SUNNICA ENERGY FARM

EN010106

Volume 7

7.6 Outline Battery Fire Safety Management Plan

APFP Regulation 5(2)(q)

Planning Act 2008

Infrastructure Planning (Examination Procedure) Rules 2010

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Planning Act 2008

Infrastructure Planning
(Examination Procedure) Rules 2010

Sunnica Energy Farm

7.6 Outline Battery Fire Safety Management Plan

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1 Technical Terms and Definitions

1.1.1 The following technical terms and definitions have been used in the document and will form the basis of understanding.

Table 1: Technical Terms and Definitions

Term	Definition
Battery System	Refers to the components inside the BESS container (cells, modules, electronic boards, cables, etc.).
BESS	Battery Energy Storage System.
BMS	Battery Management System
Cell	Refers to the Li-ion unit that provides a source of electrical energy by direct conversion of chemical energy.
CFRS	Cambridge Fire and Rescue Service.
BESS Container	Refers to the enclosed structure surrounding the BESS.
DNV GL	Det Norske Veritas Germanischer Lloyd (DNV GL) is a technical consultancy.
Electronic Boards	Refers to the electronic boards implemented in the battery system.
EMC	Electromagnetic Compatibility.
EMS	Energy Management System
Fire Suppression System	Active fire protection system placed inside the battery container.
FM Global	Factory Mutual (FM) Global is an American mutual insurance company specialising in loss prevention for large corporations in the Highly Protected Risk property insurance market sector.
FPA	The Fire Protection Association (FPA) is the UK's national fire safety organisation who work to identify the dangers of fire and help their clients reduce fire-related risks.
Heating and Cooling System	System which regulates temperature and humidity within the BESS container. Commonly referred to as HVAC.
HSE	Health and Safety Executive (HSE) is a UK government agency responsible for the encouragement, regulation and enforcement of workplace health, safety and welfare including research into occupational risks.
IEC	International Electrotechnical Commission. Key BESS safety standards are IEC 62619, IEC 63933, IEC 63056, IEC TC 120.
IEEE	Institute of Electrical & Electronics Engineers. Key BESS safety standards are IEEE 1679.1, IEEE 1815, IEEE 2686, IEEE 2688, IEEE 2962, IEEE 3189.
Module	Compact module that integrates several Li-ion cells. Set of connected battery cells integrated in a battery housing.
NFCC	National Fire Chiefs Council, representative body for the UK Fire & Rescue Service
NFPA	The National Fire Protection Association (NFPA) is an international non-profit organisation devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards. Key BESS codes and standards are NFPA 855, NFPA 68, and NFPA 69.
Off-Gassing	The event in which the battery cell emits volatile organic compounds (VOC) signalling electrolyte breakdown as a precursor to thermal runaway.
Rack	Unit for housing multiple modules connected in series, can include their management system (BMS).

Term	Definition
RiscAuthority	RiscAuthority is a research scheme supported by a significant group of UK insurers that conducts research in support of the development and dissemination of best practice on the protection of property and business.
Scheme	A nationally significant infrastructure project comprising a ground mounted solar photovoltaic generating station with a gross electrical capacity of over 50 megawatts and associated development. The details of the Scheme are described in **Chapter 3** of the Environmental Statement **[EN010106/APP/6.1]** and Schedule 1 of the draft DCO submitted with the Application. The Scheme will be known as "Sunnica Energy Farm".
SFRS	Suffolk Fire and Rescue Services.
SRF	Suffolk Resilience Forum
UL	UL Solutions is a global safety science company. Key BESS safety standards and testing include UL 1642, UL 1741, UL 1973, UL 9540, UL 9540A.

2 Scheme Description

2.1.1 This report presents an Outline Battery Fire Safety Management Plan for the Scheme, a renewable energy project proposed by Sunnica Limited (Applicant). Since submission of the original plan in November 2021, the document has subsequently been peer reviewed and updated by Paul Gregory, a battery safety and testing consultant with significant experience of large-scale battery abuse testing and suppression system testing, specialising in battery energy storage system (BESS) validation testing, compliance, and certification, see Appendix C for further details of experience.

2.1.2 Electricity will be generated and stored at Sunnica East Sites A and B and Sunnica West Site A across Cambridgeshire and Suffolk for distribution to the Burwell National Grid Substation via underground cables.

2.1.3 BESS compounds will be located on Sunnica East Sites A and B and Sunnica West Site A.

2.2 Sunnica East Site A BESS Compound

2.2.1 The landscape features surrounding Sunnica East Site A BESS compound consist of agricultural fields interspersed with individual trees, hedgerow, linear tree belts, farm access tracks, and local transport roads.

2.2.2 The area immediately surrounding the BESS compound comprises several small rural villages, including Isleham approximately 1km to the north-west and West Row approximately 1km to the north. There is also a farm located approximately 250m west of the BESS compound.

2.2.3 The nearest designated site is Chippenham Fen Site of Special Scientific Interest (SSSI) and National Nature Reserve (NNR), which forms part of the Fenland SAC and Chippenham Fen Ramsar, and is located approximately 2.8km to the south of the Sunnica East Site A BESS compound. Breckland SPA is located approximately 4.8km to the east of Sunnica East Site A BESS compound.

2.2.4 Two Scheduled Monuments are located within the village of Isleham. One (Historic Environment Record (HER) Reference 1006871) is known as the 'Lime kilns on east side of High Street' and is located approximately 1.5km to the west of Sunnica East Site A BESS compound. The other (HER Reference 1013278) is known as 'Isleham priory: an alien Benedictine priory 100m west of St Andrew's Church' and is located approximately 1.6km to the north-west of Sunnica East Site A BESS compound.

2.2.5 Sunnica East Site A BESS compound is located within Flood Zone 1[1].

2.2.6 Sunnica East Site A BESS compound is located approximately 4.5km northwest of the A11 and 6km northeast of the A142. SFRS is located approximately 9.5km southwest of the site.

[1] Flood Zone 1 - land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%). *Flood Map for Planning Risk, Environment Agency.*

2.3 Sunnica East Site B BESS Compound

2.3.1 The landscape features surrounding Sunnica East Site B BESS compound consist of agricultural fields interspersed with individual trees, hedgerow, tree belts (linear), small woodland blocks, farm access tracks, and local transport roads.

2.3.2 The area immediately surrounding Sunnica East Site B comprises several small rural villages, including Worlington approximately 1.5km to the north, Red Lodge approximately 1km to the south and Freckenham 1.5km to the west.

2.3.3 The nearest designated site is Red Lodge Heath SSSI, located approximately 750m to the south-east of Sunnica East Site B BESS compound. Chippenham Fen SSSI and NNR, which forms part of the Fenland SAC and Chippenham Fen Ramsar, is located approximately 2.6km to the south-west of Sunnica East Site B BESS compound. Breckland SPA is located approximately 1.4km to the east of Sunnica East Site B BESS compound. Cherry Hill and The Gallops, Barton Mills SSSI is located approximately 1km east of Sunnica East Site B BESS Compound.

2.3.4 A Scheduled Monument (HER Reference 1018097) is located approximately 1.5km to the north-east of Sunnica East Site B BESS compound, known as 'Bowl barrow on Chalk Hill, 380m north-west of Chalkhill Cottages'.

2.3.5 The Sunnica East Site B BESS compound is located within Flood Zone 1.

2.3.6 Sunnica East Site A BESS compound is located approximately 500m west of the A11. SFRS is located approximately 8.6km southwest of the site.

2.4 Sunnica West Site A BESS Compound

2.4.1 The landscape features surrounding Sunnica West Site A BESS compound consists of agricultural fields bound by trees, managed hedgerows, tree shelter belts (linear), small woodland and copses, and farm access tracks.

2.4.2 Newmarket Heath SSSI is located approximately 1.2km to the south of Sunnica West Site A BESS compound, beyond the A14. Chippenham Avenue Fields County Wildlife Site (CWS) is located approximately 400m to the west of Sunnica West Site A BESS compound.

2.4.3 A Scheduled Monument (HER Reference 1015246) is found approximately 100m south of Sunnica West Site A BESS compound. This comprises four separate locations adjoining the A14 known as 'Four bowl barrows north of the A11/A14 junction, part of the Chippenham barrow cemetery'. Other Scheduled Monuments in the vicinity of Sunnica West Site A BESS compound include 'The Rookery bowl barrow, part of the Chippenham barrow cemetery, approximately 250m south of Waterhall Farm' (HER Reference 1015244) and the 'Hilly Plantation bowl barrow, part of the Chippenham barrow cemetery, 500m south-west of Waterhall Farm' (HER Reference 1015245), both within 500m of Sunnica West Site A BESS compound, to the south of the A11.

2.4.4 Chippenham Registered Park and Garden (NHLE 1000615) is located approximately 650m north of Sunnica West Site A BESS compound.

2.4.5 The Sunnica West Site A BESS compound is located within Flood Zone 1.

2.4.6 Sunnica East Site A BESS compound is located approximately 500m north of the A11/A14 Waterhall Interchange. SFRS is located approximately 4km southwest of the site.

2.5 General Arrangement

2.5.1 The Scheme will consist of the following components:

a. Solar photovoltaic (PV) modules installed on mounting structures;

b. Inverters, transformers and switchgear;

c. Onsite cabling (high voltage / low voltage);

d. Battery Energy Storage Systems (BESS's) on Sunnica East Sites A and B and Sunnica West Site A;

e. Onsite Substations on Sunnica East Sites A and B and Sunnica West Site A;

f. Office / warehouse (Sunnica East Sites A and B);

g. Fencing and security measures;

h. Internal access roads and car parking;

i. Landscaping including habitat creation areas; and

j. Construction laydown areas.

2.5.2 While it is known that the BESS's will consist of a compound and battery array, details of the design for the BESS elements, including their power and energy ratings, and their final container dimensions and appearance, are currently in development and will be finalised following receipt of any Development Consent Order. Table 3 outlines the limits of the design parameters for the BESS which will allow flexibility and optimisation of the Scheme moving forward.

2.5.3 The final layout of the BESS compounds will be determined as part of the detailed design process. The final design will partially depend on the type of battery technology chosen and the associated energy density, which influences battery layout. Indicative layout designs for two different technology types currently available on the market for each of the three BESS compounds (Sunnica East Sites A and B and Sunnica West Site A) are presented in Appendix A (Technology Type 1) and Appendix B (Technology Type 2).

2.5.4 For both technology types the indicative layout designs present a form of development that complies with the design parameters outlined in this document in Table 3 below, and the Design Principles outlined in Appendix B of the Design and Access Statement **[APP-312]**. Each layout design presents the following information:

a. Areas of hardstanding;

b. Emergency access routes;

c. Fire team viewing areas;

d. Indicative access points;

e. Fire water drainage bunded lagoon location;

f. Bunded lagoon access road; and

g. Drainage system.

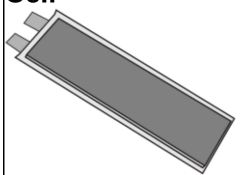
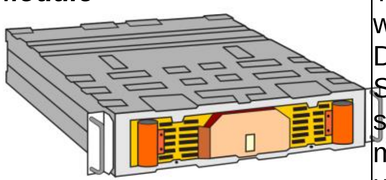
2.5.5 The total AC power (MW) and the total energy (MWh) for the indicative designs, based on a 2-hour system, has been provided in Table 2 below:

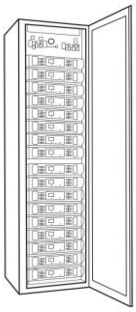
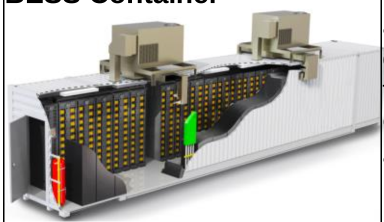
Table 2: Total AC Power (MW) and Total Energy Power (MWh)

BESS Area	Total AC Power (MW)	Total Energy (MWh)
Technology Type 1		
Sunnica East Site A	95	190
Sunnica East Site B	190	380
Sunnica West Site A	245	490
Total	**530**	**1,060**
Technology Type 2		
Sunnica East Site A	93	187
Sunnica East Site B	183	366
Sunnica West Site A	249	498
Total	**525**	**1,051**

2.5.6 As described above, the illustrated design and resulting power and energy output is indicative and the final design will conform with the design principles outlined in this document and the Design Principles outlined in Appendix B of the Design and Access Statement **[AS-312]**.

Table 3: BESS Design Parameters

Work No.	Scheme Component	Applicable Design Principle
2A, 2B, 2C	**Cell**  *Typical Pouch Cell (Ref. 2).*	The batteries selected for use on the Scheme will be from tier 1 manufacturers and will utilise lithium-ion chemistry. Each battery being procured and installed will be fully sealed by design and has no free electrolyte. The lithium-ion batteries will be either NMC (Nickel Manganese Cobalt) or Lithium Iron Phosphate ($LiFePO_4$) chemistry (Ref. 3). The cell will be certified to UL 1642 and / or UL 1973 and undergone UL 9540A testing (4th or 5th edition).
2A, 2B, 2C	***Module***  *Typical Enclosed Module (Ref. 2).*	There are several cells which make up a module. Each cell will have a thermal barrier separating adjacent cells. Dimensions vary between manufacturers. A Liquid Cooling System (LCS) allows for safer and more efficient battery system performance and will be integrated into the BESS module design. The module will be certified to UL 1973 and undergone UL 9540A testing (4th or 5th Edition) to unit or installation level.
2A, 2B, 2C	**Rack**	Modules will be stacked vertically within each rack. The battery modules will contain cells separated by a thermal barrier or an air gap to prevent one cell affecting the temperature of the adjacent one, with the modules

Work No.	Scheme Component	Applicable Design Principle
	 *Typical Rack (Ref. 2).*  *6 MW Leighton Buzzard (Ref. 4).*	themselves also separated from one another by another thermal barrier or an air gap. The rack design will have been tested to unit level UL 9540A or 3rd Party Fire & Explosion rack testing to demonstrate that rack-to-rack thermal runaway propagation does not occur or will propagate in a safe and controlled process that does not result in deflagration events which compromise BESS structural integrity. Battery rack configurations that have not undergone UL 9540A unit level testing will not be considered.
2A, 2B, 2C	**BESS Container**  *Mobile Energy Storage Container (Ref. 5).*  *Breach Farm 10 MW BESS site in Derbyshire (Ref. 6).*	The BESS container will have multiple racks with direct access either from the ends or side of the container depending on the manufacturer. The construction will be in the form of modified 20-foot / 40-foot ISO shipping containers OR factory built modular cabinets / units. The maximum anticipated footprint will be 17 m (L) x 5 m (W) with a maximum height from ground level of 6 m. The BESS container / cabinet design will have completed UL 9540A (4th or 5th Edition) unit or installation testing and / or 3rd party fire & explosion testing which incorporates full scale free burn thermal runaway events. An explosion prevention system to NFPA 69 standards and / or explosion protection system to NFPA 68 and EN 14797 standards will be integrated. If BESS design only integrates explosion protection systems i.e. deflagration panels, then performance must be validated through 3rd party BESS free burn testing and requisite pressure testing required by NFPA and EN standards. Doors will not be used as deflagration vents.

Work No.	Scheme Component	Applicable Design Principle
2A, 2B, 2C	**BESS Compound**  *Fluence Energy 30MW Site in Australia (Ref. 7)*  *Zenobe Energy 29 MW Site in Aylesford, England (Ref. 8)*	There are three centralised areas consisting of BESS containers and battery stations as follows: Sunnica East Site A: 66,000m^2 Sunnica East Site B: 162,000m^2 Sunnica West Site A: 83,000m^2
8A, 8B	**Operational Office / Warehouse Building**	The maximum anticipated size of the Operational Office and Warehouse Building for the different sites are as follows: Sunnica East Site A: 31 m(L) x 13 m(W) x 5 m(H) Sunnica East Site B: 35.5 m(L) x 25 m(W) x 8 m(H)
2A, 2B, 2C	**Indoor or Outdoor Battery Station**	A station comprising transformers, switchgear, power conversion system (PCS) or inverter, and other ancillary equipment. These will either be located outside or housed together in a container, with a maximum height of up to 6m.
3A, 3B, 3C	**Substation (adjacent to BESS)**	Electrical infrastructure consisting of transformers, switchgear, metering equipment and a substation control building or container as follows: Sunnica East Site A: 85 m (L) x 55 m (W) x 10 m (H) Sunnica East Site B: 85 m (L) x 130 m (W) x 10 m (H) Sunnica West Site A: 85 m (L) x 130 m (W) x 10 m (H) The maximum anticipated size of the substation control building or container will be 25 m (L) x 8 m (W) x 7 m (H).
2A, 2B, 2C	**Fire Water Storage Tanks**	Fire water storage tanks dedicated for firefighting operations only. The additional fire water storage tank will ensure availability and resiliency in the event of a single water storage tank not being available in the case of maintenance and / or impairment.

Work No.	Scheme Component	Applicable Design Principle
	 	The amount of water storage required for boundary cooling will be agreed with SFRS, CFRS and SRF at the detailed design stage and will be validated by an independent Fire Protection Engineer appointed by the Applicant who will review all UL 9540A and 3rd party fire & explosion test data.

2.6 The Planning Process

2.6.1 The Scheme is classified as a Nationally Significant Infrastructure Project (NSIP) because its proposed generating capacity is greater than 50 megawatts (MW). NSIP's are major developments which require consent to be granted by the relevant Secretary of State through a Development Consent Order (DCO) under the Planning Act 2008 (PA 2008).

2.6.2 Unlike local planning permissions, which are considered by local authorities, DCO applications are submitted to the Planning Inspectorate (PINS). This independent body administers the application process on behalf of the relevant Secretary of State. In this case, the relevant government department is the Department for Business, Energy & Industrial Strategy (BEIS).

2.6.3 DCO's are governed by a fixed, statutory process which requires consultations with persons with an interest in the land and certain bodies as prescribed under Section 42 of the PA 2008; the local community under Section 47 of the PA 2008; and to publicise the Scheme locally and nationally under Section 48 of the PA 2008 (Ref. 10).

2.6.4 At the time of writing this report, various consultations have been carried out with interested parties. A joint response to the statutory consultation was received from West Suffolk Council, Suffolk County Council, East Cambridgeshire District Council, and Cambridgeshire County Council (Ref. 11). The councils have expressed a concern that the risks associated with battery storage fires have not been fully explored and a request has been made to develop an Outline Battery Fire Safety Management Plan for the BESS and to be included as part of the DCO application for the Scheme. This document addresses that request.

2.6.5 Once the DCO is granted then this Outline Battery Fire Safety Management Plan will be secured through a requirement in Schedule 2 of the DCO. The requirement within the DCO will require a Battery Fire Safety Management Plan to be submitted to and approved by the relevant planning authorities prior to the commencement of the BESS. The Battery Fire Safety Management Plan must be substantially in accordance with the Outline Battery Fire Safety Management Plan, which is this document.

2.7 Building Regulations, Safety Standards and Guidelines

2.7.1 This Outline Battery Fire Safety Management Plan will be kept up-to-date by the Operations and Maintenance company that is awarded the contract for maintaining the Scheme. That company will be contractually required to produce a revised version of the Battery Fire Safety Management Plan, if relevant legislation and/or guidance is introduced that triggers a change to the Battery Fire Safety Management Plan, or if there is a change to the Scheme (development or process) itself.

2.8 Building Regulations

2.8.1 The BESS compounds are considered to be 'Class 2 Buildings not frequently used by people'. This type of Class 2 building is exempt from parts A-K, M, N, Q and P of the Building Regulations. Government guidance suggests that Part L may apply in some circumstances, which is the application of energy efficient requirements. Regulation 21 of the Building Regulations 2010 states that Part L would apply if the structure were considered to be a roofed construction having walls and using energy to condition the indoor climate. If during detailed design the building control department of the relevant local authorities state that Part L of the Building Regulations is applicable then BESS design will meet the requirements.

