Technical Appendix 3.3: BESS Fire Risk Statement

Windburn Wind Farm

Windburn Wind Farm Limited

2 Walker Street, Edinburgh, EH3 7LA

Prepared by:

SLR Consulting Limited

St. Vincent Place, Glasgow, G1 2EU

SLR Project No.: 428.07767.00009

2 June 2025

Revision: 01

Making Sustainability Happen

Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
01	2 June 2025	A. Smith	F. Mackenzie	A. Smith

Table of Contents

1.0 Introduction

1.1 This document forms the Battery Energy Storage System (BESS) Risk Statement for Windburn Wind Farm (the proposed development). This document sets out how the proposed development has considered the risk of fire, with regards BESS, how that has factored into the site design, and mitigation measures proposed.

1.2 This document is not intended as a detailed Fire Risk Management Plan. This document sets out monitoring and mitigation measures based on the current understanding of fire risk from battery storage technology.

2.0 BESS Technology

2.1 Fundamentals and System Components

2.2 Lithium-ion batteries have become dominant as a rechargeable energy storage technology, due to their high energy density, long lifespan and light weight. They are widely used in consumer electronics and electric vehicles, as well as larger scale stationary energy storage applications. BESS technology is constantly evolving therefore the technology used as part of the proposed development may be Lithium-ion, or another technology available at the time. For the purposes of this document, it is assumed that Lithium-ion batteries will be used in the BESS that forms part of the proposed development.

2.3 Lithium-ion batteries function by moving lithium ions through an electrolyte between an anode and cathode during charging and discharging. The anode is typically made from graphite, and the cathode is composed of a lithium-based material. During discharge, lithium ions move from the anode to the cathode, releasing energy. The key components of a Lithium-ion cell are:

- Anode: Typically graphite or silicon;
- Cathode: Composed of various materials, in this case lithium iron phosphate:
- Separator: Avoids direct contact between anode and cathode, allowing only ions to pass through; and
- Electrolyte: A lithium salt dissolved in an organic solvent.

2.4 The main components of a BESS are as follows:

- Batteries: The battery is composed of single cells, which can be arranged into e.g. battery modules or battery packs;
- Power Conversion System (PCS): The PCS is a bi-directional inverter that converts direct current (DC) stored by the batteries, to alternating current (AC) for the grid, or AC from the onsite generation or grid to DC for charging the batteries;
- Battery Management System (BMS): This component is responsible for the correct operation and safe functioning of the battery. The BMS maintains each battery cell within the required operational voltage, current and temperature range. The BMS also estimates the State of Charge (SoC) and State of Health (SoH) of the battery;
- Energy Management System (EMS): The EMS is responsible for the control of the BESS and plays a crucial role in managing the charging and discharging process with the purposes of optimising system performance and BESS longevity, amongst others; and
- Safety Systems: These includes systems such as cooling and heating, air conditioning, fire suppression, smoke detection, etc. A monitoring and control system will be responsible for the safe operation of the BESS and prevent fire or other hazardous events.

3.0 The Proposed Development

3.1 The proposed development would comprise 13 three-bladed horizontal axis turbines up to 149.9m tip height with a combined rated output in the region of approximately 65MW. The proposed development would include associated infrastructure including turbine foundations, crane hardstandings, new access tracks, underground cabling, and a substation compound including a control building and up to 35MW of battery storage.

3.2 The 35MW of battery storage would therefore be located within the substation compound for the proposed development (see **Figure 1**).

3.3 Battery Energy Storage System (BESS)

3.4 The 35MW BESS included as part of the proposed development is anticipated to comprise of 14 battery storage containers, each with a capacity of 2.5MW. The battery storage containers would also house the power conversion systems, inverters and transformers.

3.5 The battery storage containers are anticipated to measure approximately 12m (l) x 5m (w) x 4m (h) (see **Figure 2**).

3.6 Design Factors

3.7 The National Fire Chiefs Council (NFCC) Grid Scale Battery Energy Storage System planning – Guidance for Fire and Rescue Services (FRS), Version 1.0, was published in November 2022 (a revision to this guidance is currently expected to be published in 2025).

3.8 **Table 4-1** sets out how the BESS proposals that form part of the proposed development have taken on board the NFCC guidance where possible and practical.

Table 4-1: NFCC Guidance and the Proposed Development (BESS)

Guidance Area	Guidance	Proposed Development
Site Access	At least two separate access points to the site to account for opposite wind conditions/direction.	The substation compound (and BESS) has one main access point off the Sheriffmuir road. The spur off the Sheriffmuir road, to the substation compound, can be accessed from two directions – from the north east, and from the south west. The substation compound (and BESS) is located within a field which can be entered via existing gated entrance, thus providing additional access options.
Spacing between BESS units	A standard minimum spacing of 6 metres between containers unless suitable design features can be introduced to reduce that spacing.	The current substation compound footprint is considered to have sufficient room to accommodate adequate separation distances between BESS units, or to

Guidance Area	Guidance	Proposed Development
		accommodate safety mitigation to reduce spacing requirements.
Distance from BESS units to occupied buildings & site boundaries	25m	The substation compound (and BESS) is located in excess of 600m from the nearest occupied building. The substation compound (and BESS) is located in excess of 30m from both the field boundary and application boundary.
Combustible vegetation clearance	10m	The substation compound (and BESS) is located in excess of 80m from woodland or other combustible vegetation.
Flooding, Water run-off / Water Supply / Water Storage	Consideration should be given, within the site design, to the risk of flooding, management of water run-off, water supply and water storage.	The substation compound (and BESS) is located in excess of 200m from the nearest watercourse. Requirements for the management of water run-off, water supply and water storage Will be complied with during detailed design.

3.8.1 Battery Cells and Modules

3.9 The battery modules shall demonstrate compliance with following standards:

- Underwriters Laboratories (UL) 9540A: This involves tests for thermal runaway propagation to ensure that the fire risk within a module or between battery cells is minimized and contained. This standard demonstrates that thermal runaway propagation does not spread between modules generating potentially explosive gases, such as hydrogen for Lithium-ion cells. This would otherwise result in a potential hazard for the battery container's integrity.
- UL 1973: This covers safety for stationary battery systems, testing for mechanical integrity, electrical faults and thermal fatigue in Lithium-ion cells.
- International Electrotechnical Commission (IEC) 62619: International standard for rechargeable battery safety in industrial applications, focusing on preventing thermal runaway, overcharging, and electrical safety.
- United Nations (UN) 38.3: Transportation safety standard, ensuring that Lithium-ion batteries can safely withstand mechanical shocks, pressure, and temperature extremes during transit.

3.9.1 Battery Enclosures

3.10 The enclosures shall demonstrate compliance with following standards:

- UL 9540, Underwriters Laboratories: Governs the system-level safety of the entire energy storage system, ensuring enclosures protect components from environmental hazards and electrical faults.

- NFPA 68, National Fire Protection Association: This refers to the "Standard on Explosion Protection by Deflagration Venting," which focuses on designing systems to protect against explosions, specifically by allowing deflagration to vent safely without catastrophic damage to equipment or facilities.
- IEC 60529 International Electrotechnical Commission: Provides ingress protection (IP) ratings for electrical enclosures, determining resistance to water, dust, and accidental contact.
- BS EN 13501-2, British standards: European standard for the fire resistance of building materials, ensuring BESS enclosures and partitions provide adequate containment during fire events.
- NFPA 855 requirement states that fire-rated barriers be established between the BESS units and adjacent areas:
  - 1-hour fire resistance rating for barriers within BESS installations or between individual BESS compartments; and
  - 2-hour fire resistance rating for walls separating BESS from other occupancies or critical infrastructure.

3.10.1 Cooling and Venting Systems

3.11 The cooling and ventilation systems shall demonstrate compliance with following standards:

- ASHRAE 90.1, American Society of Heating, