive – 2011/65/EU.
    r. Protocol on Persistent Organic Pollutants.
    s. Dangerous Substances and Explosive Substances Regulations 2002.
2. Industry Guidance and Best Practice Documents:
    a. Underwriters Laboratory (UL)1973 – Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail Applications [Ref. 3].
    b. UL9540A – BESS Test Methods [Ref. 4].
    c. UN38.3 – Standard Requirements for Lithium-Ion Battery Production [Ref. 5].
    d. FM Global Property Loss Datasheet 5-33 – Lithium-Ion BESS [Ref. 6].
    e. NFCC Grid Scale BESS planning – Guidance for FRS [Ref. 7].
    f. National Fire Protection Association (NFPA) 885 – Standard for the Installation

of Stationary Energy Storage Systems [Ref. 8].

g. Department for Energy Security and Net Zero – Health and Safety Guidance for Electrical Energy Storage Systems [Ref. 9].

5.3 NFCC Recommendations

The NFCC Report Grid Scale Battery Energy Storage System Planning – Guidance for FRS details the FRS recommendations for BESS installations. These have been distilled at Table 5-1 cognisant of the site layout at Figure 4-1. At the time of the planning submission there was no specific UK regulation regarding fire safety of BESS facilities, however the Department for Energy Security and Net Zero has produced the Health and Safety Guidance for Electrical Energy Storage Systems report. For the BESS units, the NFPA 855:2023 code is the internationally recognised most relevant document and this will be considered in the procurement of the BESS units and ancillary equipment.

5.4 FRS Consultation

The site location falls within the jurisdiction of Hampshire and IoW FRS (HIoWFRS). Consultation with the HIoWFRS took place at the HIoWFRS offices in Eastleigh 14 August 2024 at which the site layout, swept path analysis and drainage was discussed. As a result of this discussion the design was revised with the addition of the elements bulleted below. HIoWFRS have provided written confirmation that these changes meet in principle with the recommendations in the NFCC guidance.

1. A widening of the access road prior to the point of entry to serve as a holding / assembly point.

2. The provision of a pedestrian gate to the east of the site with a commensurate footpath to the gate from the holding point.

3. The provision of a pedestrian gate to the south of the site, approx. 20m to the west of the primary access point, with a commensurate footpath to the gate from the holding point.

Ser	NFCC Recommendation	Status	Comment
1	Access - Minimum of two separate access points to the site	**Compliant with Caveat**	The site has a single point of vehicular access but this splits into two separate directions on entry to the compound, to the north and west. There are also two pedestrian gates in the security fence, on the southern and eastern sides, Fig 4-1 refers, with suitable pedestrian path to the gates, as such providing a secondary means of access if the primary point of access is obstructed. A review of the local metrological data indicates that the prevailing winds are from the south and southwest, as such obscuration of the access into the site is unlikely.
2	Roads/hard standing capable of accommodating fire service vehicles in all weather conditions. As such there should be no extremes of grade	**Compliant**	The proposed primary access tracks serving the sites will be a crushed stone surface 4.5m wide. There is no extreme of grade at the site, there is a slight slope east to west at the BESS facility. Access roads have been subject to vehicle tracking and is considered suitable for FRS vehicles. Swept Path Analysis, see Fig 5-1, has been conducted, using HIoWFRS appliance data applicable to the IoW fleet, and the roads at the site require to withstand site construction vehicle traffic more than 20 tonne gross vehicle weight. All roads will be maintained throughout the life of the site.
3	A perimeter road or roads with passing places suitable for fire service vehicles	**Compliant**	The BESS compound access road is a 4.5m wide hard surface access running around the perimeter the site allowing access to all BESS units, within the compound the access spurs to the substation building and this can be used as holding point, Fig 5-1 refers.
4	Road networks on sites must enable unobstructed access to all areas of the facility	**Compliant with Caveat**	The BESS facility access service roads run around the BESS units and associated infrastructure, thus allowing access to all BESS units. It should be noted that the acoustic fence will prevent direct access to the most southerly BESS units. For example, if the wind is from the south and the ability to direct water onto the fire from the southern part of the perimeter road is impeded by the acoustic fence. The Applicant would be able to fit sliding doors to the acoustic fence to allow unimpeded access to all BESS units from all directions. This can be secured by planning condition.
5	Turning circles, passing places etc. size to be advised by FRS depending on fleet	**Complaint**	The BESS compound access service road allow access to all BESS units and will in most circumstances, direction of plume permitting, allow for FRS vehicles to drive in and drive out without the need to reverse. Liaison and consultation with the FRS have established that these arrangements are satisfactory. The access road prior to entry to the site is widened to form a holding / assembly point for FRS appliances and other emergency vehicles. It is from this holding/ assemble point that the two pedestrian paths to the pedestrian gates emanate. There is the potential to fit sliding doors to the acoustic fence to allow unimpeded access to all BESS units from all directions. This can be secured by planning condition.
6	Distance from BESS units to occupied buildings & site boundaries. Initial min distance of 25m	**Compliant**	There are no occupied buildings within 25m of the BESS compound, the nearest dwellings to the BESS installation are approx. 200m southwest of the BESS, Section 4.0 details nearest dwellings.

Ser	NFCC Recommendation	Status	Comment
7	Access between BESS unit – minimum of 6.0m suggested. If reducing distances, a clear, evidence based, case for the reduction should be shown	**Compliant**	The suggested 6m separation is based on a 2017 Issue of the FM Global Loss and Prevention Datasheet 5- 33 [Ref. 6] (footnote 9 in the NFCC Guidance refers). This datasheet was revised in July 2023 and now details the following: *"For containerised LIB-ESS comprised of LFP cells, provide aisle separation of at least 5 ft (1.5 m) on sides that contain access panels, doors, or deflagration vents".* This separation of 1.5m for LFP BESS is further articulated and supported in the Department of Energy Security and Net Zero document Health and Safety for Electrical Energy Storage Systems [Ref. 9]. The BESS units for the Development will be LFP and the distance between BESS units is 5.0m distance between blocks, with the units being orientated such that no vents are opposite each other, providing compliance against the updated FM Global Specification. Discussion with the HIOWFRS has established that this separation is agreed in principle.
8	Site Conditions – areas within 10m of BESS units should be cleared of combustible vegetation	**Compliant**	Although on a greenfield site the BESS and other installations will be positioned on concrete plinths and the land between impermeable and laid out to a gravel covering. All areas within 10m of the BESS can be cleared of vegetation. This can be secured by planning condition.
9	Water Supplies	**Compliant**	There is main water access at Briddlesford Lodge Farm 230m to the west of the BESS facility. In addition, Ridge Clean Energy intend to install water tanks with a minimum of 228m^3, as directed by NFCC Guidance at the BESS facility, positioned in accordance with NFCC Guidance. This can be secured by planning condition.
10	Signage	**Compliant**	Signage will be positioned at the entrance to the site, including a site layout plan and the contact details of key personnel. Signage indicating the access routes to the two pedestrian gates will be positioned at the holding / assembly point prior to the compound access.
11	Emergency Plans	**Compliant**	An ERP will be developed for the site in conjunction with the HIOWFRS.
12	System design, construction, testing and decommissioning	**Compliant**	Not a requirement at this juncture, details will be contained in the Detailed Battery Safety Management Plan post consent. Compliant at this juncture in the planning process.
13	Deflagration Prevention and venting	**Compliant**	Deflagration venting is possibly most effective when fitted to the roof of the BESS units, as such deflecting blast upwards and away from FRS personnel. Compliant at this juncture in the planning process.

Table 5-1 - NFCC Recommendations Cross-Referenced to the Sunny Oaks Site

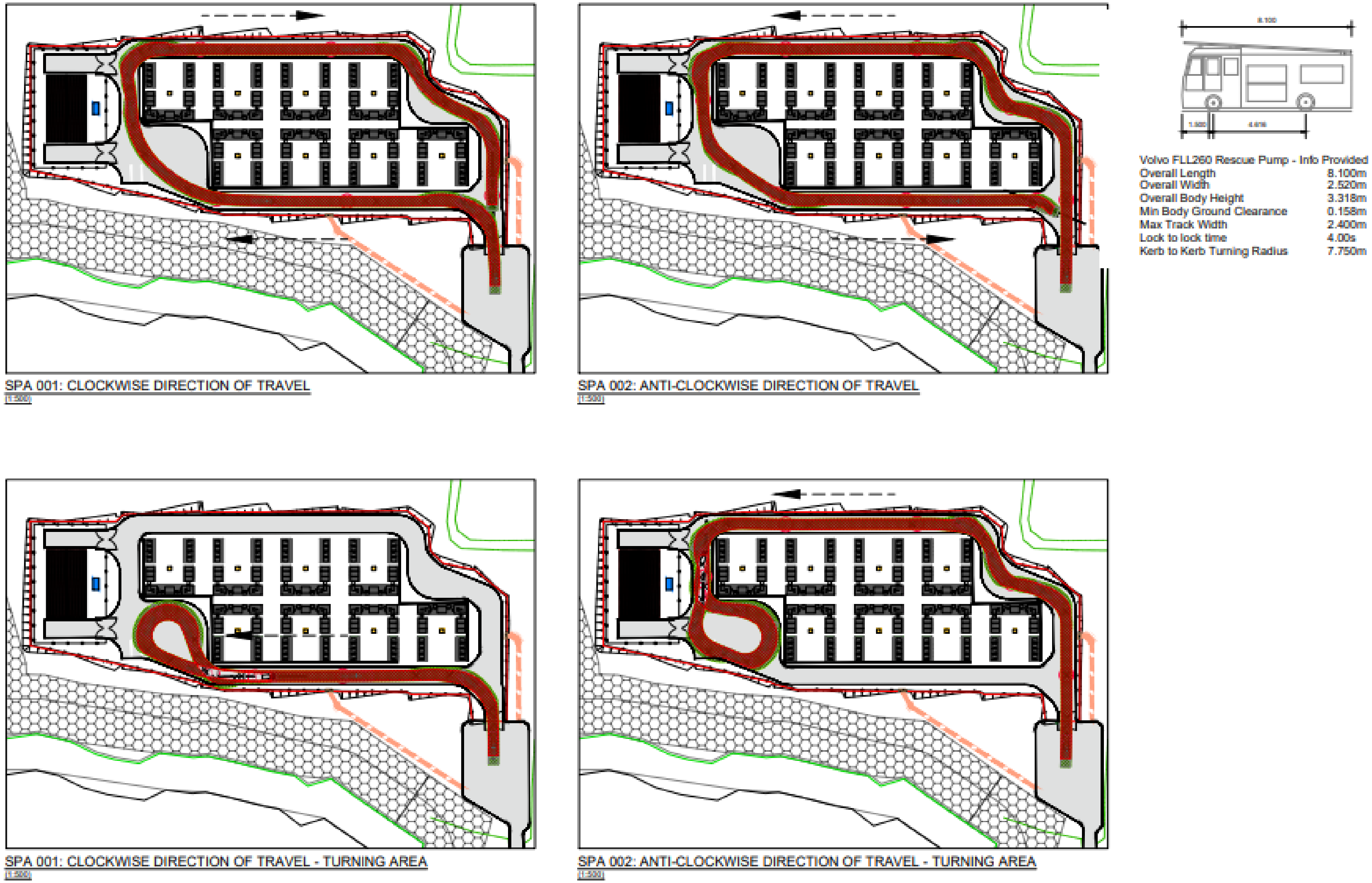


Figure 5-1 Sunny Oaks BESS Swept Path Analysis

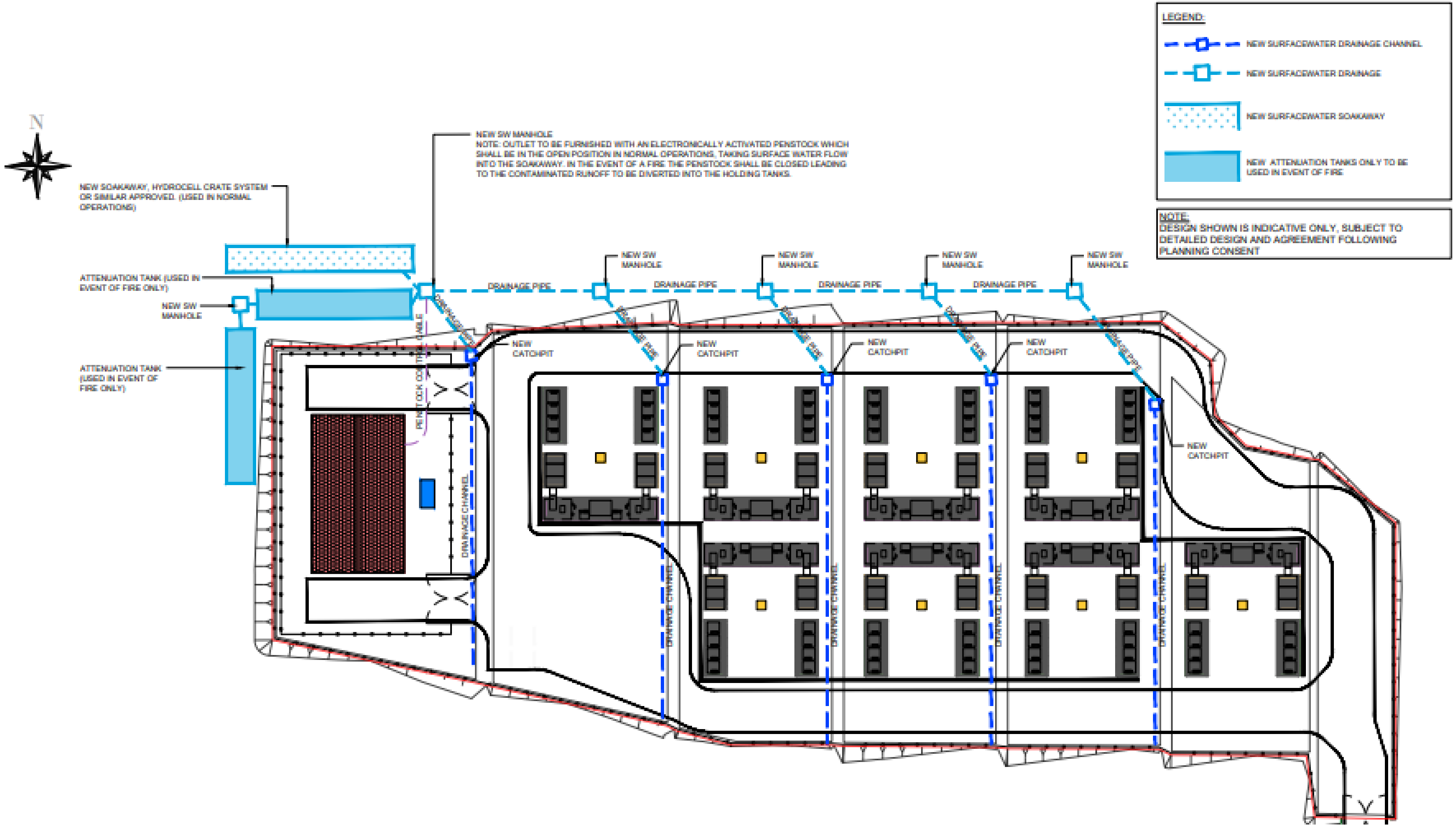


Figure 5-2 Sunny Oaks BESS Drainage Plan

6.0 Implemented Safety Strategy

6.1 Introduction

A safety strategy is required to support the design, development, installation providing the necessary assurance that the safety of the Sunny Oaks site is at an acceptable level for its role in its intended operating environment. The safety strategy employed provides a logically stated and convincingly demonstrated reason that all safety requirements are met. The overarching safety claim has the following elements:

1. A Technical Risk Element:
    a. An element that provides the argument that articulates the technical aspects of the design which serve to control the identified hazards, through the application of design control measures.
    b. It will identify system hazards and the causes that can contribute to these hazards.
    c. It will specify the risk analysis conducted and risk reduction requirements implemented.
    d. It will provide the evidence to support any risk reduction claimed.
2. A Confidence (Assurance) Element:
    a. This part seeks to demonstrate that the processes used to design, implement, and verify the product is appropriate to its contribution to overall system risk – this being specific to the development of software and provide the requisite audit trail to validate any claimed safety integrity.
    b. The development of the HL and identification of imbedded physical attributes that support risk reduction.
    c. The cross-referencing of these physical attributes (and any supporting qualification data / certification) to the relevant cause(s), providing the evidence of validity of the control measure claimed.

6.2 Safety Integrity Level Requirements

The Safety Integrity Level requirements for the BESS units specifically is driven by the functionality implemented in the design solution. The BESS supplier will demonstrate with evidence that a layered protection approach from cell to container to remote monitoring is provided. The envisaged safety control measures and design features within the BESS are detailed in the HL, albeit at this stage generically, tabulated against the appropriate cause that they control. The HL will be revised and supplemented with actual evidence once the BESS units to be employed have been selected.

6.3 Modular Safety Assurance

The construct of the safety assurance in the design of a BESS unit is vested in a ground up approach from cell to battery to rack to fully built BESS, comprising:

1. IEC 62619:2022 which specifies requirements and tests for the safe operation of secondary lithium cells and batteries used in industrial applications, including stationary applications. Safety Management Strategy and Activities.
2. UN38.3 Testing - UN38.3 is the United Nations standard that lithium batteries must meet if they are to be certified as safe to transport. Whilst lithium batteries have safeguards built-in to withstand the environmental and physical hazards they may encounter during transportation, UN38.3 acts as a 'rubber stamp' and shows that batteries are safe to move from one location to another.
3. UL1973 (the Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail Applications). This is the safety standard for energy storage systems. It specifies detailed requirements that manufacturers of BESS must meet to qualify for safety certification. UL1973 certification ensures that the BESS system is safe and reliable for use in real-world conditions. Compliance with UL1973 is necessary to ensure the safety, reliability, and proper functioning of the battery components of a BESS system.
4. UL9540A (BESS Test Method) is the Standard for Safety Test Method for Evaluating Thermal Runaway (TR) Fire Propagation in Battery Energy Storage Systems. There are four stages in the UL9540A test method:
    a. Cell Level Test: Assessing whether a cell can exhibit TR. It also checks its characteristics and flammability.
    b. Module (Battery) Level Test: The objective is to determine if TR propagates with the module. In addition, it establishes the heat release and gas composition.
    c. Rack Level Test: Assessment of the whole unit to establish initially how quickly fire spreads and secondly for the heat and gas release rates and relationship with other emerging hazards.
    d. Installation Level Test: For completeness installation testing is conducted. This is an optional test, but the objective is to determine how effective the product fire protection is.

6.4 Certification

The BESS units to be procured will be designed to meet relevant industry standards and legal requirements which contain specific safety requirements, Section 5.2 refers.

7.0 Safety Management

7.1 Hazardous Material

Any hazardous materials held and stored at the BESS facility will be fully justified and will be detailed in the Sunny Oaks ERP, detailing the location, description, precautions to be adopted and quantity.

7.2 Emergency Response Plan

As part of the initial development, an ERP will be developed, in conjunction with the

HIoWFRS, that outlines how the operator will respond to incident and accident scenarios at the site. This includes the interfaces with external first responder organisations. The ERP is iterative in approach and been developed in parallel with technical safety requirements. This ensures that the site design and ERP are properly integrated, and that appropriate information can be provided to first responders to include in their planning activities.

7.3 BESS Hazard Log

The BESS HL [Ref. 1] is currently managed in the form of an excel spreadsheet and is currently generic, detailing the risks most commonly present in a BESS utilising LFP technology. The benefit of using a HL tool is that it provides an auditable record of all decisions made for the assessment of risk for the BESS Project which will be managed through life on a central repository.

7.4 Safety Management Structure

The BESS safety management structure has yet to be fully defined and will be subject to the safety management strategies and procedures that are in place with the successful supplier and installer of the BESS. At this juncture the minimum requirement is for a formal top-down management structure that has the authority and responsibility to ensure safety management and environmental risk is at the forefront of products, procedures, and services.

7.5 Overarching Policy

All BESS development activities shall consider safety and environment as an integrated part of the BESS life cycle and shall be assessed from a safety viewpoint. This safety-focused approach shall span all programme phases. This encourages and develops a safety and environmental culture that spans all levels of the organisation and encompasses all aspects of its working practices. It views safety as a holistic quantity that is owned by the organisation rather than something to be passed by function. This safety culture is supported by training to develop and maintain expertise and awareness for good practice, knowledge of emerging standards and in the understanding of legislation.

7.6 Management Plan

This OBSMP incorporates the management activities relevant to safety. This includes the planning for Quality, Engineering Development and Configuration Management. These are important disciplines that underpin arguments for safety and environment. Further details will be captured within the OBSMP to be secured by planning condition.

7.7 Staff Competence

The BESS safety and environmental management programme shall ensure that all personnel who have any responsibility for a safety or environmental activity are competent to discharge those responsibilities or are adequately supervised/approved by someone with appropriate competencies.

8.0 Conclusions and Recommendations

8.1 Results

The HL [Ref. 1] is the tool used to monitor and manage hazards, causes and controls associated with this site. The HL is used to tabulate the level of residual risk posed by the installation. The Site Safety Audit will determine that the control measures identified are present.

8.2 Conclusions

It is concluded that, as far as reasonably practicable and for the Sunny Oaks site, that currently foreseeable hazards associated with the equipment have been identified, and these are contained in the HL [Ref. 1]. These hazards are actively managed and added to as necessary and will be reported on at each Safety Working Group.

This OBSMP has been developed using existing knowledge of renewable and BESS capability and leans heavily on the subject matter expertise that ARC have in this technological domain. Installation of the BESS in accordance with OEM instructions followed by a period of qualification and testing will provide the supporting evidence. This will also allow for the consolidation of control evidence and enhanced development of mitigation to further reduce the level of risk posed.

8.3 Recommendations

It is recommended that the safety management as defined in this OBSMP, is adhered to throughout the site life to ensure that safety management is developed as the programme progresses and remains valid through the life of the site.

Given the current understanding of the site layout, systems to be employed, and control measures to be implemented it has been determined that residual risk is Class C, Appendix B refers. The Class C hazards all relate to maintainer hazards and represent the worst-case scenario. Periodic review of the HL [Ref. 1] will identify further opportunities to improve these hazards.

Adherence to the recommendations and safety principles through detailed design, installation and operation will be demonstrated through the Operational Safety Audit Report to be approved prior to commercial operation of the site.

Given the above discourse and output of the Site Safety Audit, it will be possible to declare SFAIRP, cognisant of continued implementation of the proposed framework for safety management presented in this OBSMP.

9.0 References

1. Sunny Oaks BESS Hazard Log - ARC-1263-002-R2, Draft A, June 2024.

2. Reducing Risk, Protecting People (HSE Publications) - https://www.hse.gov.uk/risk/theory/r2p2.pdf.

3. UL1973 – Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail Applications.

4. UL9540A – BESS Test Methods.

5. UN38.3 Standard Requirements for Lithium Battery Production - 4th Revision.

6. Factory Mutual Property Loss Prevention Datasheet 5-33 dated Jan 2024 (Interim Revision).

7. NFCC Grid Scale BESS Planning – Guidance for FRS dated Nov 2022.

8. NFPA 855 Standard for the Installation of Stationary Energy Storage Systems dated Aug 2023.

9. Department for Energy Security and Net Zero – Health and Safety Guidance for Electrical Energy Storage Systems. Health and Safety Guidance for Grid Scale Electrical Energy Storage Systems (publishing.service.gov.uk)

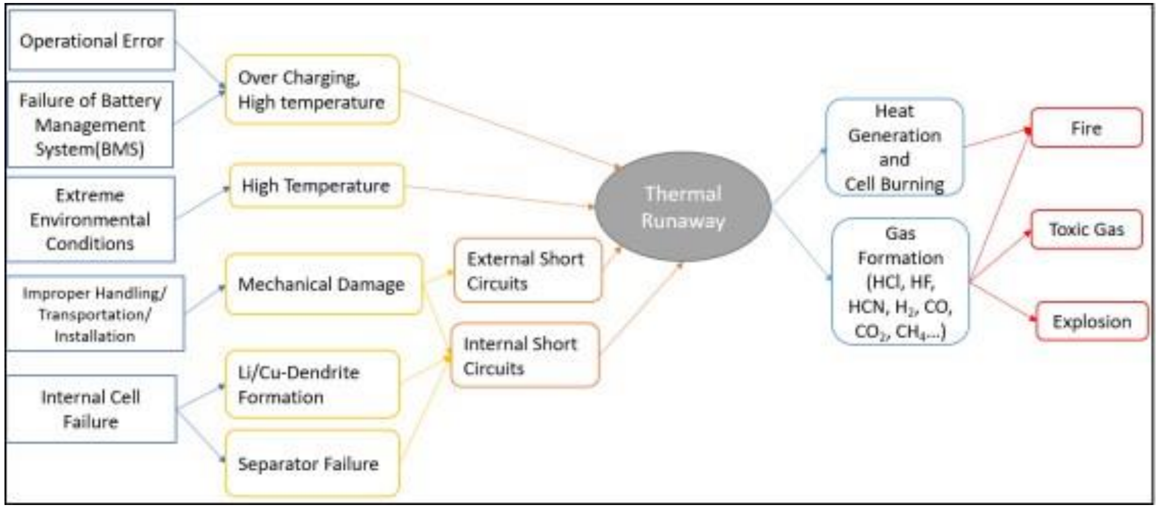
Appendix A – BESS Frequently Asked Questions

Ser	Question	Answer
1	How does a BESS work?	A BESS employs technology to temporarily store electrical energy, very much in the same manner as a mobile phone or laptop battery, but on a much bigger scale. The energy can be stored and released when demand on the National Grid is high and assists in balancing out variations in demand. BESS can be connected to a Photo Voltaic SF and store energy throughout the day for release in the evening and in this mode of operation is a green renewable technology. An alternative use for BESS is to store electrical energy generated by energy suppliers during period of low demand and releasing in periods of high demand, thus balancing out changes in supply and demand on the National Grid.
2	How safe is a BESS?	The Department for Energy Security and Net Zero, promulgates on a regular basis the Renewable Energy Planning Database. From the quarterly extract (dated Jan 2024) the data has been filtered for BESS installations in the United Kingdom (UK) and the following salient points are deduced: 1. As of Jan 2024, there were 75 BESS sites in operation across the UK. 2. The total power capable of being stored is estimated at 87000MW (8.7GW) at these 75 BESS operational sites. 3. Since 2006 BESS have operated for approximately 280,000 days, which is equivalent to 737 years of operation. 4. There has currently been only one reported UK BESS fire that required FRS attendance, this occurred at Carnegie Road, Liverpool in Sept 2020, which employed batteries using Nickel Manganese Cobalt (NMC) chemistry cells – these being more energy dense than LFP. 5. This equates to 2.11E-07 (0.000000211) failures per hour (fph) for BESS fires in the UK – relating this back to the Risk Classification Matrix at Table 6-2 this means the frequency of a BESS fire in the UK in the 'remote' category. 6. To date nobody in the UK has been killed in a BESS incident. BESS are designed to industry specific guidelines and subject to UK legislation
3	Lithium-Ion is sensitive to temperature variations – how is this controlled?	The LFP batteries are housed in a Metal container which is fitted with an ECU. The ECU maintains the temperature and humidity within the container, allowing the Lithium-Ion batteries to operate within the optimum temperature range. The temperature of individual cells in each battery is monitored by the battery management system (BMS) and is reported back to the container level BMS which adjusts the internal temperature in response. Should the ECU develop a fault the container will isolate charge and discharge to the batteries until the fault has been rectified. All faults in the BESS are remotely fed to the Operational Control Room.

<table>
<tr><th>Ser</th><th>Question</th><th>Answer</th></tr>
<tr><td>4</td><td>What is TR?</td><td>
TR is the term used to describe an internal short-circuit in one of the battery cells that can lead to cell over-pressure and the venting of combustible gases. Should this gas ignite then the cell will increase in over-pressure and the resulting fire will be self-sustaining until all the material in the cell is expended. Short circuits in cells are generally a result of:

1. Cell penetration by a foreign object (not usually an issue for a BESS as the batteries are housed in sturdy containers).
2. Impurities in the electrolyte (deposited during the manufacturing process), which over time can lead to the formation of dendrites (electrolytic crystals) which puncture the membrane isolating the anode and cathode – this can, but not always result in a short-circuit and TR. Dendrite formation was a common problem in early NMC battery chemistries but is not prevalent in LFP battery chemistries.
3. Over temperature in the cell because of:
    a. Over-charging (which is controlled by two separate BMS – battery and rack).
    b. High ambient temperature – controlled by the ECU.

The illustration below provides an outline of the possible causes of TR.



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5	How can TR be controlled?	TR is not always inevitable, and the nature of the cell design is such that early warning signs of a stressed cell can be detected by the BMS. Initial signs of cell degradation are an increase in the time it takes the cells to reach full charge (maximum voltage) and a decrease in the time it takes to discharge. These indicators are picked up by the BMS and if persistent the BMS will isolate (prevent charge and discharge) to the battery and inform the centralised control room. In turn an engineer will be dispatched to remove the battery and replace it with a serviceable item. Since the early inception of BESS safeguards in the design have developed and are now details in UL1973 and BESS are assessed against UL9540A. If these indicators are not present, and the cell enters early stages of short-circuit the over-pressure in the cell will result in the venting of off-gas which is detected by the off-gas detectors built into the container heating, Ventilation and Air Conditioning unit (the ECU). This will result in the container disabling the charge and discharge (the act of charging and discharging the batteries generates heat, which is what we want to avoid) and setting the ECU to maximum volume setting. This has a twofold effect, it clears the container of combustible gas and cools the internals, taking the energy out of the cells (the cells used in BESS, like other batteries do not perform well in low temperature conditions). It should be noted that most BESS only operate at between 80-90% of capacity provide an engineering margin that mitigates the probability of over-charging the cells. The UL9540A testing shows that H_2 is the main product during off-gassing in the event of a battery failure. Therefore, it is more relevant to monitor for H_2 rather than CO. This forms part of the explosion prevention strategy in the BESS design in addition to the ventilation system and deflagration vent. The design of the BMS (in accordance with NFPA 855:2023) recommends that the system should provide early detection for the following: • Charging and discharging voltage and current. • Temperature. • Internal ohmic (resistance). • Capacity. • State of charge. • State of health.

Ser	Question	Answer
		• Alarm or fault log. The BMS is designed to provide early detection and warning of an issue prior to TR occurring in a battery. The system is designed to monitor and isolate affected equipment to prevent the TR occurrence. In the worst-case scenario, it will mitigate the probability of a TR event propagating to other battery packs utilising the safety system design and layout of the battery units.
6	How is a BESS fire controlled and suppressed?	If the TR is not controlled and spreads, known as TR Propagation the Fire Detection and Suppression System (FDSS) will activate. There are currently two types of FDSS that are used in BESS: gaseous systems and aerosol systems. Each system has advantages and disadvantages: 1. Aerosol systems are better in terms of extinguishing the fire and benefit against gaseous systems, which generally suppress the fire by reducing the level of oxygen in the container. 2. Gaseous systems are instantaneous in operation, the gas being kept under pressure in bottles. Aerosol, by the nature of the deployment as a fine mist, take a little longer to reach all areas of the container. 3. Aerosol system generally require a more complex and intricate delivery system to reach all areas of the container. 4. Gaseous system requires a sealed environment in which to operate. As such if the container is opened and oxygen reintroduced it can lead to the fire reigniting, as such they require the ECU to close prior to activation (to prevent the ECU from pushing out the extinguishing medium). 5. Various FDSS aerosols (also known as aqueous) and gaseous systems are available, and they use a variety of suppression solutions.

Ser	Question	Answer
7	Can water be used to extinguish a Lithium-Ion fire?	The use of water to extinguish a BESS fire has some drawbacks and disadvantages over bespoke FDSS aerosol mediums, these being: 1. Due to the design of the LFP batteries and racks (in which they are contained), the inability of water to cool the cell interiors may result in reignition of a fire once the water application is halted. 2. The high conductivity of water may cause short circuiting of cells presenting collateral damage risk and increase the spread of the fire internal in the BESS. 3. A high volume of water is required to cool the cells below the critical temperature to prevent TR propagation, this results in a high volume of fire water run-off and a potential environmental impact. 4. The application of water on a BESS fire increases the generation of gases such as CO, H_2 and Hydrogen Fluoride (HF). Applying water causes incomplete combustion of organic substances inside the battery resulting in production of CO rather than CO_2; when water is applied, H_2 is released that, without combustion, can react with phosphorus pentafluoride, if present in free form, to produce gaseous HF. Whilst the NFCC Guidance suggests the utilisation of water suppression systems with BESS units (based on data from 2017), current test data analysis is determining that improvements in battery cell technology and construction and under normal operating conditions, LFP batteries are far more stable than other battery systems. Considering the addition of early detection, warning, and safety systems in the form of Battery Management Systems, gas detection and explosion protection and aerosol suppression, the provision of water suppression systems is not required under NFPA 855:2023. It is noted that water suppression systems can also cause other issues in electrical systems. In addition, test engineers within the BESS field are now considering whether water cooling is causing a negative effect when dealing with TR, as it can prolong the event by slowing down the degradation of the cell electrolytes that fuel the reaction. It is important to note that water suppression does not stop TR occurring. The UL9540A testing also confirms that there is no flaming from the batteries when entering failure mode.

Ser	Question	Answer
8	What are the environmental consequences of a BESS fire?	In the event of a BESS fire several chemicals in gaseous form can be released and the composition and concentration of the plume (also referred to as the vapour cloud). In the event of an LFP fire amongst the general gases released are Carbon Monoxide (CO), HF, Oxygen and Hydrogen. The only UK BESS fire (Carnegie Road, Liverpool – Sept 2020) was monitored and the resultant composition of the plume was determined as being negligible in toxic gas concentration. Should the resulting fire be treated with water in the presence of HF the result can be the formation of a HF acid which can be detrimental to the environment, especially the aquatic habitat. To prevent this, it is possible to contain the fire run-off water but often best, in rural locations, such as Sunny Oaks, to let the fire run its course and burn-out. It is worth noting that the fire run-off water at Carnegie is considered to have been neutralised by the lime-based gravel covering used at the base of the BESS and on testing was found to be a low alkaline level, as opposed to acidic.
9	How is the BESS site secured?	BESS sites are secured through fences / walls and monitored remotely via security cameras. Warning signs along the fence indicates the presence of electrical storage facilities within the site.
10	How is the serviceability of the BESS assured?	The Health and Usage data for each BESS is remoted to the Operational Control Room and the serviceability of each battery determined on an hour-to-hour basis. Given that the batteries have a finite number of cycles over a given period it is envisaged that the batteries will be renewed multiple times in the 40-year life of the site.

Appendix B – Sunny Oaks Hazard Log

Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
Haz_BESS_001	Uncontrolled release of chemical energy - TR	Cse_BESS_001	Internal failure of cell	Ctrl_BESS_001	The cell has been selected and configured such that the loading of the cell does not cause excessive stress. The design of the BESS will be compliant to UL1973, and the BESS has been qualified to UL9540A	Improbable	Improbable	Marginal	D
				Ctrl_BESS_002	The cell will have been tested at the expected stress levels to show no signs of premature venting/failure or excessive voltage drop or temperature rise in accordance with the requirements of UL9540A				
				Ctrl_BESS_003	The battery design spaces cells as far apart as possible to reduce direct heating effect from one cell to another, in accordance with UL1973				
				Ctrl_BESS_004	The cells are certified by an approved 3rd party to meet UN38.3 transport test requirements and IEC62619 Safety Requirements				
		Cse_BESS_003	Over Temperature	Ctrl_BESS_005	The BMS senses the individual battery temperature will isolate the Charge (CHG) and discharge (DSG) of the totality of BESS.	Improbable			
				Ctrl_BESS_006	The BESS is remotely monitored and managed. Allowing the BESS to be electrically isolated from the supply (removing the charge will remove any external stimulus to the batteries).				
		Cse_BESS_004	OC - Excessive Charge Current	Ctrl_BESS_007	BMS Charge Control - The BMS can differentiate recoverable and irrecoverable balance issues, if a single battery was so heavily depleted that it was beyond the specification, the system (as a whole) would be permanently disabled to block all further risks.	Improbable			

Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
				Ctrl_BESS_020	Fail safe: BMS is backed up by an Over Current Protection Fuse				
		Cse_BESS_005	OC - Excessive Discharge (Surge)	Ctrl_BESS_007	BMS Charge Control - The BMS can differentiate recoverable and irrecoverable balance issues, if a single battery was so heavily depleted that it was beyond the specification, the system (as a whole) would be permanently disabled to block all further risks.	Improbable			
				Ctrl_BESS_020	Fail safe: BMS is backed up by an Over Current Protection Fuse				
				Ctrl_BESS_001	Demand on cell stacks is lower than the maximum capability of the cells - Depth of Discharge within bounds and controlled via BMS				
		Cse_BESS_006	Over-Voltage (OV) - Continuous Charge	Ctrl_BESS_001	Demand on cell stacks is lower than the maximum capability of the cells - Depth of Discharge within bounds and controlled via BMS	Improbable			
				Ctrl_BESS_007	BMS Charge Control - The BMS can differentiate recoverable and irrecoverable balance issues, if a single battery was so heavily depleted that it was beyond the specification, the system (as a whole) would be permanently disabled to block all further risks.				
		Cse_BESS_007	Low Temperature Charging	Ctrtl_BESS_021	The BESS is a temperature-controlled environment and as such unlikely to be subject to temperatures below the operating capability of the Li-Ion Cells. In the event of ECU failure (or failure to maintain the temperature parameters, the BESS will inhibit charging)	Improbable			

Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
		Cse_BESS_008	Under-Voltage (UV) - Continuous Discharge	Ctrl_BESS_001	Demand on cell stacks is lower than the maximum capability of the cells - Depth of Discharge within bounds and controlled via BMS				
				Ctrl_BESS_001	Demand on cell stacks is lower than the maximum capability of the cells - Depth of Discharge within bounds and controlled via BMS	Improbable			
				Ctrl_BESS_007	BMS Charge Control - The BMS can differentiate recoverable and irrecoverable balance issues, if a single battery was so heavily depleted that it was beyond the specification, the system (as a whole) would be permanently disabled to prevent further discharge.				
Haz_BESS_002A	Contact with exposed electrical components - HV-3P	Cse_BESS_009	Exposure to electrical source (e.g., contacts, wiring etc.)	Ctrl_BESS_008	Access to the sites is controlled and the access secured. The site is remotely monitored 24/7 with security cameras.	Improbable	Improbable	Critical	D
				Ctrl_BESS_009	Access to the invertors is controlled and the access secured when in operation.	Improbable			
		Cse_BESS_010	Effect of high current pulses (Electro Magnetic (EM)) introduce a conductive path	Ctrl_BESS_010	3P cables are routed in separate cable tray and kept distant from other cables to reduce propensity for current induction	Improbable			
		Cse_BESS_011	Internal short to casing provides conductive path	Ctrl_BESS_011	Inverters will be fully earthed to ground	Improbable			
Haz_BESS_002B	Contact with exposed electrical components - HV-DC	Cse_BESS_009	Exposure to electrical source (e.g., contacts, wiring etc.)	Ctrl_BESS_008	Access to the sites is controlled and the access secured. The site is remotely monitored 24/7 with security cameras.	Improbable	Improbable	Critical	D

Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
				Ctrl_BESS_009	Access to the BESS is controlled and the access secured when in operation.				
		Cse_BESS_010	Effect of high current pulses (EM) introduce a conductive path	Ctrl_BESS_010	BESS sourced will be Electromagnetic Compatibility (EMC) certified to IEC 61000-6-2 and IEC 61000-6-4	Improbable			
		Cse_BESS_011	Internal short to casing provides conductive path	Ctrl_BESS_011	All infrastructure is fully earthed to ground and monitored. All infrastructure is subject to periodic inspection	Improbable			
Haz_BESS_002C	Contact with exposed electrical components - LV-DC	Cse_BESS_009	Exposure to electrical source (e.g. contacts, wiring etc.)	Ctrl_BESS_008	Access to the sites is controlled and the access secured. The site is remotely monitored 24/7 with security cameras	Improbable	Improbable	Critical	D
				Ctrl_BESS_009	Access to the BESS is controlled and the access secured when in operation.				
		Cse_BESS_011	Internal short to casing provides conductive path	Ctrl_BESS_011	BESS units are fully earthed to ground and monitored by the BESS BMS	Improbable			
Haz_BESS_003	Failure of EMC/EMI protection impacts on system functionality	Cse_BESS_012	BESS not EM compatible with environment in which it is located	Ctrl_BESS_012	BESS is located remotely and EMC compatible with all associated site infrastructure	Improbable	Improbable	Marginal	D
Haz_BESS_004	Operator / maintainer exposure to Hazardous substances	Cse_BESS_013	Operator/Maintainer accesses internal components of the BESS	Ctrl_BESS_013	All hazardous substance listed in the OEM documentation. All maintainers provided with the appropriate PPE. A list of hazardous substance held on site is detailed in the ERP	Occasional	Occasional	Marginal	C
Haz_BESS_005	Ingress of water	Cse_BESS_014	Water Ingress into the BESS internals excessive to the degree that it effects the functionality of BESS	Ctrl_BESS_014	BESS is housed in a container and a minimum of IP44 compliant and elevated on concrete plinths	Remote	Remote	Marginal	D
				Ctrl_BESS_015	The BESS design is such that the batteries are off the floor and held in shelving				

Hazard ID	Hazard Description	Cause ID	Causes Summary	Control ID	Control Measures	Cause Prob	Hazard Prob	Worst-Case Severity	Classification
Haz_BESS_006	Maintainers required to access in the internals of BESS	Cse_BESS_013	Operator/Maintainer accesses internal components of the BESS	Ctrl_BESS_017	A Safe System of Work (SSOW) is to be developed and a BESS maintenance course provided to maintainers. All maintainers will require to be qualified and current prior to work on the BESS	Improbable	Improbable	Critical	D
Haz_BESS_007	Maintainer required to lift, move, or carry heavy BESS components (in confined spaces)	Cse_BESS_015	Maintainer required to access and remove/refit heavy BESS components	Ctrl_BESS_017	A SSOW is to be developed and a BESS maintenance course provided to maintainers. All maintainers will require to be qualified and current prior to work on the BESS	Occasional	Occasional	Marginal	C
				Ctrl_BESS_018	MHE to be provided for the movement of components more than 25kg				
Haz_BESS_008	Gases vented during BESS operation (off-nominal) accumulate within enclosure	Cse_BESS_013	Cells stressed through failure of BMS to monitor status correctly	Ctril_BESS_016	BESS are fitted with off-gas sensors that activate ECU on detection of off-gas from cells and concurrently notify the 24/7 Remote Monitoring Facility for additional action	Improbable	Improbable	Critical	D
			Operator/Maintainer accesses internal components of the BESS	Ctrl_BESS_017	A SSOW is to be developed and a BESS maintenance course provided to maintainers. All maintainers will require to be qualified and current prior to work on the BESS	Improbable			
Haz_BESS_009	Operation / maintenance of the BESS exposes the user to sharp edges and hard surfaces	Cse_BESS_013	Operator/Maintainer accesses internal components of the BESS	Ctrl_BESS_017	A SSOW is to be developed and a BESS maintenance course provided to maintainers. All maintainers will require to be qualified and current prior to work on the BESS	Occasional	Occasional	Marginal	C
				Ctrl_BESS_019	All sharp edges to be radiused or covered to ameliorate				
Haz_BESS_010	Operator / Maintainer exposure to biological growth in the BESS	Cse_BESS_013	Operator/Maintainer accesses internal components of the BESS (after a prolonged period of use)	Ctrl_BESS_017	A SSOW is to be developed and a BESS maintenance course provided to maintainers. All maintainers will require to be qualified and current prior to work on the BESS	Improbable	Improbable	Negligible	D