2.9 Safety Standards

2.9.1 The minimum safety standards proposed by this Outline Battery Fire Safety Management Plan for this Scheme have been divided into group categories shown in Table 4. This list is non-exhaustive and based on experience from other projects of a similar nature for life safety purposes. These safety standards will be confirmed in the final Battery Fire Safety Management Plan, which will be submitted for approval to the relevant planning authorities and will be updated during the project lifecycle.

2.9.2 In addition, the final BFSMP will be in accordance with the new or upcoming standards and codes outlined in section 2.1.6 of the Applicant's Response to BESS Safety Issues Raised During ISH3 **[EP4-044]**.

2.9.3 Sunnica Ltd will publish annual updates (2023 & 2024) to identify new safety codes and standards which will be incorporated into the final BFSMP.

Table 4: Applicable Safety Standards

Group Category	Standard	Year	Description
Electrical Installation	BS 7671	2018	Requirements for electrical installations. Institute of Engineering and Technology (IET) wiring regulations.
Explosion prevention	NFPA 69	2019	Standard on Explosion Prevention Systems
Explosion protection	NFPA 68	2023	Standard on Explosion Protection by Deflagration Venting
	BS EN 14797	2006	Explosion venting devices
	BS EN 54	-	All parts.

Group Category	Standard	Year	Description
Fire Detection and Alarm	BS 5839-1	2017	Fire detection and fire alarm systems for buildings. Code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises.
	BS 6266	2011	Fire protection for electronic equipment installations.
	BS EN 60079-29-3	2014	Part 29-3. Gas detectors. Guidance on functional safety of fixed gas detection systems.
	NFPA 855 2nd Edition IFC 2021	2023 2021	Fire & gas detection equipment appropriate for BESS installations
Firefighting	BS 9990	2015	Non automatic firefighting systems in buildings. Code of practice.
Building Safety	BS 9999	2021	Design, management and use of buildings to achieve acceptable levels of fire safety.
Automatic Fire Protection	BS 5306-0	2020	Fire protection installations and equipment on premises. Guide for selection, use and application of fixed firefighting systems and other types of fire equipment.
	BS EN 12845	2015	Fixed firefighting systems. Automatic sprinkler systems. Design, installation and maintenance.
	BS EN 14972-1	2020	Fixed firefighting system. Water mist Systems. Design, installation, inspection and maintenance.
	UL 9540A – 5th Edition	2023	Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems
	3rd Party Fire & Explosion testing for BESS	2023	Stipulated in NFPA 855 (2023) – to be conducted at installation level to demonstrate that rack-to-rack propagation and deflagrations can be prevented or contained by the BESS containers
Product Safety General	BS EN 62619 UL 1973 3rd Edition	2022 2022	Secondary cells and batteries containing alkaline or other non-acid electrolytes. Safety requirements for secondary lithium cells and batteries, for use in industrial applications. Standard for Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications
	UL 9540 3rd Edition	2023	Standard for Energy Storage Systems and Equipment
Product Safety Inverters	BS EN 62109-1	2010	Safety of power converters for use in photovoltaic power systems. General requirements.
	BS EN 62109-2	2011	Safety of power converters for use in photovoltaic power systems. Particular requirements for inverters.
	BS EN 62477-1	2012	Safety requirements for power electronic converter systems and equipment. General.
	BS EN IEC 62368-1	2020	Audio / video, information and communication technology equipment. Safety requirements.
Product Safety EMC	BS EN IEC 61000-6-1	2019	Electromagnetic compatibility (EMC). Generic standards. Immunity for residential, commercial and light-industrial environments.
	BS EN 61000-6-3	2007	Electromagnetic compatibility (EMC). Generic standards. Emission standard for residential, commercial and light-industrial environments.
Energy Storage Systems	BS EN IEC 62933-1	2018	Electric Energy Storage (EES) systems. Part 1. Vocabulary.

Group Category	Standard	Year	Description
	BS EN IEC 62933-2-1	2018	Electrical Energy Storage (EES) systems. Part 2-1 Unit parameters and testing methods – General specification.
	BS EN IEC 62933-5-2	2023	Electrical Energy Storage (EES) systems. Part 5-2 Safety requirements for grid integrated EES systems. Electrochemical-based systems.
	UL 9540 3rd Edition	2023	Safety standard for an energy storage system and equipment intended for connection to a local utility grid or standalone application.
Transport	BS EN IEC 62281	2019	Safety of primary and secondary lithium cells and batteries during transport.

2.10 Guidelines and Recommendations

2.10.1 The proposed guidelines and recommendations for the Fire Safety of the BESS's on this Scheme have been divided into group categories as shown in Table 5. This list is non-exhaustive and based on experience from other projects of a similar nature for property protection purposes. Furthermore, the requirements listed in the documents below are supplementary and not prescriptive code requirements for the Scheme.

Table 5: Safety Guidance and Recommendation

Group Category	Document No.	Year	Description
Firefighting	-	2007	Water UK National Guidance Document on the Provision of Water for Firefighting.
Product Safety General	RC61 (RiscAuthority)	2014	Recommendations for the storage, handling and use of batteries. Published by the FPA.
	RC62 (RiscAuthority)	2016	Recommendations for fire safety with photovoltaic panel installations. Published by the FPA.
Energy Storage Systems	10209302-HOU-R-01	2020	DNV GL McMicken Battery Energy Storage System Event Technical Analysis and Recommendations.
	OAPUS301WIKO	2017	DNV GL Considerations for ESS Fire Safety
	DNVGL-RP-0043	2017	DNV GL Recommended Practice: Safety, Operation and Performance of Grid-connected Energy Storage Systems
	FM DS 5-33	2020	FM Global Datasheet. Electrical Energy Storage Systems.
	NFPA 855	2023	Standard for the Installation of Stationary Energy Storage Systems.

2.11 Contributors and Consultees

2.11.1 Effective stakeholder engagement and consultation is a key requirement of the PA 2008. The following stakeholders have been identified with the aim of ensuring collective agreement and acceptance of the Outline Battery Fire Safety Management Plan:

a. **Sunnica Ltd** is the developer for the project. It is owned by PS Renewables, a leading Engineering, Procurement and Construction (EPC) company within the UK solar power sector, and Tribus Clean Energy Limited, a solar developer that is currently developing 250 MW of stand-alone BESS in Norfolk as part of a separate scheme.

b. **AECOM** is a multidisciplinary engineering consultancy appointed to advise on the environment and fire safety of this Scheme.

c. **Cambridge Fire and Rescue Service** (CFRS) is the statutory fire and rescue service for the combined authorities of Cambridgeshire and Peterborough. CFRS and SFRS agreed that consultation and engagement will be with the SFRS for the purpose of the Outline Battery Fire Safety Management Plan. CFRS have however been consulted as part of the statutory consultation in relation to the Preliminary Environmental Information Report.

d. **Suffolk Fire and Rescue Service** (SFRS) is the statutory fire and rescue service covering Suffolk. SFRS was consulted as part of the statutory consultation in relation to the Preliminary Environmental Information Report and this Outline Battery Fire Safety Management Plan.

e. **The Health and Safety Executive** (HSE) is a UK government agency responsible for the encouragement, regulation and enforcement of workplace health, safety and welfare, and for research into occupational risks in Great Britain. HSE has been closely studying battery safety for several years, using its bespoke battery testing facility to help customers understand how best to manage the risks faced by many industry sectors during battery manufacture, storage, transport and use. The HSE has been consulted over the Scheme.

f. **Paul Gregory** is an independent BESS expert with significant experience testing and validating lithium ion battery and BESS safety solutions / equipment and has been appointed by the Applicant as a peer reviewer to provide guidance.

3 Purpose and Scope

3.1.1 The scope of this Outline Battery Fire Safety Management Plan covers the life safety, welfare and property protection fire safety requirements of the BESS at Sunnica East Site A, Sunnica East Site B and Sunnica West Site A.

3.1.2 The purpose of the Outline Battery Fire Safety Management Plan is to demonstrate that the location of BESS within the Scheme does not give rise to a significant increase in fire risk and that any risk that does exist can be addressed by ensuring that the Scheme is constructed, operated and decommissioned in accordance with the approved Outline Battery Fire Safety Management Plan. This Outline Battery Fire Safety Management Plan has been developed in collaboration with SFRS. CFRS deferred consultation on the Outline Battery Fire Safety Management Plan to SFRS. Table 6 summarises the statutory consultation response received from West Suffolk Council, East Cambridgeshire District Council, Suffolk County Council and Cambridgeshire County Council, together with the Applicants responses to those items.

3.1.3 Concerns have also been raised by local communities about the fire safety of historical BESS projects. This Outline Battery Fire Safety Management Plan will consider the experience gained from those projects and implement solutions where effective for life safety, welfare and property protection. The Battery Fire Safety Management Plan to be submitted for approval pursuant to requirement 7 of the DCO will require compliance with new UL, IEC, and IEEE BESS codes and standards to ensure that risk mitigation proposals reflect the latest codes and standard, third-party evaluation of protection of BESS electronic controls such as UL's Cybersecurity Certification Standard for Distributed Energy & Inverter-Based Resources (in development) or DNV-RP-0575 is standard practice for BESS system integrators and will be provided at the detailed design stage. Recommendations from the 2023 UK National Fire Chiefs Council Grid Scale BESS Planning Guidance Document will be integrated into the Battery Fire Safety Management Plan where required.

Table 6: Statutory Consultation Requirements

Item	Requirement	Response
1	Procuring components and using construction techniques which comply with all relevant legislation.	Components and construction will comply with relevant legislation and the guidance outlined in Section 3. If any deviation from industry guidance is proposed during the Scheme, agreement with CFRS, SFRS and the ~~HSE~~ NFCC will be obtained prior to implementation and will be validated by an independent Fire Protection Engineer.
2	Developing an emergency response plan with both counties' fire services, to minimise the impact of an incident during construction, operation, and decommissioning of the facility.	This document is the start of that process and it will be further developed as the project progresses. Refer to paragraph 2.7.1 of this document. The Battery Fire Safety Management Plan will include an emergency response plan during the detailed design stage of the Scheme. The emergency response plan will be drafted based on local, national and

Item	Requirement	Response
	The UK National Fire Chiefs Council is producing a BESS guidance document which will cover ERP expectations.	international input and best practice recommendations, including CFRS, SFRS, UK National Fire Chiefs Council, NFPA 855 and Electric Power Research Institute (EPRI).
3	Ensuring 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.	Consideration of the release of toxic gases, including prevailing wind direction, has been undertaken as part of the Major Accidents and Disasters section of **Chapter 16: Other Environmental Topics** of the Environmental Statement **[EN010106/APP/6.1]** and the **Appendix 16D: Unplanned Atmospheric Emissions from Battery Energy Storage Systems (BESS)** of the Environmental Statement **[EN010106/APP/6.2]**. The report entitled 'Unplanned Atmospheric Emissions from Battery Energy Storage Systems (BESS)' **[EN010106/APP/6.2]** provides an overview of the nature of the risk and assesses how local meteorological conditions would dilute emissions between the proposed battery locations and potential sensitive receptors using dispersion modelling. The report concludes that in the unlikely event that a fire were to break out in a single cell or module, it is considered very unlikely given the control measures that the fire would spread to the rest of the BESS. Even should all the systems fail and a large scale fire break out within one of the BESS containers, then the resultant hydrogen fluoride concentration at the closest receptors would be below the level that Public Health England (PHE) has identified as resulting in notable discomfort to members of the general population. However, the Applicant will undertake a detailed consequence modelling exercise at the detailed design stage in order to ensure there are no significant off-site impacts from an unplanned fire. Further to the above, the selected battery system will have completed unit or installation level UL 9540A testing, demonstrating that thermal runaway propagation will not spread between modules or between battery racks and the generation of explosive gases do not threaten container structural integrity. If the BESS system is designed to safely burn out without internal fire suppression systems, UL 9540A heat flux test data will establish safe distances between containers and ESS equipment and additional 3rd Party fire & explosion testing will be required to demonstrate that structural integrity is maintained and toxic gas emissions to the closest receptors are below PHE guidelines. An independent Fire Protection Engineer specialising in BESS will review all UL 9540A test results and any additional fire and explosion test data which has been provided.

Item	Requirement	Response
4	The emergency response plan should include details of the hazards associated with lithium-ion batteries, isolation of electrical sources to enable firefighting activities, measures to extinguish or cool batteries involved in fire, management of toxic or flammable gases, minimise the environmental impact of an incident, containment of fire water runoff, handling and responsibility for disposal of damaged batteries, establishment of regular onsite training exercises.	Details of known hazards are shown in Table 7 to Table 11 for the different phases of the Scheme. Risk Mitigation Methods are outlined in Section 5: • Isolation of electrical sources is covered under section 5 Risk Mitigation Methods RMM 10 and RMM 13. • Measures to extinguish and cool fires is covered under clause 6 Risk Mitigation Methods RMM 18, RMM 19 and RMM 21. • The environmental impact is considered within the Major Accidents and Disaster Assessment of the EIA and reported in the ES. • Methods to minimise the environmental impact and the containment of fire water runoff is covered under section 5 Risk Mitigation Method RMM 15. • Handling and responsibility for disposal of damaged batteries has been added into this Outline Battery Fire Safety Management Plan. • Regular onsite training exercises will be required in the Battery Fire Safety Management Plan.
5	The emergency response plan should be maintained and regularly reviewed by the Applicant and any material changes will be agreed and notified to SFRS, CFRS and SRF.	Refer to item 2 above. The emergency response plan will be maintained and regularly reviewed within the Battery Fire Safety Management Plan. A hard copy will stored at the Sunnica site and digital versions will also be shared with SFRS, CFRS and SRF (Suffolk Resilience Forum).
6	Environmental impact should include the prevention of ground contamination, water course pollution, and the release of toxic gases.	Refer to item 4 above. Minimising environmental impact and containment of fire water runoff is covered under risk mitigation method RMM 15. The environment impacts associated with this has been considered within the **Chapter 9: Flood Risk, Drainage and Water Resources** and **Chapter 16: Other Environmental Topics** of the Environmental Statement **[EN010106/APP/6.1]**.
7	The BESS facilities should be designed to provide automatic fire detection and suppression systems are available, but the Service's preferred system would be a water drenching system as fires involving Lithium-ion batteries have the potential for thermal runaway. Other systems, such as inert gas, would be less effective in preventing reignition.	Automatic fire detection systems will be provided as per risk mitigation methods RMM 17, RMM 18 and RMM 19. A gas fire extinguishing system with enhanced extinguishing agent design concentration was originally proposed which is now upgraded to an automatic water-based system in response to the Fire and Rescue Services' preference. An automatic water mist system will be considered as an alternative option to an automatic sprinkler system, with the final choice to be agreed with the Fire and Rescue Services post-consent at detailed design stage. Water

Item	Requirement	Response
		mist is known to scrub the surrounding air of toxins produced by fire and will provide cooling throughout the BESS container including concealed spaces, such as modules within racks, which a conventional automatic sprinkler system would otherwise find difficult to penetrate with larger water droplets. The choice of automatic suppression (sprinklers or mist) will be agreed with the Fire and Rescue Services and must be capable to operate in conjunction with a gas exhaust system to minimise deflagration risks. The water supply for the automatic sprinkler or water mist system will be integrated into the design of each BESS container and located either internally or externally adjacent to the BESS container. Alternatively, the water supply and pumps will be located centrally in each of Sunnica East Site A, Sunnica East Site B and Sunnica West Site A with underground connections to each BESS container. Further to the above, the BESS fire detection and suppression systems will conform to NFPA 855 (2023) guidelines and the suppression system will be tested to UL 9540A latest standard or significant scale 3rd Party fire & explosion testing. Fire suppression system performance will be benchmarked against free burn testing. An independent Fire Protection Engineer specialising in BESS will review all UL 9540A test results and any additional fire and explosion test data which has been provided and validate the suppression system design. If the BESS system is designed to safely burn out without internal fire suppression systems, UL 9540A heat flux test data will establish safe distances between containers and ESS equipment and additional 3rd Party fire & explosion testing will be required to demonstrate that structural integrity is maintained and toxic gas emissions to the closest receptors are below PHE guidelines. An independent Fire Protection Engineer specialising in BESS will review all UL 9540A test results and any additional 3rd Party fire and explosion test data which has been provided.
8	The BESS facilities should be designed to provide redundancy in the design to provide multiple layers of protection.	The electronic protection for the battery system is provided with multiple layers of redundancy. If battery system faults and abnormalities are detected, the battery module, rack or entire container will be isolated as fail safes and disconnected from grid, as per NFPA 855 (2023) specifications. An explosion prevention system to NFPA 69 standards and / or explosion protection system to NFPA 68 and EN 14797 standards will be integrated. If BESS design only integrates explosion protection systems i.e. deflagration panels, then performance must be validated through BESS free burn testing and requisite pressure testing required by NFPA and EN standards.

Item	Requirement	Response
		An automatic water-based suppression system will also be included unless the BESS system is design to safely burn out. The system will integrate the requirements recommended in NFPA 855 (2023), UK NFCC (2023) and EPRI guidelines (2023).
9	The BESS facilities should be designed to provide design measures to contain and restrict the spread of fire using fire-resistant materials, and adequate separation between elements of the BESS.	Thermal barriers or adequate fire separation will be provided in accordance with legislative code requirements and NFPA 855 (2023) and will be referenced in section 5, Risk Mitigation Method RMM 01. Separation distances will be established with heat flux data provided by UL 9540A testing and / or 3rd Party Fire & Explosion testing. If detailed consequence modelling is used to establish fire separation spacing, modelling will be based upon module or battery rack free burn data.
10	The BESS facilities should be designed to provide adequate thermal barriers between switch gear and batteries.	Thermal barriers are covered under section 5, Risk Mitigation Method RMM 01. Thermal barriers should only be provided as a mitigation solution of last resort. Free burn BESS heat flux test data should demonstrate that distances between BESS and ESS equipment minimise risk of fire spread.
11	The BESS facilities should be designed to provide adequate ventilation or an air conditioning system to control the temperature. Ventilation is important since batteries will continue to generate flammable gas if they are hot. Also, carbon monoxide will be generated until the batteries are completely cooled through to their core.	Heating and cooling of the BESS units is covered under section 5, Risk Mitigation Method RMM 23 where permanent mechanical ventilation will be provided with an air flow monitoring system to prevent concentration of hazardous gases. The BESS ventilation system will comply with IFC 2021 / NFPA 855 (2023) / NFPA 69 guidelines which require the prevention of a dangerous build-up of toxic (50% IDLH) or explosive gases (25% LEL). The gas exhaust / ventilation system must have redundancy and can be separate to any HVAC system providing climate control. Heating and cooling of the battery modules will be provided by an independent liquid cooling system which is separate to any HVAC system providing climate control for the BESS enclosure.
12	The BESS facilities should be designed to provide a very early warning fire detection system, such as aspirating smoke detection.	An aspirating smoke detection system will be provided as set out in section 5, Risk Mitigation Method RMM 19. The BESS fire and gas detection system will comply with NFPA 855 (2023) and NFPA 69, this means that smoke, fire and gas detection equipment will be installed. New BESS multi-sensor equipment in development which measures combinations of air temperature, hydrogen, VOCs, overpressure, shock & vibration, and moisture ingress will also be

Item	Requirement	Response
		considered if fully tested with the BESS design. Gas detection system will have external BESS beacon and audible alert facility.
13	The BESS facilities should be designed to provide carbon monoxide (CO) detection within the BESS containers.	A carbon monoxide detection system will be provided as set out in section 5, Risk Mitigation Method RMM 19. Gas detection system will comply with IFC 2021/ NFPA 855 (2023).
14	The BESS facilities should be designed to install sprinkler protection within BESS containers. The sprinkler system should be designed to adequately contain and extinguish a fire.	A dedicated automatic water-based system will be provided within each BESS container designed to control or fully suppress a fire, without the intervention of the Fire & Rescue Service. If the BESS system is designed to safely burn out to remove the risk of stranded energy in the battery systems, then full scale free burn testing will have been conducted to demonstrate that loss will be safely limited to one container without the intervention of the Fire & Rescue service. The automatic water-based system will have been tested to unit or installation level UL 9540A (latest edition) and will comply with performance criteria. An independent Fire Protection Engineer specialising in BESS will review all UL 9540A test results and any additional fire and explosion test data which has been provided.
15	The BESS facilities should be designed to ensure that sufficient water is available for manual firefighting. An external fire hydrant should be in close proximity of the BESS containers. The water supply should be able to provide a minimum of 1,900 l/min for at least 2 hours. Further hydrants should be strategically located across the development. These should be tested and regularly serviced by the operator.	Sufficient water storage will be provided for all firefighting systems (manual and automatic). Minimum water supply requirement taken from British standard BS 9990 is 1500 l/min flow for 45 minutes. To align the requirement with the UK market, it is proposed to use a flow of 1500 l/min for a duration of 120 minutes. This has been discussed and agreed with SFRS. The amount of water storage required will be agreed with SFRS at detailed design stage and will be validated by an independent Fire Protection Engineer. In terms of fire hydrant provision, due to the remote site location and lack of water supply infrastructure, Approved Document B (Ref. 11) allows for the use of natural water source or the provision of a full holding capacity tank for firefighting operations. Where a natural water supply is used, then the seasonal availability of natural water supplies for each site applicable will be investigated and verified at detailed design stage. Natural water supplies will only be dedicated for use by fire hydrants and no other firefighting systems. If a natural water source is not available on site, a full holding capacity tank will then be used for fire and rescue services to relay water to the incident area and use the fire services own appliances for pumping operations.
16	A safe access route for fire appliances to manoeuvre within the site (including turning circles). An alternative access point	A safe access route and alternative access route will be provided for each of the Sites within the Scheme (details of access are provided in **Chapter 13: Transport and Access** of the

Item	Requirement	Response
	and approach route should be provided and maintained to enable appliances to approach from an up-wind direction. Please note that SFRS requires a minimum carrying capacity for hardstanding for pumping/high reach appliances of 15/26 tonnes, not 12.5 tonnes as detailed in the Building Regulations 2000 Approved Document B, 2006 Edition, due to the specification of our appliances.	Environmental Statement **[EN/010106/APP/6.1]**) and is detailed in clause 6 Risk Mitigation Method RMM 24. Where both access routes are located on the same road into a site, internal roads will be arranged to allow approach from an upwind direction (details of access are provided in **Chapter 13: Transport and Access** of the Environmental Statement **[EN/010106/APP/6.1]**).
17	The risk assessments refer to undesirable outcome to persons being burnt. There is a potential for death because of an explosion or toxic gas release. This outcome should be referenced throughout risk assessment.	Loss of life has been added to the risk assessment matrix where people in proximity are at risk, see Table 7 below. Further, the battery system will have been tested to unit and / or installation level UL 9540A testing and comply with NFPA 69 explosion prevention standards, ensuring that explosive gases are safely vented, and toxic gas releases are minimised. An independent Fire Protection Engineer specialising in BESS will review all UL 9540A test results and any additional fire and explosion test data which has been provided.
18	The impact of the risk mitigation measures on the overall risk rating appear to be over generous.	The overall risk rating of the risk mitigation measures have been reviewed and amended accordingly for this planning stage. The risk mitigation methods will be revised in subsequent stages of design when the project specific design is developed. It is proposed that at detailed design stage, a Hazard Identification Study (HazID) and Hazard and Operability Study (HAZOP) workshop will be arranged with CFRS, SFRS, SRF and the Applicant to identify risks and review/agree risk rating for each hazard. UK NFCC grid scale BESS planning guidelines will be followed and this process will be conducted in advance of submitting the Battery Safety Management Plan for approval.
19	Details of the BESS technology needs to be presented as part of the consultation and not developed post consent. This includes the total storage capacity and locations.	Details of the BESS technology has been provided in Table 3 for each element of the Scheme including cell, module, rack, BESS container and BESS compound. The maximum parameters of the BESS have been provided, which provides a good understanding in terms of the built form. More detailed information of the BESS technology will be provided within the detailed Battery Fire Safety Management Plan as the project develops during detailed design.
20	Management of, and mitigation measures, following a catastrophic failure and inadvertent release of toxic and flammable gases need to be included in the Outline Battery Fire Safety Management Plan. This should include the potential impact on site to staff and responders, off site to	The Battery Fire Safety Management Plan will include an emergency response plan. The emergency response plan will be drafted based on local, national and international input and best practice recommendations, including CFRS, SFRS, UK National Fire Chiefs Council, NFPA 855 and Electric Power Research Institute (EPRI).

Item	Requirement	Response
	surrounding community, and environmental impact. These should form part of the risk assessment and detail the measures included in the risk mitigation measures to reduce the impact and risk.	Further, the battery system will have been tested to unit and / or installation level UL 9540A testing and comply with NFPA 69 explosion prevention standards, ensuring that explosive gases are safely vented, and toxic gas releases are minimised. An independent Fire Protection Engineer specialising in BESS will review all UL 9540A test results and any additional fire and explosion test data which has been provided.
21	The Service would want the Applicant to observe the minimum of 6m separation between containers rather than the provision of 1-hour fire separation. This is due to the potential for thermal runaway that could last for several hours rendering the effectiveness of the barriers insufficient.	6m separation will be observed unless UL 9540A unit or installation level testing and / or 3rd Party Fire & Explosion testing has demonstrated through heat flux data that distances can be reduced. Separation specifications must be in accordance with legislative code requirements available at detailed design stage and are referenced in section 6, risk mitigation method RMM 01. This will be provided within the detailed Battery Fire Safety Management Plan. Test data and separation distances will be assessed by an independent Fire Protection Engineer. This approach has been agreed with SFRS.
22	The manufacturing, transporting, storing, installation and maintenance should be independently quality assured to ensure the highest standards are maintained.	Quality assurance will be to UK industry standards for all stages of the project in sections 4.3 to 4.8. Manufacturing, transportation and maintenance operations will be audited by an independent third party. Factory Acceptance Tests and Site Acceptance Tests will be conducted and certified to IEC 62933-5-2.
23	The Service continues to support the installation of a water drenching system rather than a gaseous suppression system. Thermal runaway is most effectively minimised and contained using water rather than an inert gas system.	Refer to item 7. Aerosol or Gaseous Suppression systems will not be considered.
24	The provision of a dry pipe system, for the use by the Fire Service, to support an inert gas system would not be sufficient to prevent thermal runaway, due to the time delay for sufficient resources to arrive on site and set up operations. A dry pipe connected to the sprinkler system would enable the Service to augment the supply. Any sprinkler augmentation dry pipe needs to be accessible without placing personnel at risk.	This proposal is no longer applicable. Refer to item 7 for the current proposal.
25	The design of the containers to provide a sump for contaminated water removal is not sufficient to mitigate against the environmental impact of a significant fire in a container. The body of the container may become breached due to fire, explosion of excessive heat build-up. No details of	Currently the design options for containment are either: • Sump on each BESS container, OR • External floor surface surrounding each BESS container, which will be impermeable.

Item	Requirement	Response
	how the Applicant would remove contaminated water from the site during firefighting operations has been provided.	The current proposal in this Outline Battery Fire Safety Management Plan combines both of the above options as one solution to provide resiliency and an extra layer of protection should the BESS container be breached from explosion or excessive heat build-up. The BESS area will be lined with an impermeable membrane. The drainage strategy will include for bunded holding lagoons within the BESS area which will contain the fire water runoff. This will be tested following the fire and if contaminated will be tankered offsite to a suitable waste facility for treatment. The approach has been discussed and agreed with the Environment Agency.
26	The provision of water to support operations for 45 minutes would be insufficient to contain and extinguish a fire if the installation experienced thermal runaway. In addition of water for firefighting, water would also be required to create a thermal barrier to prevent radiated heat transfer to adjacent structures and containers.	The most onerous design requirement for the water supply for either of the automatic sprinkler or automatic water mist system options will apply. For the option of the automatic water suppression system, it is proposed a water supply duration of at least 60 minutes will apply unless a specific fire test protocol indicates that a lower or higher water supply duration is proven to extinguish a fire. For the option of the automatic sprinkler system, a water supply duration of at least 45 minutes will apply based on FM Global fire testing for the protection of Energy Battery Storage Systems. As stipulated in Item 15 the firefighting water flow of 1500 l/min for a duration of 120 minutes shall be sufficient to prevent radiant heat transfer between BESS containers. An independent Fire Protection Engineer will review firefighting water requirements at the detailed design stage. Water releasing coatings could be applied to the exterior of BESS containers to reduce the threat of radiant heat transfer. External sprinkler systems for BESS containers are another potential solution to reduce any requirement for FRS intervention.
27	The Service has previously recommended the following Ensure that sufficient water is available for manual firefighting. An external fire hydrant should be in close proximity of the BESS containers. The water supply should be able to provide a minimum of 1,900 l/min for at least 2 hours. Further hydrants should be strategically located across the Scheme. These should be tested and regularly serviced by the operator.	Refer to item 15.

Item	Requirement	Response
28	This capacity is in addition to the provision of water to support the drencher system when operating.	The total water supply provision will be sufficient for the operation of all firefighting systems (manual and automatic), the required volume will be verified by an independent Fire Protection Engineer.
29	The design should ensure that following the activation of the detection system the container is isolated and batteries discharged to ensure the safety of responding personnel.	If battery abuse is detected, all battery racks and modules within the affected container will be isolated automatically depending on failsafe. Battery discharge is not possible once isolated.
30	The Service will need confirmation that the affected container has been isolated from the system and no residue charge remains within the batteries or structure. This should be in writing from a suitably qualified person before firefighting measures can commence.	In the event of an incident at a container there will be the ability to isolate that container on site, but remote to the container itself ensuring that first/second responders and site staff are protected. Once isolation has taken place there will be a requirement for first/second responders to analyse the system data which will be available from the onsite control room, or mobile digital devices as per NFPA 855 (2023) guidelines. This will explain the status of the container. In some circumstances it will be necessary to discharge the batteries to enable the first/second responders to deal with the incident. This capability could be potentially achieved through the onsite control room or from a remote facility (24/7). The precise methodology in this regard will be agreed in the Emergency Response Plan once the detailed design of the BESS is known. This will be prepared in conjunction with the relevant fire services and is secured through this document.
31	The production of a fire service site specific risk assessment should be developed during construction and operation of the facility. This should include regular familiarisation visits for local operational personnel and periodic training.	A fire services site specific risk assessment will be added to the final Battery Fire Safety Management Plan at later stages of design; the details of the risk assessment will be implemented during construction and operation of the Scheme. In addition to the above, an emergency response plan (ERP) will be drafted based on local, national and international input and best practice recommendations, including CFRS, SFRS, SRF, UK National Fire Chiefs Council, NFPA 855 and Electric Power Research Institute (EPRI).

4 Risk Management and Risk Assessment

4.1.1 In accordance with NFCC guidelines a Risk Management Plan will be developed by the operator, which provides advice in relation to potential emergency response implications including:

a. The hazards and risks at and to the facility and their proposed management.

b. Any safety issues for firefighters responding to emergencies at the facility.

c. Safe access to and within the facility for emergency vehicles and responders, including to key site infrastructure and fire protection systems.

d. The adequacy of proposed fire detection and suppression systems (eg., water supply) on-site.

e. Natural and built infrastructure and on-site processes that may impact or delay effective emergency response.

4.2 General

4.2.1 This section details the proposed methods used to mitigate the potential risk of a fire event leading to the spread of heat and uncontrolled fire with associated emissions through the Scheme lifecycle.

4.2.2 The Scheme will minimise fire risk using safety features that are becoming well-established within the industry, and these features will be applied throughout the Scheme lifecycle. Many of the features focus on the cell level fire hazards. Regardless of the size, the safety of Li-ion batteries is intrinsically related with the safety at the cell level where several phenomena can occur at cell level, such as chemical imbalance or internal short-circuit, resulting in failures.

4.2.3 In order to mitigate these risks, the following steps have been taken from the STABALID project (Ref. 12) and adapted to suit the Scheme to address life safety, welfare and property protection requirements:

a. Risk Identification - Identification of the risks that may appear in each stage of the battery life cycle.

b. Risk Evaluation - Qualitative evaluation of the risks that may appear in each stage of the battery life cycle.

c. Mitigation Measures - Safety measures to mitigate the risks identified.

d. Risk Re-evaluation - Qualitative evaluation of the risks that may appear in each stage of the battery life cycle because of the mitigation measures being implemented.

4.2.4 Further detail regarding these steps are presented in Sections 4.3 to 5.

4.2.5 The first stage of the risk analysis is the identification of all the fire hazards that may arise during the life cycle of the battery (Ref. 12). After analysing all the hazards (orange shapes), they were separated into five main categories (blue shapes), as shown in Figure 1.

4.2.6 In the next (risk evaluation) step of the risk control process, this Outline Battery Fire Safety Management Plan considers the fire events further.

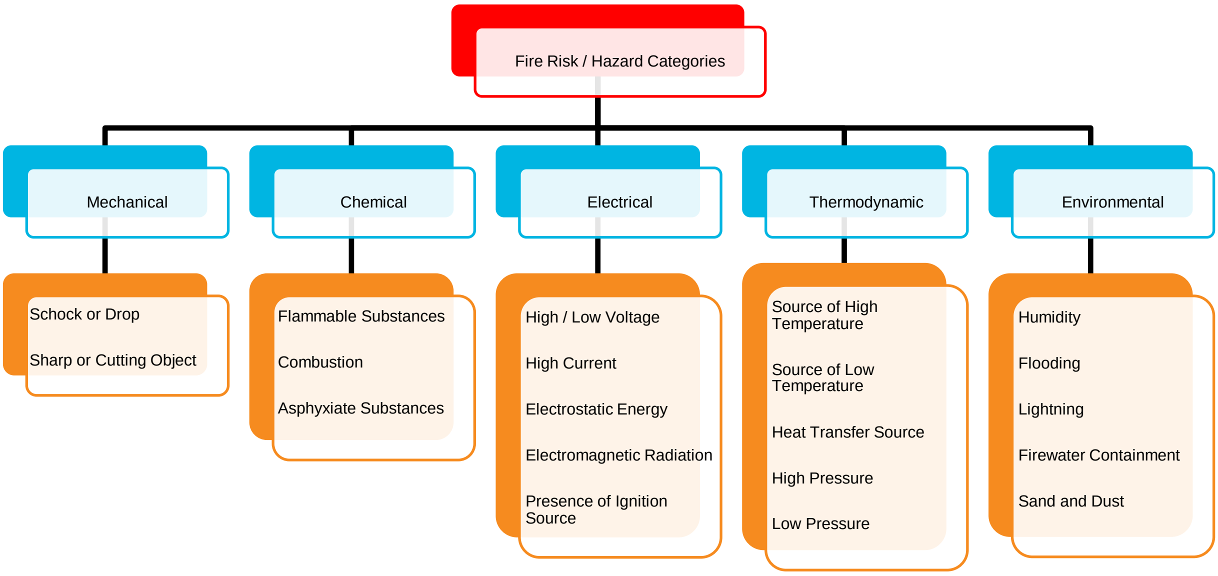


Figure 1: Risks and Hazards Considered (Ref. 12)

4.3 Risk Evaluation

4.3.1 The second stage of the risk control process is to break down the hazards identified into the different phases of the battery life cycle. The stages considered are presented in Figure 2. For the purpose of this work, the risks of the transportation / removal, periodic inspection / maintenance, and installation / decommissioning are considered similar in nature as the activities in these stages.

4.3.2 The hazards previously identified in Figure 1 are mapped to the different stages of the battery life cycle of Figure 2. The same hazard may therefore appear in different stages of the battery life cycle. The results of this mapping process are presented for fire events in tables (one for each life-cycle process stage) in the following sections (Sections 4.4 to 4.7).

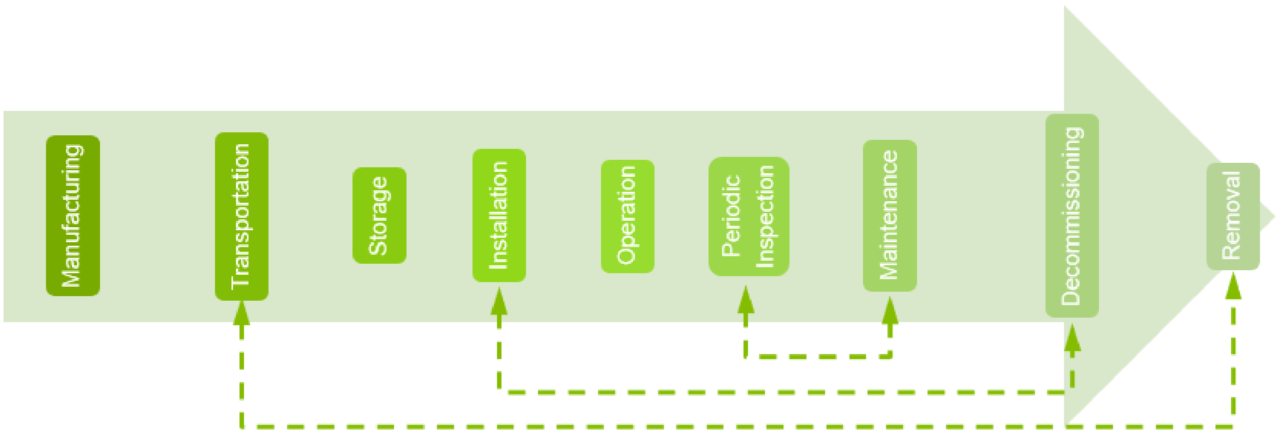


Figure 2: Stages of Battery Life Considered (Ref. 12)

4.3.3 The following step in the risk control process is to evaluate the risks. This is done by describing and characterising the risk, as described by the following bullet points, and illustrated in Figure 3 and Figure 4) and presented for fire events in detail for each lifecycle stage in the subsequent sub-sections of this Outline Battery Fire Safety Management Plan (Section 4.4).

a. **Hazard** – something that is dangerous and likely to cause any kind of damage.

b. **Element** – specific part or item that may cause or be exposed to damage.

c. **Cause** – Origin of the failure that may cause damage to people / equipment in the nearby surrounding area or to the battery element itself.

d. **Dangerous Occurrence** – An action or circumstance that may lead to an undesirable event.

e. **Undesirable Event** – The result of a dangerous occurrence and a dangerous situation.

f. **Probability** – The probability level of the undesirable event occurring. Refer to Figure 3.

g. **Severity** – The severity level of the undesirable event. Refer to Figure 3.

h. **Risk Rating** – The residual risk remaining when applying the risk probability and risk severity of an undesirable event. Refer to Figure 4.

i. **Risk Mitigation Methods** – Action(s) designed to eliminate, reduce or control the impact of the identified risks. The identifier used is RMM and referenced in Table 12.

Probability	Severity				
	5 - Catastrophic	4 – Critical	3 – Major	2 – Moderate	1 - Minor
5 – Frequent	25	20	15	10	5
4 – Probable	20	16	12	8	4
3 – Occasional	15	12	9	6	3
2 – Remote	10	8	6	4	2
1 - Improbable	5	4	3	2	1

Figure 3: Risk Probability and Severity Matrix (Ref. 13)

Risk Rating (Probability x Severity)
1 to 4 (Low)
5 to 9 (Medium)
10 to 25 (High)

Figure 4: Risk Rating Scoring (Ref. 13)

4.3.4 Table 7 to Table 11 present the identified fire event risks for each project stage, along with the proposed risk mitigation method identification number (further described in Section 5).

4.4 Manufacturing Stage

4.4.1 Li-ion batteries are slowly becoming a more significant and important technology regarding energy storage solutions. In this context, adequate safety performances in addition to an extended life cycle are key factors that shall be considered by the manufacturers. An appropriate design and manufacturing process of the cells/modules and their incorporation into flexible storage systems, that can be rapidly deployed in the grid, are essential to meet customer's exact power and energy requirements. Failures during assembling, due to technical or human nature, can damage or influence the future performance of the battery.

4.4.2 At the assembly line, visible and detectable defects, such as dropped, or physically damaged modules shall be immediately replaced. There are several possible defects during cell manufacturing that may escape this visual inspection such as contaminants introduction, electrode defects, components misalignment or welding defects. To deal and mitigate these defects several manufacturing quality control techniques must be applied including undertaking reliability tests (such as charge/discharge cycles, resistance measurements or X-ray) to ensure that the equipment is distributed without damage or defects as this could lead to internal short circuits or battery fires at a later stage.

4.4.3 The manufacturer shall ensure that fire tests for their assembled racks of modules reflect the same installed condition (i.e. within a predefined space) to assess conditions such as a flash over, heat radiation, etc. (Ref. 12).

Table 7: Manufacturing Stage Hazard and Risk Mitigations (Ref. 12)

Hazard and Risk Identification							Pre-mitigation Assessment				Post-mitigation Assessment		
Item	Hazard	Element	Cause	Dangerous Occurrence	Dangerous Situation	Undesirable Event	Probability	Severity	Risk Rating	Risk Mitigation Methods	Probability	Severity	Risk Rating
1	Cell internal short- circuit during control process (charge)	Cell	Cell contamination	Thermal runaway	Incorrect quality evaluation	Toxic gas release / Fire	2	3	6	RMM02	1	3	3

4.5 Transportation and Removal Stages

4.5.1 Transportation and removal should be neutral stages for the Li-ion batteries, in the sense that transportation/removal means moving the battery from the factory to the location where it is going to be installed and from here to somewhere else. These stages will be carried out by trained personnel with the adequate equipment to maintain the original characteristics of the batteries. Safety regulations and supervision during these phases are essential procedures to maintain the safety conditions. The most common procedures for moving the battery container are road and sea transportation. The latter is more commonly used for long distance journeys.

Table 8: Transportation and Removal Stages Hazard and Risk Mitigations (Ref. 12)

Hazard and Risk Identification							Pre-mitigation Assessment				Post-mitigation Assessment		
Item	Hazard	Element	Cause	Dangerous Occurrence	Dangerous Situation	Undesirable Event	Probability	Severity	Risk Rating	Risk Mitigation Methods	Probability	Severity	Risk Rating
1	Flammable substances	Cell	Electrolyte leakage and inflammation	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM04 RMM05	1	3	3
					Equipment in proximity	Fire propagation	2	4	8		1	4	4
2	High temperature or Heat transfer source	Cell	Thermal Runaway (the cell can reach thermal runaway in case of abnormal conditions such as: cell over charge, charge after an over discharge, external short circuit on cell/module, internal short circuit on cell/module, etc.)	Battery fire	People in proximity	Burns / loss of life	3	4	12	RMM01 RMM02	1	4	4
					Equipment in proximity	Fire propagation	3	4	12		1	4	4

Hazard and Risk Identification							Pre-mitigation Assessment				Post-mitigation Assessment		
Item	Hazard	Element	Cause	Dangerous Occurrence	Dangerous Situation	Undesirable Event	Probability	Severity	Risk Rating	Risk Mitigation Methods	Probability	Severity	Risk Rating
		Battery System, Module or Cell	High temperature induced by the environment (fire, external heat source) or heat radiation coming from the external environment	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM01 RMM07	1	3	3
					Equipment in proximity	Fire propagation	2	4	8		1	4	3
3	Shock or drop	Module or Cell	Shock against a heavy object or drop	Battery fire	Equipment in proximity	Fire propagation	3	4	12	RMM01	1	4	4
4	Sharp or cutting objects	Module or Cell	Impact against a heavy object	Battery fire	Equipment in proximity	Fire propagation	3	4	12	RMM01	1	4	4

4.6 Storage Stage

4.6.1 The storage of the battery prior to installation, as considered in the risk analysis, is the act of keeping the battery in a specific place for use in the future. Thus, the storage phase occurs at different times of the battery life cycle. The battery can be stored on the manufacturer site waiting to be transported by road or ship, on the harbour waiting to be boarded on a ship or on the client site, waiting to be installed and put in operation. The storage sites shall be safe places with restricted access to reduce the probability of shock or other external aggression occurrence. It is also important to assure that during the storage phase the temperature of the environment external to the battery system and modules is lower than the maximum recommended by the manufacturer.

Table 9: Storage Stage Hazard and Risk Mitigation (Ref. 12)

Hazard and Risk Identification							Pre-mitigation Assessment				Post-mitigation Assessment		
Item	Hazard	Element	Cause	Dangerous Occurrence	Dangerous Situation	Undesirable Event	Probability	Severity	Risk Rating	Risk Mitigation Methods	Probability	Severity	Risk Rating
1	Flammable substances	Cell	Electrolyte leakage and inflammation	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM04 RMM05	1	3	3
					Equipment in proximity	Fire propagation	2	4	8		1	4	4
2	High current	Rack	High current delivered by the battery system	High current	People in contact with the battery	Electrical shock	4	2	8	RMM06	2	2	4
3	High temperature or Heat transfer source	Cell	Thermal Runaway (the cell can reach thermal runaway in case of abnormal conditions such as: cell over charge, charge after an over discharge, external short circuit on cell/module, internal short circuit on cell/module, etc.)	Battery fire	People in proximity	Burns / loss of life	3	3	9	RMM01 RMM02	1	3	3
					Equipment in proximity	Fire propagation	3	4	12		2	4	8
		Battery system, module or cell	High temperature induced by the environment (fire, external heat source) or heat radiation coming from the external environment	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM01 RMM07	1	3	3
					Equipment in proximity	Fire propagation	2	4	8		2	2	4
4	High pressure	Cell		Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM01	1	3	3

Hazard and Risk Identification							Pre-mitigation Assessment				Post-mitigation Assessment		
Item	Hazard	Element	Cause	Dangerous Occurrence	Dangerous Situation	Undesirable Event	Probability	Severity	Risk Rating	Risk Mitigation Methods	Probability	Severity	Risk Rating
			Thermal Runaway (the cell can reach thermal runaway in case of abnormal conditions such as: cell over charge, charge after an over discharge, external short circuit on cell/module, internal short circuit on cell/module, etc.)		Equipment in proximity	Fire propagation	2	4	8		1	3	3
5	Shock or drop	Battery system, module or cell	Shock against a heavy object	Battery fire	People in proximity	Burns / loss of life	4	3	12	RMM01 RMM06	2	3	6
					Equipment in proximity	Fire propagation	4	4	16		2	4	8
6	Sharp or cutting objects	Battery system, module or cell	Impact against a heavy object	Battery fire	People in proximity	Burns / loss of life	3	3	9	RMM01	1	3	3
					Equipment in proximity	Fire propagation	3	4	12		2	4	8
7	High voltage	Module or cell	During storage of modules, as spare parts, some charge could be done. Failure in charger or not appropriate charger.	Module fire	People in proximity	Burns / loss of life	3	3	9	RMM01 RMM06 RMM09	1	3	3
					Equipment in proximity	Fire propagation	3	4	12		2	4	8
8	High current	Module or cell	During storage of modules, as spare parts, some charge could be done. Failure in charger or not appropriate charger.	Module fire	People in proximity	Burns / loss of life	3	3	9	RMM01 RMM09	1	3	3

4.7 Installation and Decommissioning Stages

4.7.1 It is very important to collect information and specifications from the manufacturer so that the batteries selected can meet the required performance without unexpected reactions or limitations. At this point, the batteries characteristics must meet, without reservations, the customer requirements since the installation stage precedes the operational phase where it is expected that the selected storage solution will attend its purpose. Correct connections, proper protections, sustained by technical supervision should be the main concerns at the installation stage, as well as at decommissioning stage since this is basically the opposite of the installation. Site Acceptance Tests (SAT) will follow IEC 62933-5-2 and IEEE 2962 (in development) standards and protocols.

4.7.2 The risks during decommissioning are the same in nature as the installation phase. A decommissioning plan shall be provided by the owner / operator to the SFRS and CFRS as part of the Emergency Response Plan documentation at the detailed design stage, content will follow NFPA 855 (2023) guidelines and recommendations.

Table 10: Installation and Decommissioning Stages Hazard and Risk Mitigations (Ref. 12)

Hazard and Risk Identification							Pre-mitigation Assessment				Post-mitigation Assessment		
Item	Hazard	Element	Cause	Dangerous Occurrence	Dangerous Situation	Undesirable Event	Probability	Severity	Risk Rating	Risk Mitigation Methods	Probability	Severity	Risk Rating
1	Flammable substances	Cell	Electrolyte leakage and inflammation	Battery fire	People in proximity	Burns loss of life	2	3	6	RMM04 RMM05	1	3	3
					Equipment in proximity	Fire propagation	2	4	8		1	4	4

Hazard and Risk Identification							Pre-mitigation Assessment				Post-mitigation Assessment		
Item	Hazard	Element	Cause	Dangerous Occurrence	Dangerous Situation	Undesirable Event	Probability	Severity	Risk Rating	Risk Mitigation Methods	Probability	Severity	Risk Rating
2	High temperature or Heat transfer source	Cell	Thermal Runaway (the cell can reach thermal runaway in case of abnormal conditions such as: cell over charge, charge after an over discharge, external short circuit on cell/module, internal short circuit on cell/module, etc.)	Battery fire	People in proximity	Burns / loss of life	3	3	9	RMM01 RMM02 RMM06	1	3	3
					Equipment in proximity	Fire propagation	3	4	12		2	3	6
		Battery system, module or cells	High temperature induced by the environment (fire, external heat source) or heat radiation coming from the external environment	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM01 RMM07	1	3	3
					Equipment in proximity	Fire propagation	2	4	8		1	4	4
3	High pressure	Cell	Thermal Runaway (the cell can reach thermal runaway in case of abnormal conditions such as: cell over charge, charge after an over discharge, external short circuit on cell/module, internal short circuit on cell/module, etc.)	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM01 RMM06	1	3	3
					Equipment in proximity	Fire propagation	2	4	8		1	4	4
4	Shock or drop	Battery system, module or cell	Shock against a heavy object	Battery fire	People in proximity	Burns / loss of life	4	3	12	RMM01 RMM06	2	2	4
					Equipment in proximity	Fire propagation	4	4	16		2	3	6
5	Sharp or cutting objects	Battery system, module or cell	Impact against a heavy object	Battery fire	People in proximity	Burns / loss of life	4	3	12	RMM01	2	2	4
					Equipment in proximity	Fire propagation	4	4	16	RMM06	2	3	6

4.8 Operation Stage

4.8.1 Large stationary Li-ion batteries are required to deal with unexpected power fluctuation in the electricity grid. Therefore, a safe and continuous service is expected from this kind of asset. The operation phase starts from the moment when the battery system is fully integrated in the electricity grid and all procedures related with its installation are concluded.

Table 11: Operation Stage Hazard and Risk Mitigations (Ref. 12)

Hazard and Risk Identification							Pre-mitigation Assessment				Post-mitigation Assessment		
Item	Hazard	Element	Cause	Dangerous Occurrence	Dangerous Situation	Undesirable Event	Probability	Severity	Risk Rating	Risk Mitigation Methods	Probability	Severity	Risk Rating
1	Flammable substances	Cell	Electrolyte leakage and inflammation	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM04 RMM05	1	3	3
					Equipment in proximity	Fire propagation	2	4	8		1	4	4
2	High temperature or Heat transfer source	Module or cell	Thermal Runaway (the cell can reach thermal runaway in case of abnormal conditions such as: cell over charge, charge after an over discharge, external short circuit on cell/module, internal short circuit on cell/module, etc.)	Battery fire	People in proximity	Burns / loss of life	3	3	9	RMM01 RMM02 RMM06	1	3	3
					Equipment in proximity	Fire propagation	3	4	12		2	3	6
		Battery system, module or cells	High temperature induced by the environment (fire, external heat source) or heat radiation coming from the external environment	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM01	2	3	6
					Equipment in proximity	Fire propagation	2	4	8		1	4	4
3	High pressure	Cell	Thermal Runaway (the cell can reach thermal runaway in case of abnormal conditions such as: cell over charge, charge after an over discharge, external short circuit on cell/module, internal short circuit on cell/module, etc.)	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM01	1	3	3
					Equipment in proximity	Fire propagation	2	4	8		1	4	4
		BESS container	Thermal runaway propagation inside the BESS container or operation of gaseous fire extinguishing system	Pressure rise in the container due to fire propagation or gaseous fire extinguishant release	-	BESS container over pressure	1	4	4	RMM22	1	4	4
4	Overheat	Cell	Bad Connections, fault in cell	Battery fire	People in proximity	Burns / loss of life	4	3	12	RMM01 RMM10	2	3	6
					Equipment in proximity	Fire propagation	4	4	16		2	3	6
		Battery system	Bad battery cooling, high number of cycling or failure of the heating / cooling system	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM01 RMM13 RMM21	1	3	3
					Equipment in proximity	Fire propagation	2	4	8		1	4	4
5	Over charge	Cell	Failure in Battery Management	Battery fire	People in proximity	Burns / loss of life	3	3	9	RMM01 RMM11	2	3	6
					Equipment in proximity	Fire propagation	4	4	16		2	3	6
6	Forced discharge or recharge of an over discharged cell	Module or cell	Failure in Battery Management	Battery fire	People in proximity	Burns / loss of life	3	3	9	RMM01 RMM12	2	3	6
					Equipment in proximity	Fire propagation	3	4	12		1	4	4
7	Internal short circuit	Cell	Production failure that results in internal short circuit with possible thermal runaway	Battery fire	People in proximity	Burns / loss of life	3	3	9	RMM01 RMM02	1	3	3
					Equipment in proximity	Fire propagation	3	4	12		1	4	4

Hazard and Risk Identification							Pre-mitigation Assessment				Post-mitigation Assessment		
Item	Hazard	Element	Cause	Dangerous Occurrence	Dangerous Situation	Undesirable Event	Probability	Severity	Risk Rating	Risk Mitigation Methods	Probability	Severity	Risk Rating
		Module	Module internal short circuit (equivalent to a cell external short)	Battery fire	People in proximity	Burns / loss of life	3	3	9	RMM01	1	3	3
					Equipment in proximity	Fire propagation	3	4	12	RMM03 RMM08	2	4	8
		Rack	Rack internal short circuit is equivalent to a module external short	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM01	1	3	3
					Equipment in proximity	Fire propagation	2	4	8	RMM08 RMM14	1	4	4
		Battery system	A battery system internal short is equivalent to a module external or internal short or a rack external or internal short	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM01	1	3	3
					Equipment in proximity	Fire propagation	2	4	8	RMM08 RMM14	1	4	4
8	External short circuit	Cell	Bus bar or another electronic component in short circuit	Battery fire	People in proximity	Burns / loss of life	3	3	9	RMM01	1	3	3
					Equipment in proximity	Fire propagation	3	4	12	RMM03 RMM08	2	4	8
		Module	External short circuit between one or several modules caused by bad assembly or short circuit on bus bar	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM01	1	3	3
					Equipment in proximity	Fire propagation	2	4	8	RMM08 RMM14	1	4	4
			Bad assembly or a short circuit on the Battery Management Module	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM01	1	3	3
					Equipment in proximity	Fire propagation	2	4	8	RMM08 RMM14	1	4	4
9	Fire propagation in the BESS container	Battery system	Thermal Runaway (the cell can reach thermal runaway in case of abnormal conditions such as: cell over charge, charge after an over discharge, external short circuit on cell/module, internal short circuit on cell/module, etc.)	Battery fire or explosion	People in proximity	Burns / loss of life	3	4	12	RMM17	2	4	8
					Equipment in proximity	Fire propagation	3	4	12	RMM18 RMM19	2	4	8
			Automatic suppression system failure	Battery fire	People in proximity	Burns / loss of life	1	3	3	RMM01	1	3	3
					Equipment in proximity	Fire propagation	1	4	4		1	4	4
10	Shock or drop	Battery system	Shock against a heavy object of a module/cell during operation phase (human error)	Battery fire	People in proximity	Burns / loss of life	3	3	9	RMM01	1	3	3
					Equipment in proximity	Fire propagation	3	4	12		2	4	8
11	Sharp or cutting objects	Battery system	Shock against a sharp object	Battery fire	People in proximity	Burns / loss of life	3	3	9	RMM01	1	3	3
					Equipment in proximity	Fire propagation	3	4	12	RMM06	2	4	8
12	High voltage	Battery system	High voltage from external or failure in charger	Battery fire	People in proximity	Burns / loss of life	3	3	9	RMM11	2	3	6
					Equipment in proximity	Fire propagation	3	4	12	RMM01 RMM06	1	4	4
13	High current	Battery system	High current from external or failure in charger or an external short circuit or overload	Battery fire	People in proximity	Burns / loss of life	3	3	9	RMM14	2	3	6
					Equipment in proximity	Fire propagation	3	4	12	RMM01 RMM06	1	4	4

Hazard and Risk Identification							Pre-mitigation Assessment				Post-mitigation Assessment		
Item	Hazard	Element	Cause	Dangerous Occurrence	Dangerous Situation	Undesirable Event	Probability	Severity	Risk Rating	Risk Mitigation Methods	Probability	Severity	Risk Rating
14	Electromagnetic radiation	Electronic board	Electromagnetic from surrounding environment or external sources	Battery fire	People in proximity	Burns / loss of life	3	3	9	RMM11 RMM01 RMM06	1	3	3
					Equipment in proximity	Fire propagation	3	4	12		1	4	4
15	Sand and dust	BESS container	Dust particles, due to rural location, entering the BESS container and causing short circuit	Battery fire	People in proximity	Burns / loss of life	3	2	6	RMM20	2	2	4
					Equipment in proximity	Fire propagation	3	2	6		2	2	4
16	Lightning	Battery system	High current can damage the electronic components	Battery fire	Equipment in proximity	Fire propagation	3	4	12	RMM01	2	4	8
17	Firewater containment	BESS container	Manual firefighting operations by fire and rescue services	Environment contamination	-	Environment contamination	5	4	20	RMM15	3	3	9
18	Insufficient access	Fire rescue service access	Delayed attendance of fire rescue services	Uncontrolled fire	People in proximity	Burns / loss of life	3	4	12	RMM24	2	4	8
					Equipment in proximity	Fire propagation	3	4	12		2	4	8
19	Water ingress in BESS container from flooding following heavy rain fall	Battery system, module or cell	Short circuit of battery system	Battery fire	People in proximity	Burns / loss of life	3	2	6	RMM20	2	2	4
					Equipment in proximity	Fire propagation	3	2	6		2	2	4
20	Explosion originating from inside BESS container	BESS container	Accumulating hazardous gas	Explosion and fire	People in proximity	Burns / loss of life	3	4	12	RMM23	2	4	8
					Equipment in proximity	Fire propagation	3	4	12		2	4	8

4.9 Maintenance and Inspection Stages

4.9.1 Periodic inspection and maintenance require careful considerations to ensure that the return to the operational stage occurs as planned. The personnel involved in these stages will be trained and technically prepared to successfully perform inspection and maintenance tasks. Also, machinery and utilities used during inspection and maintenance must not damage the battery modules and the manoeuvres performed must not affect the module integrity as well as the neighbouring equipment. Periodic inspection will be performed to ensure that the battery modules are operating as expected. The evaluation will be performed by trained personnel, without compromising the normal operation of the modules. It is performed with specified time intervals, depending on the operator planning. This process typically consists in several visual and physical inspections executed according to a pre-set schedule. The maintenance stage consists in replacing or adjusting pre-selected components that failed or are potential targets for failure. The removal of the pre-selected elements must not compromise or damage other components. Safety procedures and technical supervision are crucial at this stage.

Table 12: Maintenance and Inspections Stages Hazard and Risk Mitigations (Ref. 12)

Hazard and Risk Identification							Pre-mitigation Assessment				Post-mitigation Assessment		
Item	Hazard	Element	Cause	Dangerous Occurrence	Dangerous Situation	Undesirable Event	Probability	Severity	Risk Rating	Risk Mitigation Methods	Probability	Severity	Risk Rating
1	Flammable substances	Cell	Electrolyte leakage and inflammation	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM04 RMM05	1	3	3
					Equipment in proximity	Fire propagation	2	4	8		1	4	4
2		Cell		Battery fire	People in proximity	Burns / loss of life	3	3	9	RMM01	1	3	3

Hazard and Risk Identification							Pre-mitigation Assessment				Post-mitigation Assessment		
Item	Hazard	Element	Cause	Dangerous Occurrence	Dangerous Situation	Undesirable Event	Probability	Severity	Risk Rating	Risk Mitigation Methods	Probability	Severity	Risk Rating
	High temperature or Heat transfer source		Thermal Runaway (the cell can reach thermal runaway in case of abnormal conditions such as: cell over charge, charge after an over discharge, external short circuit on cell/module, internal short circuit on cell/module, etc.)		Equipment in proximity	Fire propagation	3	4	12	RMM02 RMM06	2	4	8
		Battery System, Module or Cells	High temperature induced by the environment (fire, external heat source) or heat radiation coming from external environment	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM01 RMM07	1	3	3
					Equipment in proximity	Fire propagation	2	4	8		1	4	4
3	High pressure	Cell	Thermal Runaway (the cell can reach thermal runaway in case of abnormal conditions such as: cell over charge, charge after an over discharge, external short circuit on cell/module, internal short circuit on cell/module, etc.)	Battery fire	People in proximity	Burns / loss of life	2	3	6	RMM01 RMM06	1	3	3
					Equipment in proximity	Fire propagation	2	4	8		1	4	4
4	Shock or Drop	Battery System, Module or Cell	Shock against a heavy object	Battery fire	People in proximity	Burns / loss of life	4	3	12	RMM01 RMM06	2	3	6
					Equipment in proximity	Fire propagation	4	4	16		2	4	8
5	Sharp or cutting objects	Battery System, Module or Cell	Impact against a heavy object	Battery fire	People in proximity	Burns / loss of life	4	3	12	RMM01 RMM06	2	3	6
					Equipment in proximity	Fire propagation	4	4	16		2	4	8

5 Mitigation and Control Measures

5.1 General

5.1.1 This section details the possible methods used to mitigate the potential residual risks of fire event leading to the spread of heat and uncontrolled fire with associated emissions through the project cycle. The Scheme will minimise fire risk using life safety features that are listed minimum code requirements as well as recommended industry practice (property protection) throughout the project lifecycle. The priority of the risk mitigation approach must be:

a. Fire and explosion prevention safety design measures.

b. Guards and protective devices such as BESS disconnection and shutdown controls.

c. Information and training for end users.

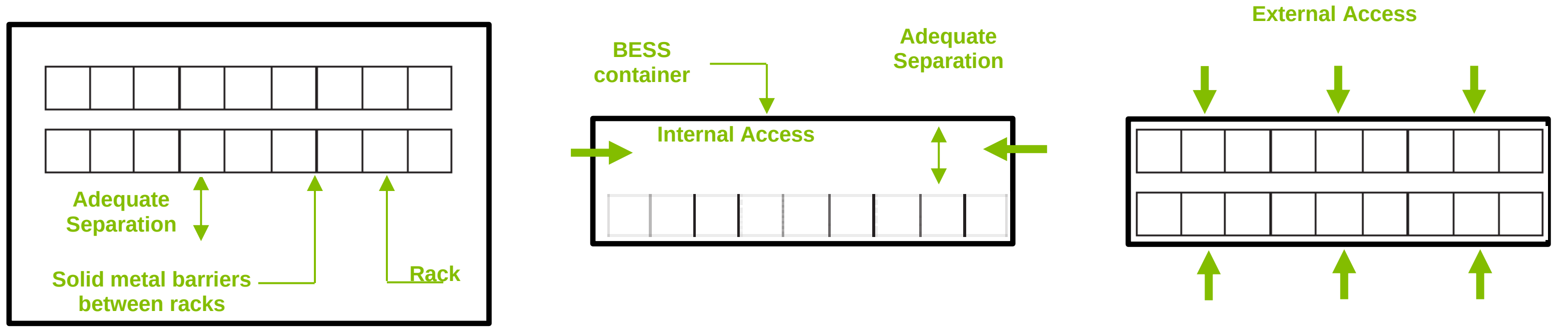
5.1.2 The mitigation measures for the hazards and risks proposed by this Outline Battery Fire Safety Management Plan, along with the person responsible for providing the mitigation, is shown in Table 13. The battery system mitigation measures adopted in the Battery Fire Safety Management Plan, which is to be approved subject to requirement 7 of the Development Consent Order, will reflect the latest BESS safety codes and standards applicable at that stage.

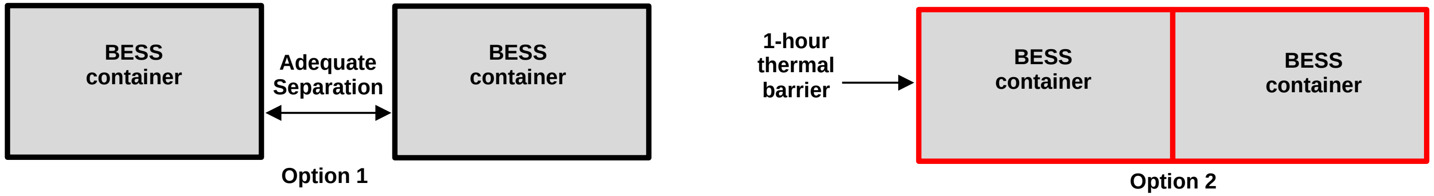
5.1.3 At the same stage, a Failure Modes and Effects Analysis (FMEA) of the BESS system will be conducted to lay the foundation for predictive maintenance requirements and compliment the fault indicator capabilities of the BMS data analytics system.

5.1.4 Comprehensive Hazard Mitigation Analysis (HMA) will be conducted by a BESS specialist independent Fire Protection Engineer following NFPA 855 (2023) guidelines and recommendations.

5.1.5 Additional risk assessments likely to be conducted at the detailed design stage are Fire Risk Analysis (FRA), Explosion Risk Analysis (ERA), Hazard and Operability Analysis (HAZOP). BESS system 3rd Party risk analysis is sometimes automatically provided by Tier one BESS system manufacturers and / or BESS integrators.

Table 13: Proposed List of Risk Mitigation Methods (Ref. 12)

Risk Mitigation Method	Description	Action
RMM01	Implement thermal barriers between cells or provide adequate separation to limit propagation within battery module during thermal runaway. Implement thermal barriers between battery modules or provide adequate separation to limit fire contamination outside the battery modules. The module construction and assembly shall be solid to minimise internal damage arising from drop or shock. Provide thermal barriers to separate switchgear and battery module areas within BESS container in accordance with FM Global Datasheet 5-33. Racks within the BESS container shall be installed either in single row or double row arrangements with racks back to back. Each rack will be separated by non-combustible thermal barriers to prevent heat transfer. Racks will also have adequate separation from the perimeter walls and between the aisle faces of adjacent racks.  Each BESS container will have non-combustible walls, floor and ceiling, and will have a minimum internal fire resistance rating of 1-2 hours. 6 metre separation will be observed unless UL 9540A unit or installation level testing and / or 3rd Party Fire & Explosion testing has demonstrated through heat flux data that distances can be reduced. An independent Fire Protection Engineer specialising in BESS will review all UL 9540A test results and any additional fire and explosion test data which has been provided. 6 metre BESS container spacing provision will be observed for site indicative planning purposes.	Manufacturer

Risk Mitigation Method	Description	Action
	Cable and pipe penetrations into each BESS container will be sealed and provided with rating equal to that required for the BESS container.  	
RMM02	Protective devices and electric circuits shall be rated in accordance with the safety requirements of BS EN IEC 62933-5 to protect electric circuits against short-circuits.	Manufacturer
RMM03	Use an electronic board design which avoids fire contamination on cell in case of short circuit on the board.	Manufacturer
RMM04	Find out, according to the empty space existing in the battery container, the air leak and nature of gas generated, the acceptability of the substances released in case or thermal runway, venting or leaking cell. Calculate the maximum number of cells below which the concentration of flammable substances is not hazardous.	Manufacturer
RMM05	The cell size must be enough to create enough air renewal and stay below the hazardous concentration of flammable substances threshold.	Manufacturer
RMM06	The maintenance and installation operators must be qualified, strictly follow the maintenance and installation protocols and wear individual protective equipment.	Developer Installer Operator
RMM07	The maximum allowable cell operating temperature set by the manufacturer must be higher than the highest anticipated temperature of the internal environment external to the battery system and modules.	Installer
RMM08	During assembling phases (cells and modules) verify if each connection is correct.	Manufacturer
RMM09	Strictly follow the maintenance and user manuals.	Operator
RMM10	Implement an electronic protection against cell overheat. High cell temperature trip will isolate the module or rack when detecting cell temperatures that exceed limits. Thermal runaway trip will isolate the battery system when a cell is detected to have entered a thermal runaway condition. Rack switch fail-to-trip will disconnect the rack if any failure is detected. Inverter / charger fail-to-trip will isolate the BESS container at the breaker if the inverter / charger fails to respond to a trip command.	Manufacturer
RMM11	Implement an electronic protection against overcharge on cell (to stop charge/discharge if a cell reaches the maximum voltage value).	Manufacturer
RMM12	Implement an electronic protection against cell charge after an over discharge.	Manufacturer

Risk Mitigation Method	Description	Action
RMM13	Implement on the battery an electronic protection against overheating on battery which may lead to a battery fire or thermal runaway. The electronic protection will consist of high cell temperature trip which will isolate the module or rack when detecting cell temperatures that exceed limits. A thermal runaway trip will isolate the battery system when a cell is detected to have entered a thermal runaway condition. Rack switch fail-to-trip will disconnect the rack if any failure is detected. Inverter / charger fail-to-trip will isolate the BESS container at the breaker if the inverter / charger fails to respond to a trip command. This will provide additional layers of protection and protection features will be fully compliant with NFPA 855 (2023) stipulations.	Manufacturer
RMM14	Implement on the battery an electronic and electrical protection against short circuit and overload to avoid fires.	Manufacturer
RMM15	Each BESS container will be provided with a sump and drain valve to allow extraction of contaminated fire water and / or electrolyte spill without having to open the door of the container and will prevent contamination of surrounding environment with the extracted liquid being taken off site for treatment (Ref. 14). The sump construction will be designed to allow for chemical resistance of electrolyte which may be released from a battery fire and have capacity to hold the total volume of electrolyte plus a 10% safety factor. The sump will encompass the entire floor area of the BESS container with a mentis grating type floor to allow spilled electrolyte to drain without pooling near other racks, other designs proven capable to protect against electrolyte spills will be permissible i.e. separate fire water drainage and electrolyte spill systems. An extra layer of protection will be provided for containment of firewater external of the BESS container in case of rupture or overflow of contaminants. The external floor surface surrounding each BESS container will be lined with an impermeable membrane. The drainage strategy will include for bunded holding lagoons within the BESS area which will contain the firewater runoff. The firewater will be tested post incident and if contaminated, will be tankered off site to a suitable waste facility for treatment. The approach has been discussed and agreed with the Environment Agency.	Developer Installer
RMM17	Install a fire detection and alarm system using coincidence detection in accordance with BS 7273-1 and NFPA 855 (2023) guidelines. The BESS detection system will comply with NFPA 855 (2023) and NFPA 69, this means that smoke, fire and gas detection equipment will be installed. New BESS multi-sensor equipment in development which measures combinations of air temperature, hydrogen, VOCs, overpressure, shock & vibration, and moisture ingress will also be considered if fully tested with the BESS design. The gas detection system will operate in accordance with NFPA 69 explosion prevention standards and additional carbon monoxide detection will be installed, an external BESS beacon and audible alert facility will be linked to the gas detection equipment to provide a warning to site operatives and first responders. The BESS detection system will be reviewed and signed off by an independent Fire Protection Engineer at the detailed design stage, alert communications and protocols will be agreed with SFRS, CFRS, and SRF and implemented into the Emergency Response Plan (ERP).	Developer Installer

<table>
<tr><th>Risk Mitigation Method</th><th>Description</th><th>Action</th></tr>
<tr><td>RMM18</td><td>The CFRS preferred system for the protection of the BESS containers is a water drenching system. The selected fire suppression system will be tested with the BESS system at UL 9540A unit and / or installation level and be fully compliant with UL 9540A fire and explosion prevention objectives. An independent Fire Protection Engineer specialising in BESS will review all UL 9540A test results and any additional fire and explosion test data which has been provided.</td><td>Developer
Installer</td></tr>
<tr><td>RMM19</td><td>Due to the remote location of the BESS compounds and limited availability and supply of water, the following options will be considered. For both options, an underground private fire hydrant system will be provided around the site.

<u>Option 1</u>
Two half capacity fire water storage tanks dedicated for firefighting operations only. The additional fire water storage tank will ensure availability and resiliency in the event of a single water storage tank not being available in the case of maintenance and / or impairment.

The water supply for the firefighting operations will be 180m^3 based on two jets of 750 l/min operating for a duration of 120 minutes as required by CFRS. It's expected the firefighting operations will limit fire spread beyond a single BESS container. Each of the BESS containers will have their own dedicated water storage tank for the water drenching system operation. Until the choice of water drenching system is confirmed, the most onerous requirement will be used. Therefore, the water supply will be 62.5m^3, based on a design density of 12.2mm/min/m^3 for a duration of 45 minutes as required by FM Global Datasheet 5-33.

Static water storage tanks designed to be used for firefighting must be located at least 10 metres away from any BESS container. They will be clearly marked with appropriate signage. They will be easily accessible to FRS vehicles and their siting will be considered as part of a risk assessed approach that considers potential fire development / impacts. Outlets and connections will be agreed with the SFRS and CFRS. Any outlets and hard suction points will be protected from mechanical damage (e.g. through use of bollards).

The fire water storage tanks will be remotely monitored and filled with water tankers when the level of water drops. Frost protection measures to the fire water storage tanks shall be provided. The options for the fire water storage tank will be as follows but the siting, volume and number of tanks will be determined by an independent Fire Protection Engineer and agreed with SFRS / CFRS Service at the detailed design stage of the project. The options for the water storage tanks will be as follows.
<table>
<tr><td>Two half capacity sectional steel panel tanks
6m (L) x 6m (W) x 3m (H) (97.2m^3 effective)</td><td>Two half capacity cylindrical steel tanks
4.58mØ x 6m (H) + 0.3m (H) concrete base (91.9m^3 effective)</td></tr>
</table></td><td>Developer
Installer</td></tr>
</table>

Risk Mitigation Method	Description	Action
	 Example of Sectional Steel Panel Tank (Ref. 15)  Example of Cylindrical Steel Tank (Ref. 16) <u>Option 2</u> Two half capacity fire water storage tanks for the simultaneous operation of the water drenching system and firefighting operations. The water supply for firefighting operations will be 180m³ as calculated in Option 1. The water supply for the water drenching system will be 62.5m³ as calculated in Option 1. Therefore, the total effective fire water storage for simultaneous operation of the water drenching system and firefighting operations will be 242.5m³. The options for the water storage tanks will be as follows. Two half capacity sectional steel panel tanks 8m (L) x 6m (W) x 3m (H) (129.6m³ effective) Two half capacity cylindrical steel tanks 5.35mØ x 6m (H) + 0.3m (H) concrete base (124.8m³ effective)	
RMM20	The BESS container shall be installed by third party certified and qualified installer. The BESS container will be UL 9540 certificated. Ingress protection testing of BESS enclosures is conducted under UL 9540 and / or IEC62933-5-2 certification of any BESS system. Typical BESS enclosure ingress protection levels are IP 55 / NEMA 3R or IP 66 / NEMA 4. IEC Factory Acceptance Testing or a 3rd party manufacturing audit will be obtained to assure the supplied BESS enclosures comply with the requisite certified ingress protection levels. IP ratings of BESS containers will be shared with SFRS and CFRS at the detailed design stage so that risks associated with boundary cooling can be understood and implemented into the Emergency Response Plan (ERP). Potential boundary cooling water ingress points such as HVAC systems and deflagration vents will need to be considered as part of an incident response strategy.	Manufacturer Developer Installer
RMM21	A heating and cooling system will be provided on each BESS container to prevent the battery system experiencing extreme temperatures that will increase risks of thermal runaway, battery modules will integrate liquid cooling systems to provide better performance and a higher level of protection from thermal abuse of battery cells. Additional electric heater may be provided for	Installer Operator

Risk Mitigation Method	Description	Action
	humidity control. Monitoring will be provided by the EMS. In the event of a heating / cooling failure being detected, the container will be automatically switched into standby mode, preventing the battery modules from charging or discharging, and sending a notification to the maintenance team for action. This reduces the risk of temperature rise within the modules and allows time for a repair to take place on site before the system is restarted. The heating and cooling system will be subject to routing maintenance inspections to ensure the risk of failure is minimised.	
RMM22	The BESS container will be designed to withstand overpressures generated by the battery system during thermal runaway. An explosion prevention system to NFPA 69 standards and / or explosion protection system to NFPA 68 and EN 14797 standards will be integrated. If BESS design only integrates explosion protection systems i.e. deflagration panels, then performance must be validated through BESS free burn testing and requisite pressure testing required by NFPA and EN standards. Further, the BESS container will have completed UL 9540A unit and / or installation testing or large-scale 3rd Party Fire & Explosion testing without pressure waves occurring or shrapnel being ejected. An independent Fire Protection Engineer specialising in BESS will review all UL 9540A test results and any additional fire and explosion test data which has been provided.	Manufacturer Developer Installer
RMM23	Permanent operating mechanical ventilation with a rate of at least 0.3 $m^3/min/m^2$ will be provided with air flow monitoring system and alarm to prevent concentration of hazardous gas. Gas exhaust / ventilation system performance requirement will be defined through 3rd Party testing, UL 9540A unit / installation testing and NFPA 69 (Explosion prevention) standard. An independent Fire Protection Engineer specialising in BESS will review all UL 9540A test results and any additional fire and explosion test data which has been provided.	Developer Installer
RMM24	Access will be provided for pump appliances to manoeuvre within the Scheme with full access to all BESS containers. The structures and containers within the Scheme are expected to be lower than 6 m height and high reach appliances will therefore not be required. The access routes will be structurally designed to allow a minimum carrying capacity of 15 tonnes (Ref. 17) for hardstanding of pumping appliances. An alternative site access point shall be provided and maintained to enable pump appliances to approach from an up-wind direction. *Example of Turning Facilities Provided (Ref. 18)*	Developer

5.2 Emergency Response Plan

5.2.1 As outlined above, an emergency response plan will be prepared during the detailed design stage of the Scheme and maintained and regularly reviewed throughout operation. The emergency response plan will form part of the Battery Fire Safety Management Plan developed for the Scheme and will be in accordance with this document. This is secured by requirement 7 of the DCO. The Emergency Response Plan will be prepared in consultation with CFRS, SFRS and the Suffolk Resilience Forum at the detailed design stage.

5.2.2 The emergency response plan will be drafted based on local, national and international input and best practice recommendations, including CFRS, SFRS, UK National Fire Chiefs Council (NFCC), NFPA 855 and Electric Power Research Institute (EPRI). NFPA has recently published its guidelines and template and UK NFCC and EPRI are anticipated to publish their guidelines and templates 2023. Therefore, to ensure the latest information is utilised in the development of an emergency response plan, the plan would be developed towards the end of 2023, at the earliest. This would also ensure that new codes and regulations for BESS can be captured which will be published during 2023. However, this section of the document outlines the minimum level of content that will be included within the emergency response plan(s) in line with the current information available from NFCC and NFPA.

5.2.3 The UK NFCC BESS ERP guidelines (December 2022) state an emergency response plan should be developed to facilitate effective and safe emergency response and should include:

a. How the fire service will be alerted and incident communications and monitoring capabilities.

b. Facility description, including infrastructure details, operations, number of personnel, and operating hours.

c. Site plan depicting key infrastructure:

   i. site access points, internal roads, agreed access routes, observation points, turning areas, etc.
   ii. firefighting facilities (water tanks [including re-filling requirements], pumps, booster systems, fire hydrants, fire hose reels etc).
   iii. water supply locations & capacity.
   iv. drainage and water capture design & locations.

d. Details of emergency resources, including fire detection and suppression systems and equipment; gas detection; emergency eyewash and shower facilities; spill containment systems and equipment; emergency warning systems; communication systems; personal protective equipment; first aid.

e. Up-to-date contact details for facility personnel, and any relevant off-site personnel that could provide technical support during an emergency.

f. A list of dangerous goods stored on site.

g. Site evacuation procedures.

h. Emergency procedures for all credible hazards and risks, including building, infrastructure and vehicle fire, wildfires, impacts on local respondents and residents, impacts on transport infrastructure.

i. The operator should develop a post-incident recovery plan that addresses the potential for reignition of ESS and de-energizing the system, as well as removal and disposal of damaged equipment.

5.2.4 NFPA 855 state an emergency response plan should address the following key safety elements:

a. Full facility description and plans

b. Emergency Management - 4 phases: discovery, initial response / notification, incident actions, resolution and post incident actions / responses)

c. Fire Suppression Systems, locations, and size of water supplies

d. Emergency manual BESS Estop and electrical isolation switchgear locations

e. Fire department access locations and observation points

f. Alarm panels

g. Signage

h. Chain of command and emergency phone numbers

i. Ventilation system details, including discharge location including deflagration panel locations (if integrated)

j. Evacuation routes

k. Fire incidents and other emergency incidents

l. Medical emergency procedures

m. Other procedures as deemed necessary by local first responders to ensure the safety of site operatives, BESS site respondents, emergency responders and local residents.

5.2.5 In addition to the above, the emergence response plan will include water capacity requirements, including that the:

a. final water tank capacity will be designed to hold enough water to deal with an incident based upon a range of fire and explosion test data and independent review. The location and design of the water tanks will allow for refilling by first responders, if needed.

b. test data will be reviewed by an independent Fire Protection Engineer specialising in BESS projects. The data together with the independent review will be shared with the SFRS / CFRS / SRF and used to draft the final ERP.

5.2.6 The site integrator and operators will be ultimately responsible for drafting and implementing the specific H&S policy for the Scheme, as they will define the standard operating procedures (SOPs) for the detailed BESS and site design.

5.2.7 The integrator and operator will consider the NFPA 855 (2023) guidance which defines five BESS hazard categories. The hazards are assessed under both normal operating conditions and emergency / abnormal conditions:

a. Fire & explosion hazards

b. Chemical hazards

c. Electrical hazards

d. Stored / stranded energy hazards

e. Physical hazards

5.2.8 Hazard Mitigation Analysis, Fire Risk Analysis and Explosion Risk Analysis plus detailed consequence modelling which are a key part of this health and safety assessment process will be defined within the BFSMP and emergency response plan.

5.2.9 However, NFPA 855 (2023) does define some basic operation H&S protocols for all BESS systems which will be incorporated into the emergency response plan:

a. Potential debris impact radius is defined as 100 feet / 30.5 metres i.e. this is a typical explosion risk safe exclusion zone radius as modelling and previous BESS incidents typically show 25 metres to be maximum radius.

b. Automatic building evacuation area is defined as 200 feet / 61 metres from the affected BESS container.

c. BESS hazards for first responders and site operatives once a fire has started, depend on the BESS design but are typically defined as: fire, explosion, chemical hazards, carbon monoxide, carbon dioxide, hydrocarbon gases, and hydrogen. Full PPE should be worn, and operations should not generally be conducted within blast exclusion zones.

6 Conclusion

6.1.1 This Outline Battery Fire Safety Management Plan has demonstrated in a systematic way the mitigation of the fire safety risks posed by the BESS's in the Scheme.

6.1.2 The next step is for further stakeholder consultations to be held to review and agree the plan, or determine actions for further iterations, as required.

7 References

Ref. 1 Sunnica Ltd, "Downloads," 9 September 2020. [Online].

Ref. 2 FM Global, "Datasheet 5-33 Electrical Energy Storage Systems," Factory Mutual Insurance Company, 2020.

Ref. 3 WYG, "Pivot Power - Bustleholme: Proposed Substation Battery Storage Facility," 2020.

Ref. 4 Energy Institute, "Battery Storage Guidance Note 1: Battery Storage Planning," Energy Institute, London, 2019.

Ref. 5 Liyuan Battery Co., LTD, "Solar Energy Storage with Lithium Battery," [Online].

Ref. 6 Anesco, "News & Blog," Anesco, [Online].

Ref. 7 Fluence Energy, "Ballarat Energy Storage System," 22 October 2018. [Online].

Ref. 8 Zenobe Energy, "Zenobe Energy," [Online].

Ref. 9 AECOM, "Preliminary Environmental Information Report (PEIR) - Chapter 3: Scheme Description," AECOM, London, 2020.

Ref. 10 Sunnica Ltd, "Downloads," 21 September 2020. [Online].

Ref. 11 W. S. Council, S. C. Council, E. C. D. Council and C. C. Council, "Sunnica Energy Farm - Response to Statutory Consultation," Local Authorities Section 42 Statutory Consultation, 2020.

Ref. 12 F. Soarea, L. Carvalho, I. Costa, J. Iria, J.-M. Bodet, G. Jacinto, A. Lecocq, J. Roessner and B. Caillard, "The STABALID Project: Risk Analysis of Stationary Li-ion Batteries for Power System Applications," 2015.

Ref. 13 AECOM, "EMEA Safety in Design," 2019.

Ref. 14 Denios Ltd, "Lithium Energy Storage Devices - Safe Storage and Testing," [Online].

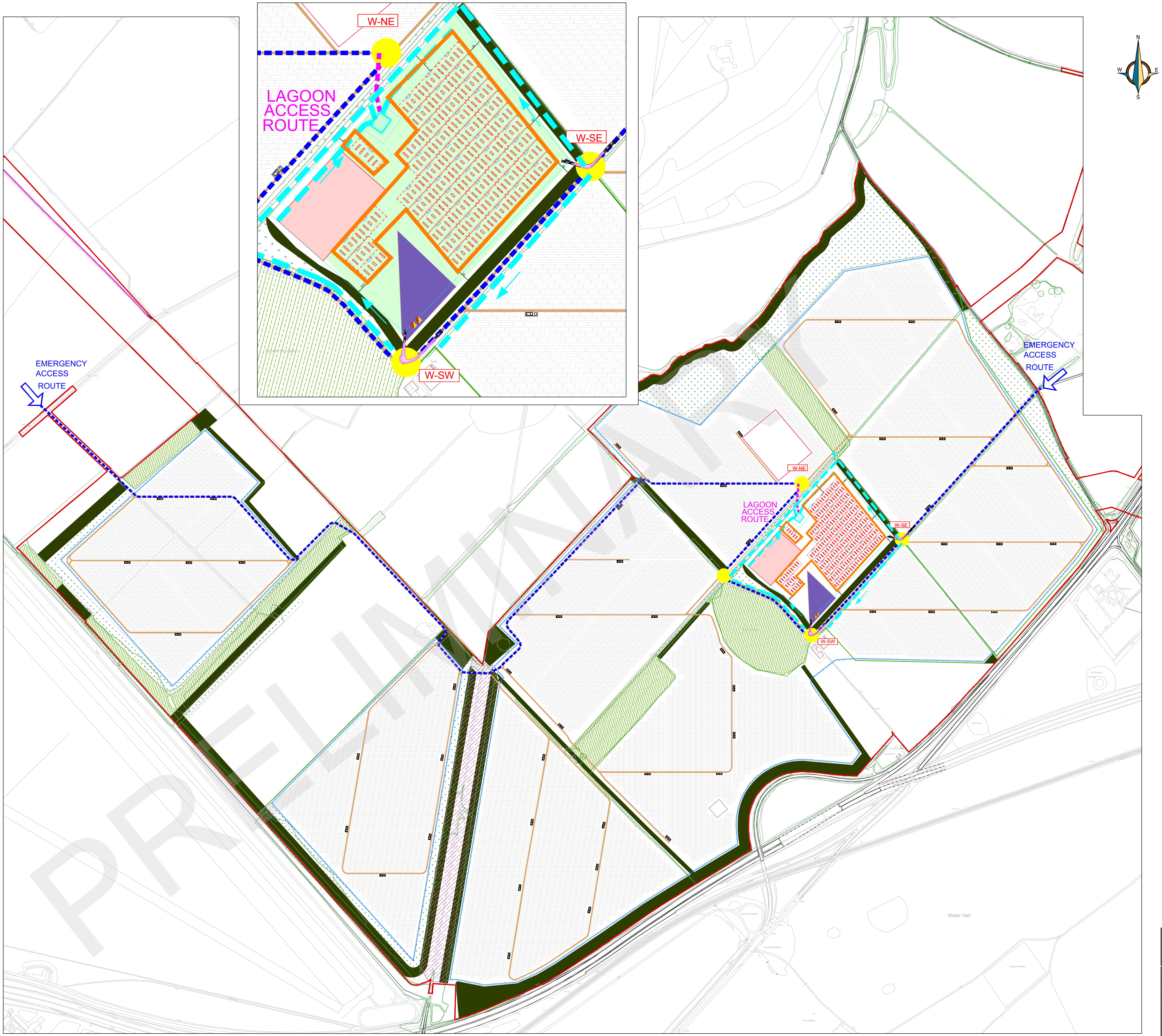
Ref. 15 Covac, "How to keep your water storage tanks clean and free from bacteria," 6 February 2018. [Online].

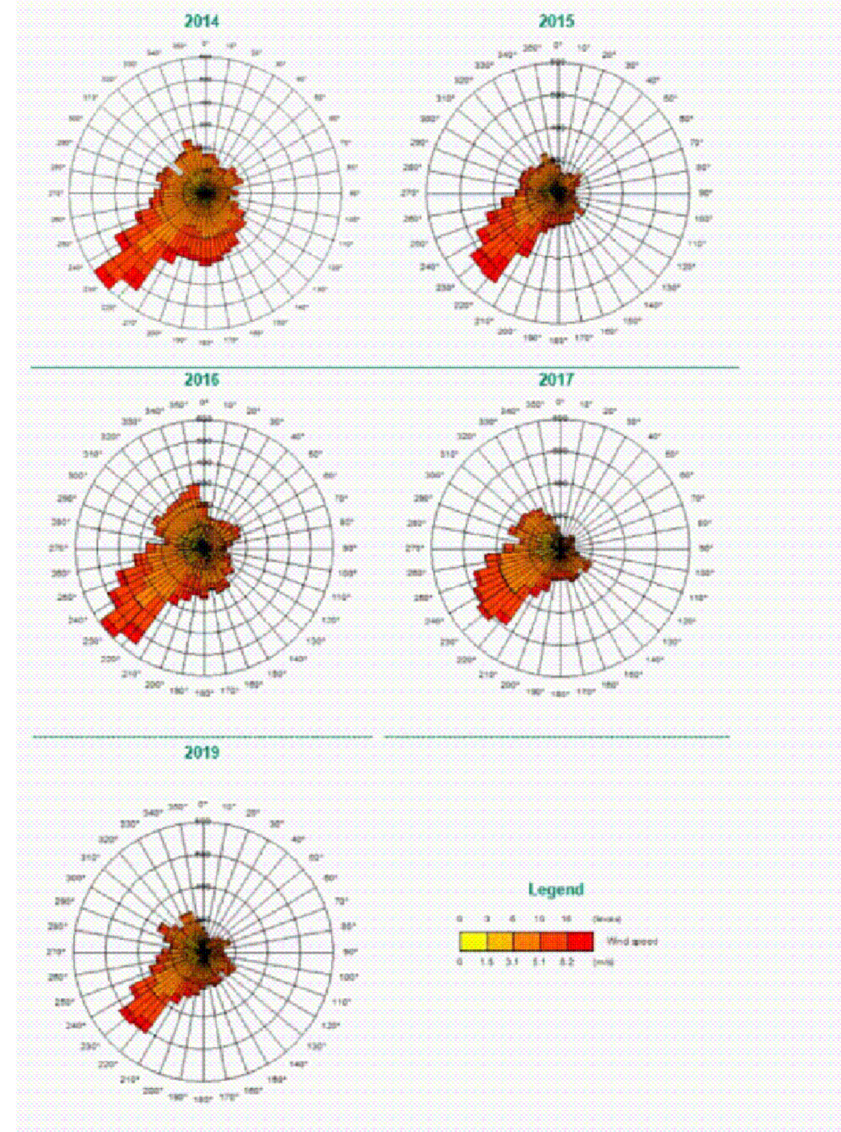
Ref. 16 Kingspan, "Permastore Industrial Tanks," Kingspan, [Online]

Ref. 17 West Yorkshire Fire & Rescue Service, "Fire Safety - Public Advice: Access for Fire Appliances," 5 May 2015. [Online].

Ref. 18 HM Government, "The Building Regulations 2010 Fire Safety - Approved Document B Volume 1," 2019.

Appendix A Indicative BESS Compound Layout Designs – Technology 1



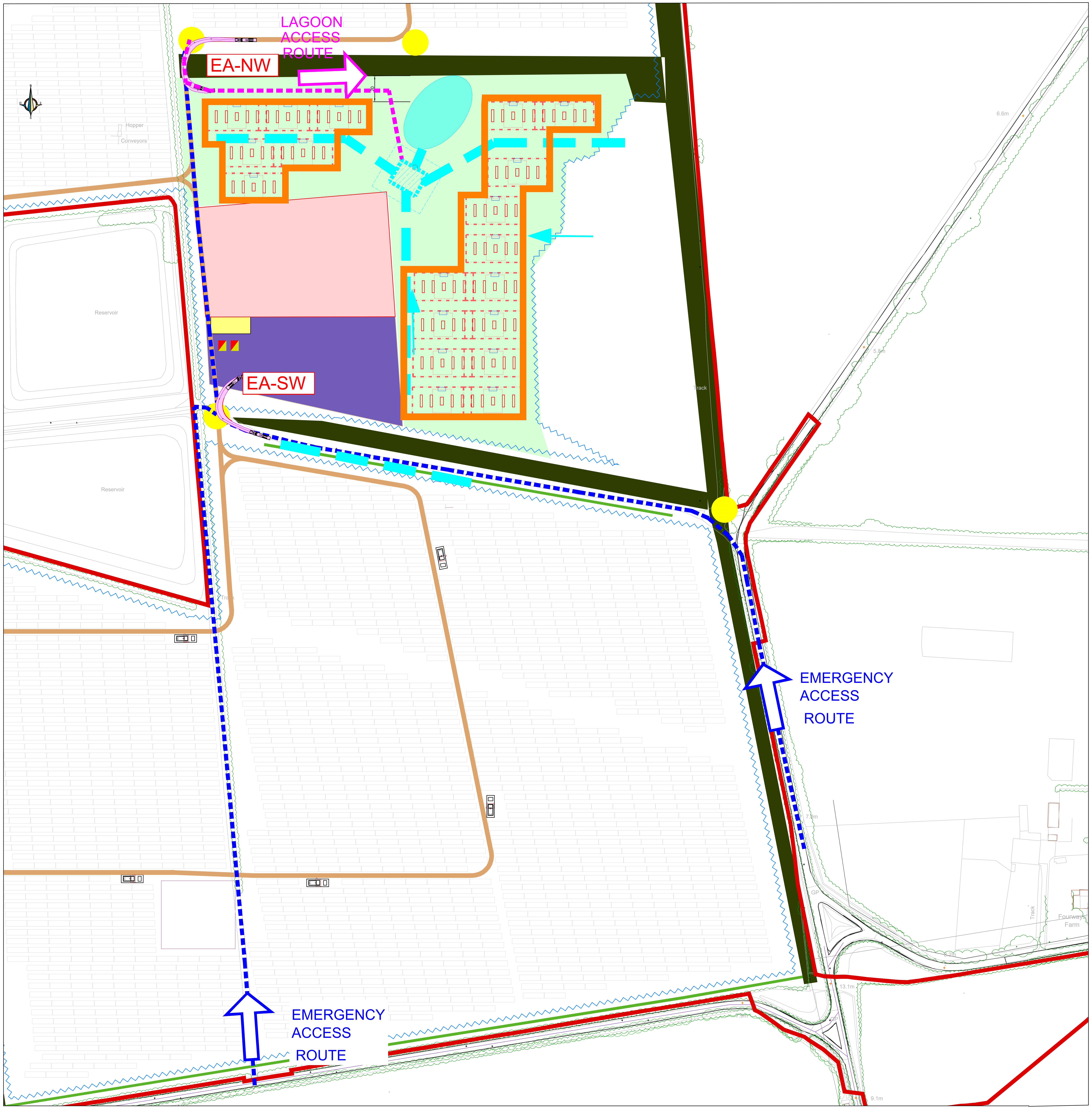


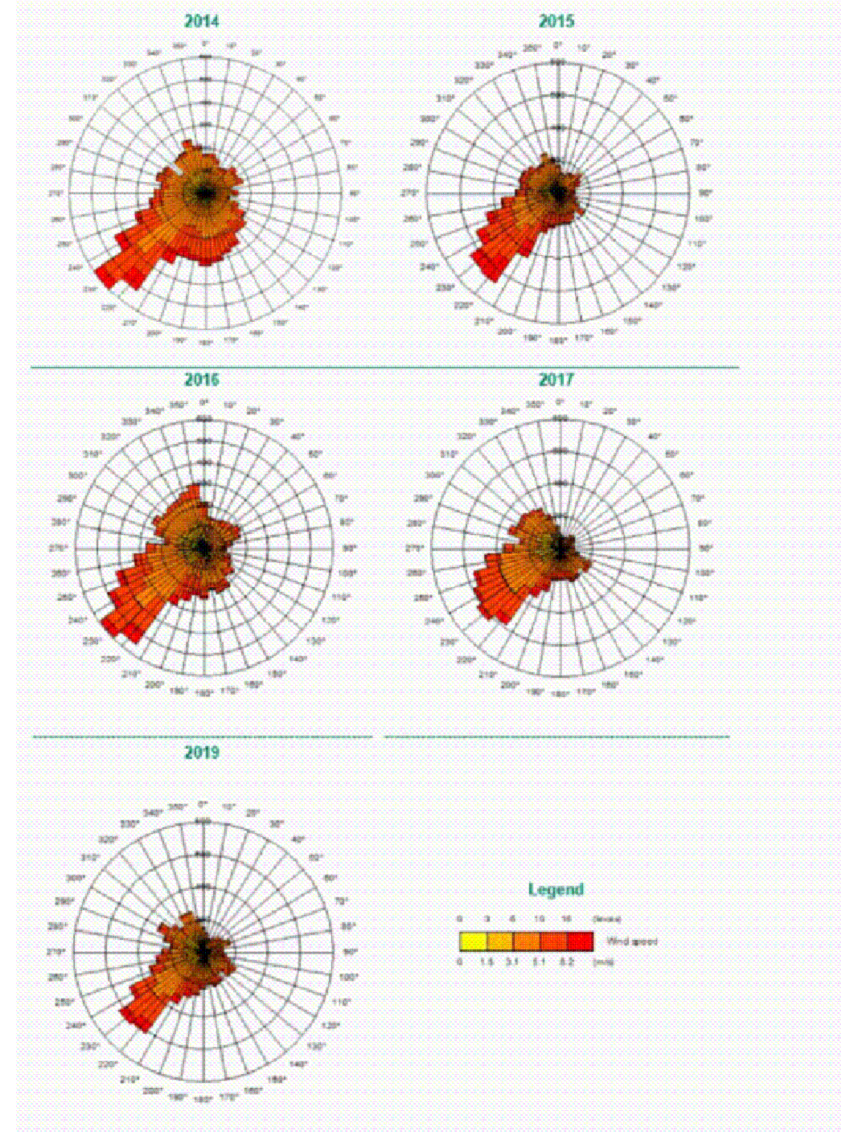
WIND ROSE STUDY FOR STANSTED AIRPORT

- INTERNAL PV ROAD
- TREE CANOPIES HEDGEROWS AND FOLIAGE
- PROPOSED HEDGEROWS
- PROPOSED WOODLAND
- AREAS OF HARDSTANDING
- BATTERY COMPOUND AREA
- SUBSTATION
- ORDER LIMITS
- FENCE
- BESS SOLUTION OPTION 1 (BESS container, PCS-SC5000)
- SPRINKLERS´S WATER TANK
- EXTERNAL FIRE FIGHTING WATER TANKS
- EMERGENCY ACCESS ROUTE
- VIEWING AREA FOR FIRE TEAM
- W-SE INDICATIVE ACCESS POINTS
- LAGOON ACCESS ROUTE
- DRAINAGE SYSTEM
- BUNDED LAGOON
- INFILTRATION BASIN
- IMPERMEABLE AREA (part of drainage system)

PS Renewables
Green Energy Investments

PROJECT:	SUNNICA ENERGY FARM DEVELOPMENT CONSENT ORDER (DCO)			
COMPANY:	PS RENEWABLES			
LAYOUT:	Sunnica WEST A – Illustrative BESS layout			
DRAW BY:	Sergio Serna	PS RENEWABLES: 5 Stubbings Estate Maidenhead, Berkshire SL6 6QL	DATE:	18/08/2022
DESIGN BY:	Nacho Perez - Laura Picazo		SCALE:	1:1.250
CHECK BY:	David Ortiz		SIZE:	A1



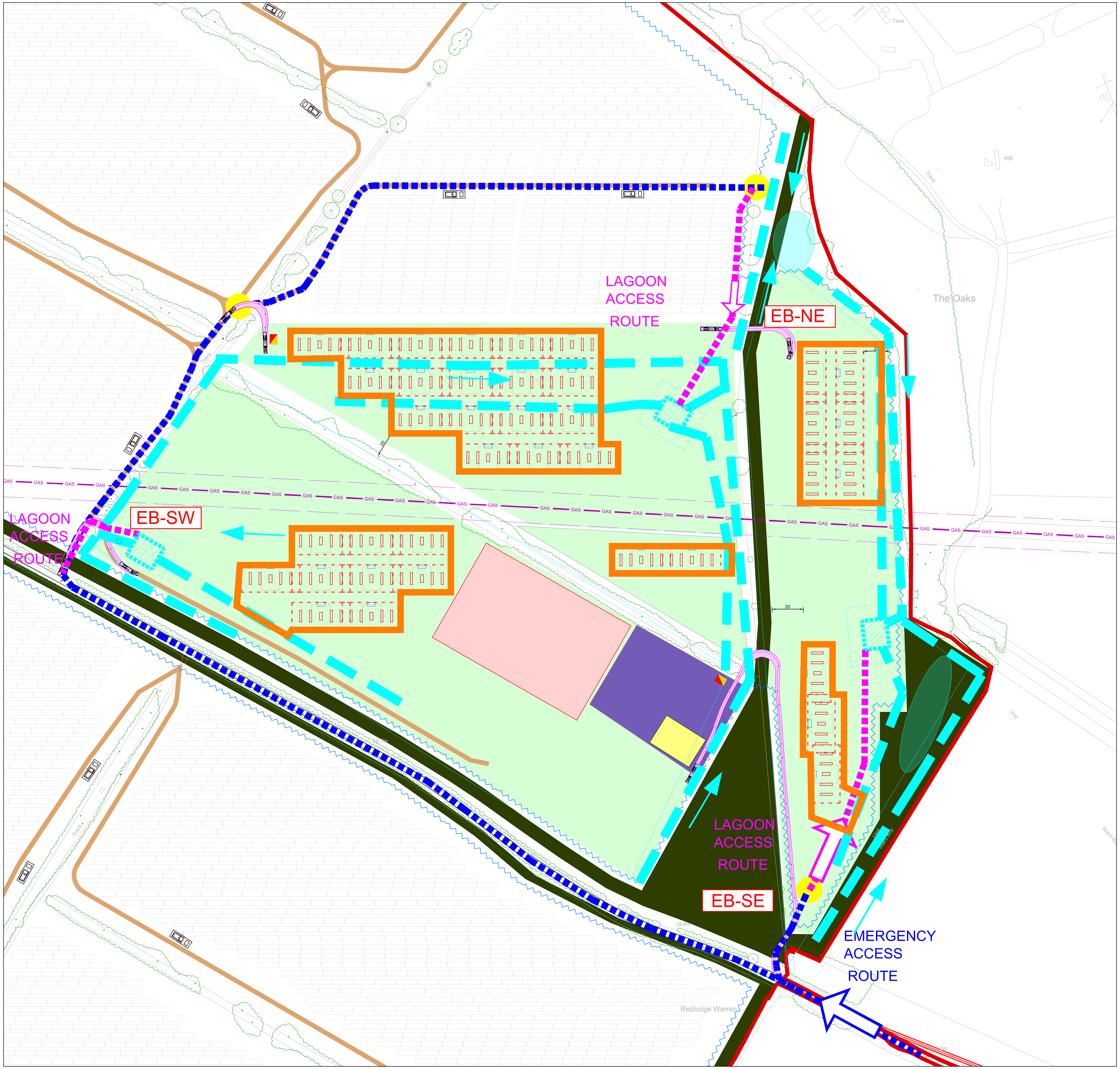


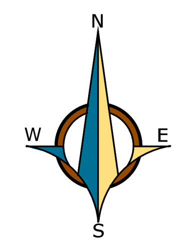
WIND ROSE STUDY FOR STANSTED AIRPORT

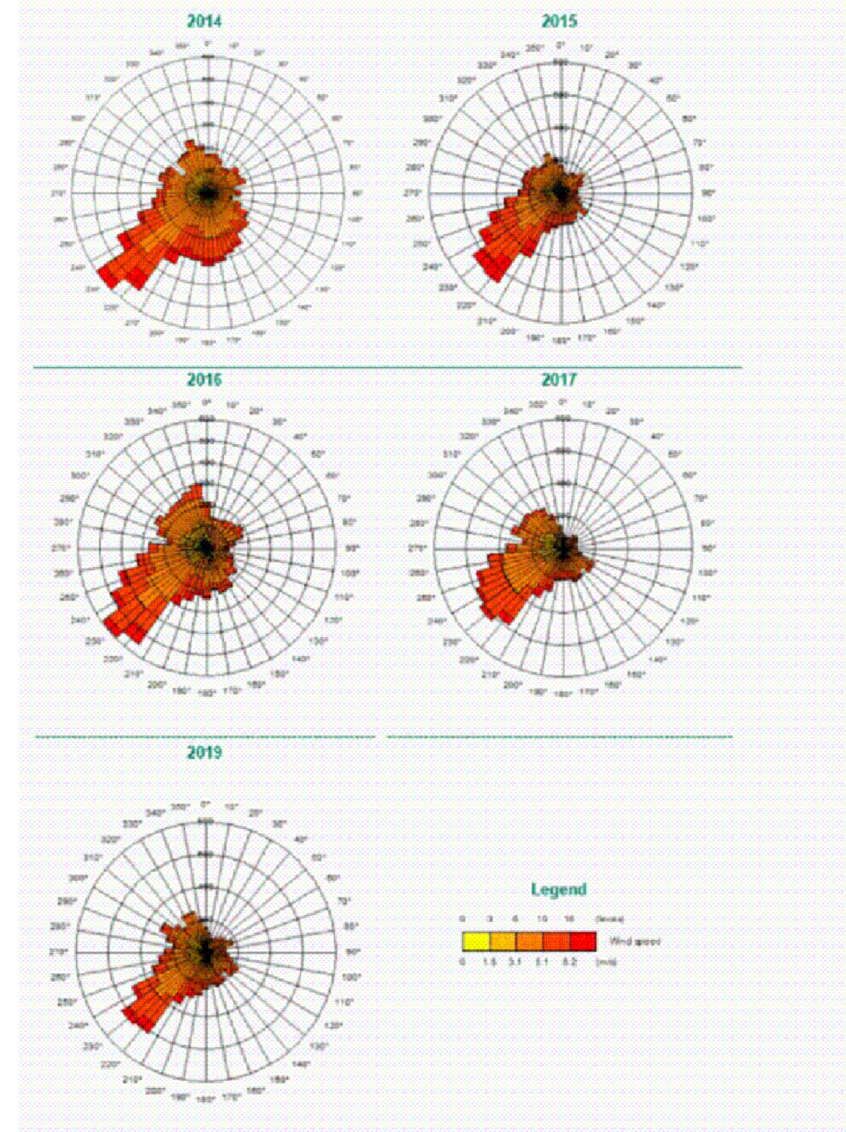
- INTERNAL PV ROAD
- TREE CANOPIES HEDGEROWS AND FOLIAGE
- PROPOSED HEDGEROWS
- PROPOSED WOODLAND
- AREAS OF HARDSTANDING
- BATTERY COMPOUND AREA
- SUBSTATION
- WAREHOUSE
- ORDER LIMITS
- FENCE
- BESS SOLUTION OPTION 1
- SPRINKLERS'S WATER TANK
- EXTERNAL FIRE FIGHTING WATER TANKS
- EMERGENCY ACCESS ROUTE
- VIEWING AREA FOR FIRE TEAM
- W-SE — INDICATIVE ACCESS POINTS
- LAGOON ACCESS ROUTE
- DRAINAGE SYSTEM
- BUNDED LAGOON
- INFILTRATION BASIN
- IMPERMEABLE AREA (part of drainage system)

PS Renewables
Green Energy Investments

PROJECT:	SUNNICA ENERGY FARM DEVELOPMENT CONSENT ORDER (DCO)			
COMPANY:	PS RENEWABLES			
LAYOUT:	Sunnica East Site A – Illustrative BESS layout			
DRAW BY:	Sergio Serna	PS RENEWABLES: 5 Stubbings Estate Maidenhead, Berkshire SL6 6QL	DATE:	18/08/2022
DESIGN BY:	Nacho Perez - Laura Picazo		SCALE:	1:1.500
CHECK BY:	David Ortiz		SIZE:	A1







WIND ROSE STUDY FOR STANSTED AIRPORT

- INTERNAL PV ROAD
- TREE CANOPIES HEDGEROWS AND FOLIAGE
- PROPOSED HEDGEROWS
- PROPOSED WOODLAND
- AREAS OF HARDSTANDING
- BATTERY COMPOUND AREA
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- BESS SOLUTION OPTION 1
- SPRINKLERS'S WATER TANK
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- EMERGENCY ACCESS ROUTE
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- W-SE INDICATIVE ACCESS POINTS
- LAGOON ACCESS ROUTE
- DRAINAGE SYSTEM
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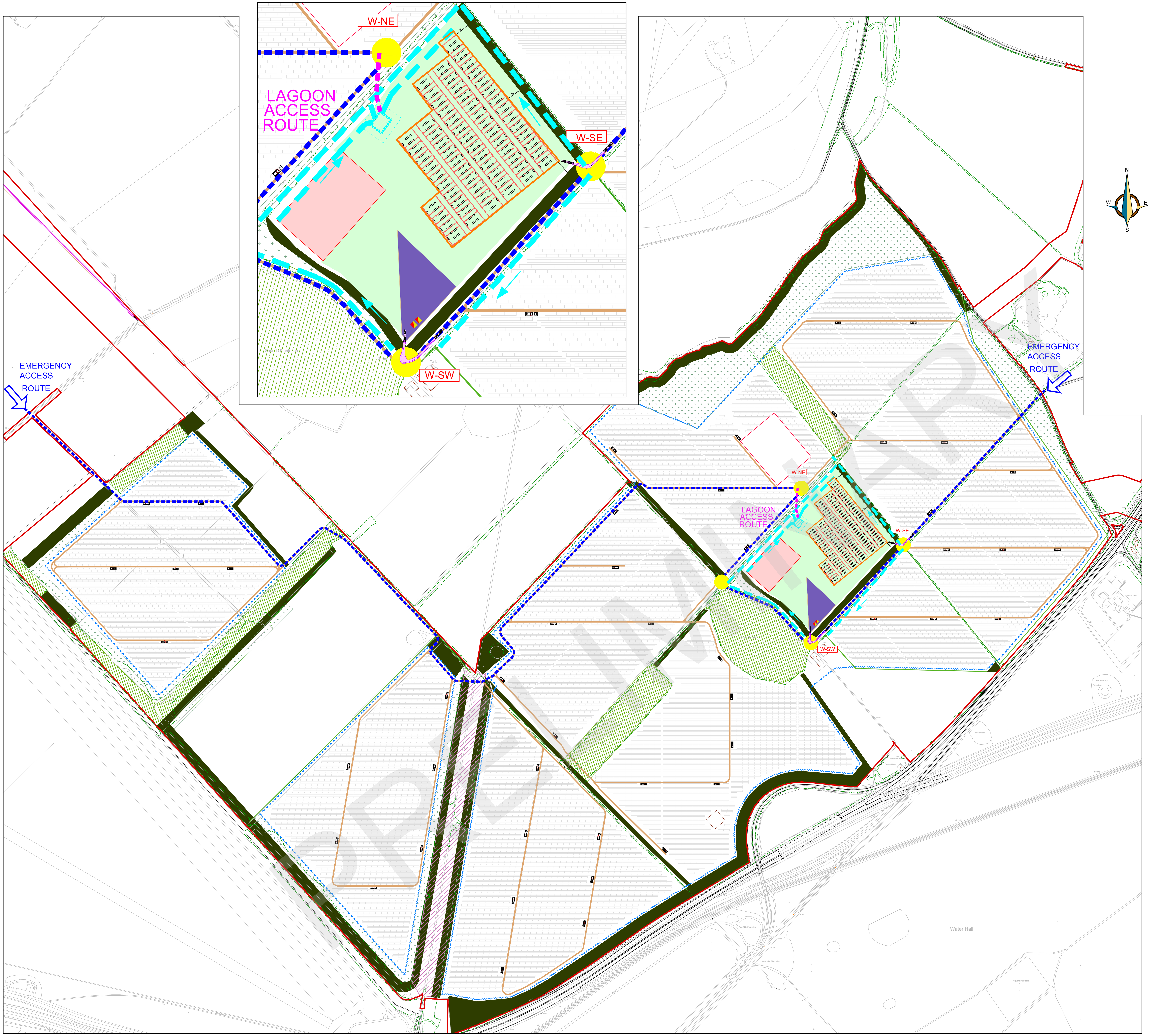
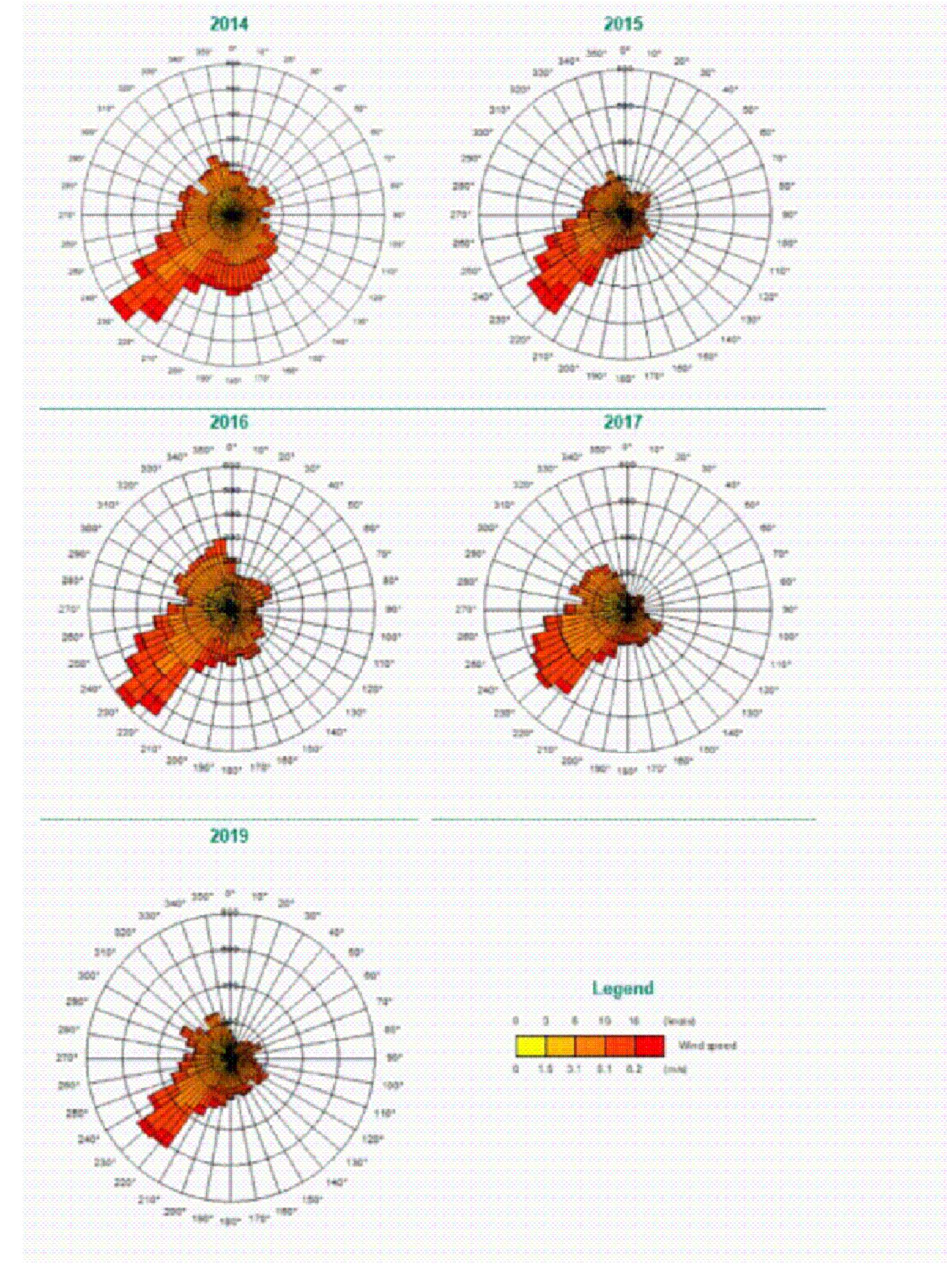
- INFILTRATION BASIN
- IMPERMEABLE AREA (part of drainage system)

PS Renewables
Green Energy Investments

PROJECT:	SUNNICA ENERGY FARM DEVELOPMENT CONSENT ORDER (DCO)			
COMPANY:	PS RENEWABLES			
LAYOUT:	Sunnica East Site B – Illustrative BESS layout			
DRAW BY:	Sergio Serna	PS RENEWABLES: 5 Stubbings Estate Maidenhead, Berkshire SL6 6QL	DATE:	18/08/2022
DESIGN BY:	Nacho Perez - Laura Picazo		SCALE:	1:1.500
CHECK BY:	David Ortiz		SIZE:	A1

Appendix B Indicative BESS Compound Layout Designs – Technology 2





WIND ROSE STUDY FOR STANSTED AIRPORT

- INTERNAL PV ROAD
- TREE CANOPIES HEDGEROWS AND FOLIAGE
- PROPOSED HEDGEROWS
- PROPOSED WOODLAND
- AREAS OF HARDSTANDING
- BATTERY COMPOUND AREA
- SUBSTATION
- ORDER LIMITS
- FENCE
- BESS SOLUTION OPTION 2
- CUSTOMER SWITCHROOM
- EXTERNAL FIRE FIGHTING WATER TANKS
- EMERGENCY ACCESS ROUTE
- VIEWING AREA FOR FIRE TEAM
- W-SE — INDICATIVE ACCESS POINTS
- LAGOON ACCESS ROUTE
- DRAINAGE SYSTEM
- BUNDED LAGOON
- INFILTRATION BASIN
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PS Renewables
Green Energy Investments

PROJECT:	SUNNICA ENERGY FARM DEVELOPMENT CONSENT ORDER (DCO)				
COMPANY:	PS RENEWABLES				
LAYOUT:	Sunnica WEST A – Illustrative BESS layout				
DRAW BY:	Sergio Serna	PS RENEWABLES: 5 Stubbings Estate Maidenhead, Berkshire SL6 6QL		DATE:	18/08/2022
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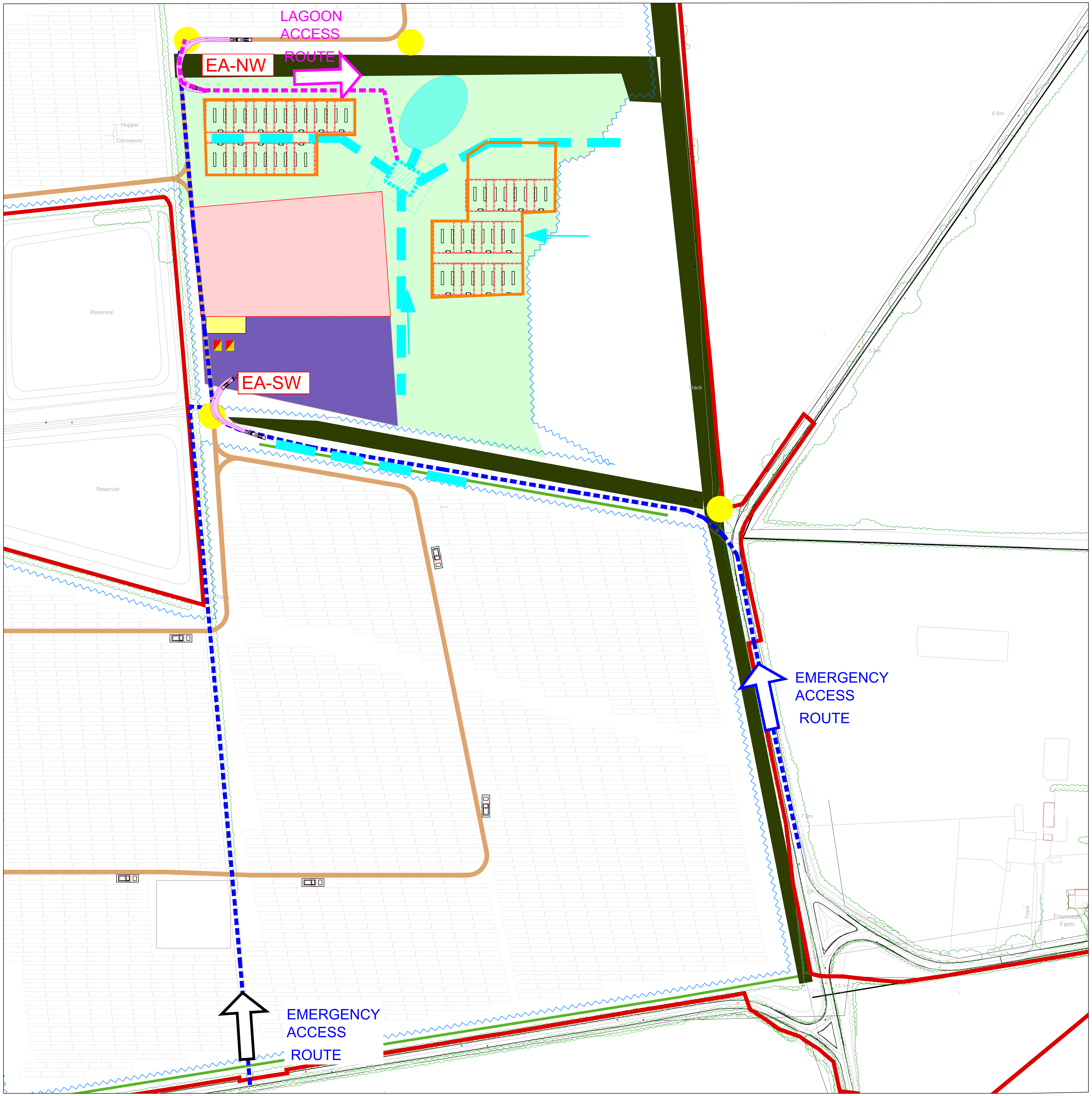

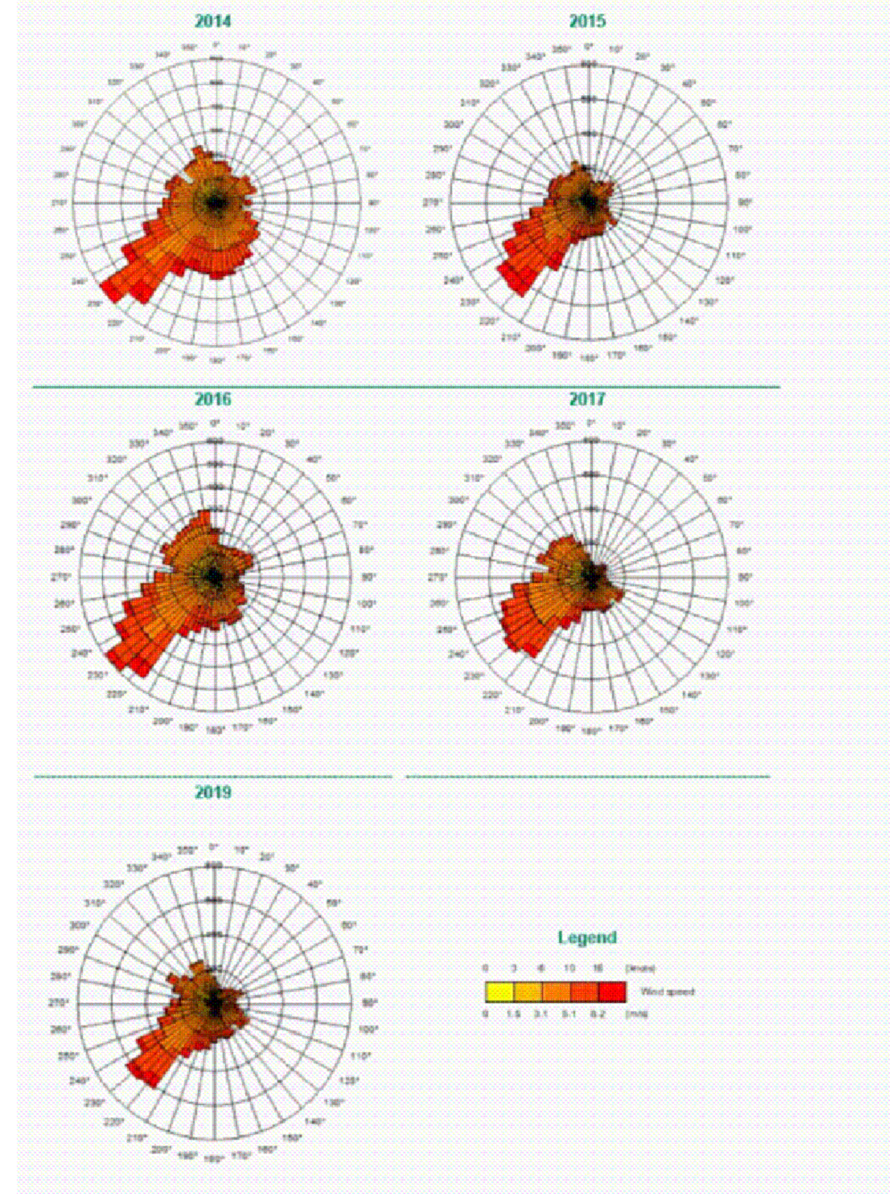

WIND ROSE STUDY FOR STANSTED AIRPORT

- INTERNAL PV ROAD
- TREE CANOPIES HEDGEROWS AND FOLIAGE
- PROPOSED HEDGEROWS
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- BUNDED LAGOON
- INFILTRATION BASIN
- IMPERMEABLE AREA (part of drainage system)

PS Renewables
Green Energy Investments

PROJECT:	SUNNICA ENERGY FARM DEVELOPMENT CONSENT ORDER (DCO)			
COMPANY:	PS RENEWABLES			
LAYOUT:	Sunnica EAST A – Illustrative BESS layout			
DRAW BY:	Sergio Serna	PS RENEWABLES: 5 Stubbings Estate Maidenhead, Berkshire SL6 6QL	DATE:	18/08/2022
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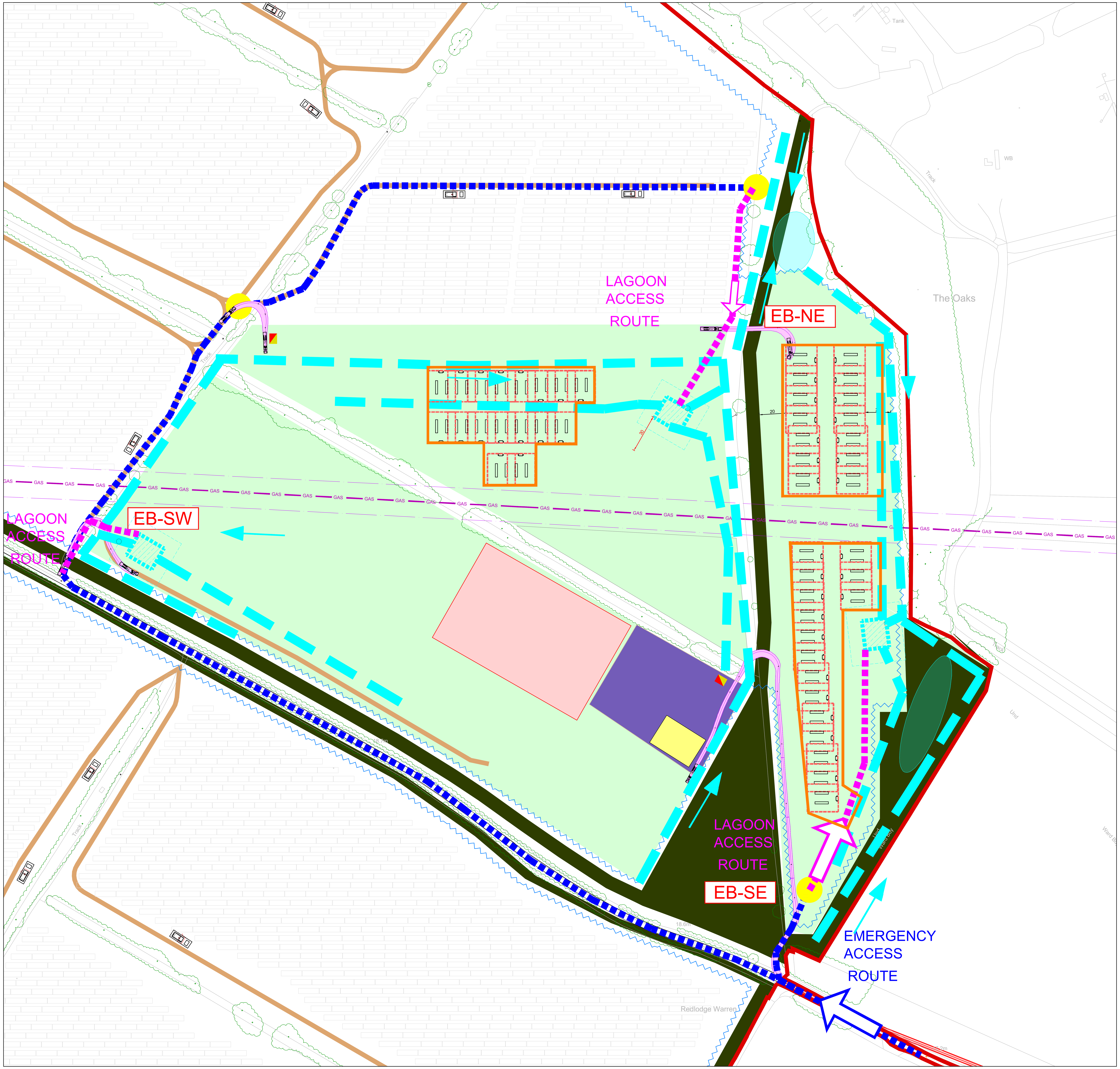

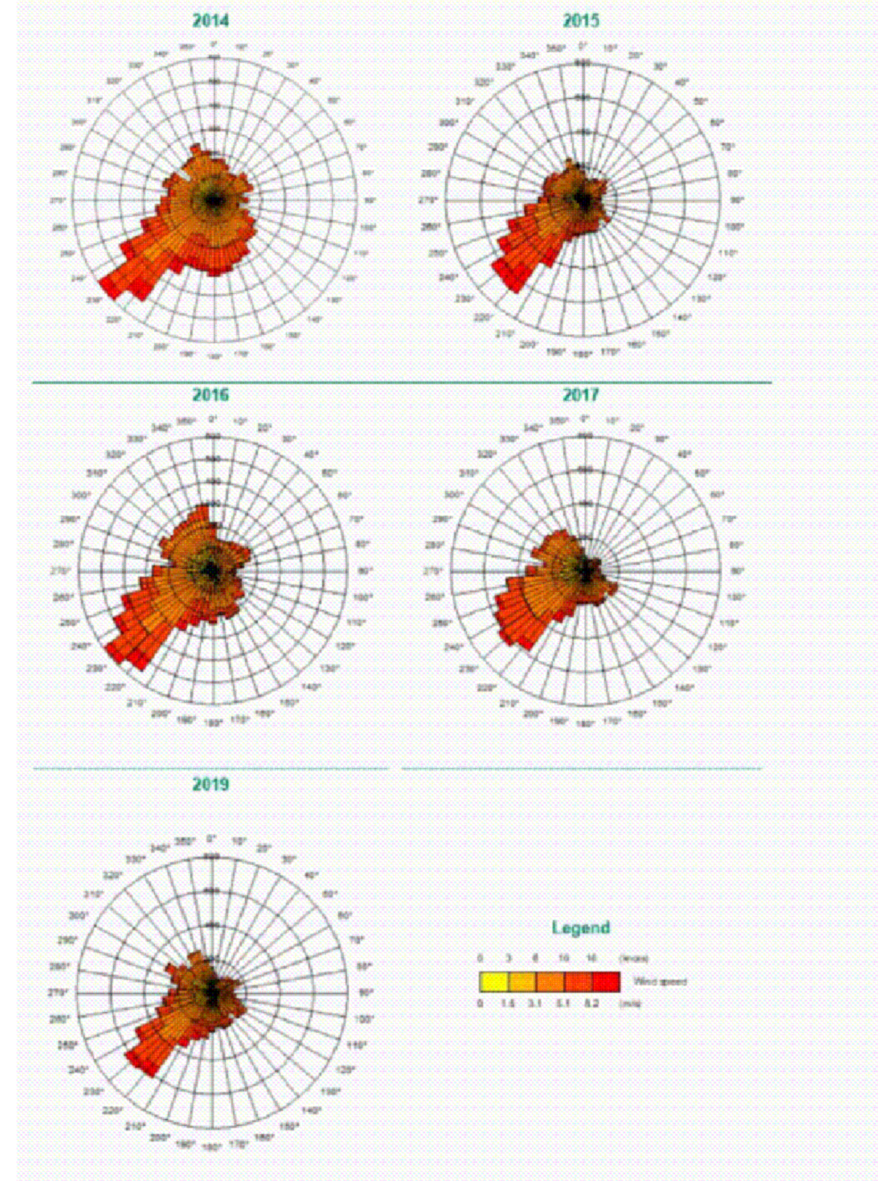

WIND ROSE STUDY FOR STANSTED AIRPORT

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PS Renewables
Green Energy Investments

PROJECT:	SUNNICA ENERGY FARM DEVELOPMENT CONSENT ORDER (DCO)			
COMPANY:	PS RENEWABLES			
LAYOUT:	Sunnica EAST B – Illustrative BESS layout			
DRAW BY:	Sergio Serna	PS RENEWABLES: 5 Stubbings Estate Maidenhead, Berkshire SL6 6QL	DATE:	18/08/2022
DESIGN BY:	Nacho Perez - Laura Picazo		SCALE:	1:1.000
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Appendix C Professional experience for Paul Gregory

Professional History
Paul is a specialist battery safety and testing consultant whose areas of expertise include: safety & mitigation strategies, validation & abuse testing, risk assessment & training, operations & battery systems sanity checking. Paul's recent projects have included full scale battery abuse and validation testing, design consultancy for battery abuse / suppression testing facilities, testing and validation of BESS safety equipment, test review and planning consultant for fire / explosion tests for a variety of battery application suppression systems. Multi-application experience of testing a variety of high energy density lithium battery (both primary and secondary) technologies. Paul has a detailed understanding of new battery technologies, safety codes and regulations, application performance requirements and key safety and mitigation factors.

Several key projects are NDA protected - examples of recent projects that can be shared are listed below:

- **Johnson Controls International (JCI) Lithium-ion Battery (LIB) Working Group, Review Board Member (2022) - Lead for test planning and data review (BESS and EVs):** Lead test consultant for JCI's large scale battery abuse and suppression testing program. Paul has put together a large ongoing program of performance tests for water and aqueous suppression agents on a wide range of battery systems and chemistries.
- **Fire & Rescue New South Wales, Safety of Alternative and Renewable Energy Technologies (SARET) – Test Planning Review Board Member (2022)**: Lead member of Test Planning Review Board to assist in development of abuse and suppression test programs for a range of high-risk LIB applications including BESS.
- **UL & ISO, Stationary Energy Storage Systems Working Group member:** Member of the BESS first responder working group who are working to devise and implement international ISO safety protocols and signage for BESS emergency incident response.
- **Northvolt, consultant for BESS system validation and certification to UL 9540A (2021-2023):** Lead consultant to advise on key safety codes and regulations for BESS system validation and certification (UL 1973, UL 9540, UL 9540A, NFPA 855). Paul is also part of the consultant team to plan and implement large scale 3rd party fire & explosion testing. Paul is assisting Northvolt in developing new testing procedures to quantify the performance of their BESS system mitigation solutions which will be 3rd Party certified in the US and Europe.
- **EaglePicher production facilities risk assessment and suppression system evaluation testing (2019-2023):** Lead for US project team tasked with comprehensive risk assessment of EaglePicher battery production facilities. Member of working group to establish rigorous test program of suppression system / suppression agent evaluation testing. EaglePicher required effective suppression / mitigation solutions for both primary and secondary lithium battery cells / packs. EaglePicher specialises in high energy density battery production used in specialist applications for NASA and the US military.
- **Gridserve, Solar & BESS systems for utility scale energy / EV charging (2022):** Lead battery safety consultant for a variety of ongoing UK projects, advising on battery safety standards, global fire code compliance, BESS site design risks and Emergency Response Plan (ERP) drafting. Responsible for sanity checking all battery and fire safety performance test results and advising on additional mitigation or retrofit / remedial actions (if required).
- **Trina Solar, BESS system safety (2022):** Lead battery safety consultant responsible for risk assessing Trina' partner Battery OEM BESS systems and drafting Emergency Response Plans (ERP). This involves comprehensive risk assessments of battery systems and analysis of UL / 3rd Party large scale abuse testing to establish if further safety testing should be conducted by the battery OEM. Paul is helping Trina establish new independent testing protocols to further identify fire and explosive risks which could impact on BESS site design parameters e.g., suppression system design selection, BESS enclosure spacing, BESS electronic control capabilities, gas exhaust design review, HVAC capabilities, etc.
- **Pointer Fire & Security, Utility scale BESS projects (2021)**: Lead consultant responsible for extensive sanity checks of all BESS suppression, detection and monitoring equipment used by Pointer for utility scale BESS projects. Paul provided BESS fire and explosion risk safety training for key Pointer BESS project workers together with an introduction to key BESS global safety codes and testing requirements.

- **AVD fire suppression agent development (2016-2019), North America**: Paul's primary focus was LIB project and test planning development in North America. The role encompassed: application risk research, strategic planning, regulatory certification and compliance testing, establishing a large scale battery fire test facility, suppression system hardware development, lithium battery pack risk assessment, Thermal runaway detection and prevention, LIB application suppression system / mitigation solution performance testing, leading battery application working groups to cover all areas of risk assessment, mitigation, passive protection and suppression solutions.

  Examples of project experience: military grade primary lithium battery packs, high energy density Lithium-Ion battery designs, effective mitigation, and suppression strategies for LIB applications e.g., battery production and storage, EV production, BESS applications, battery testing facilities & equipment protection, aviation applications. Identifying & testing passive protection products, suppression agent comparison performance testing in variety of LIB applications. Project partners included: **Jensen Hughes, ESPEC, Collins Aerospace, EnerSys, NEC Energy Solutions, General Motors, US Navy, UL, TUV SUD, IATA, Kidde, Hiller, APi Group**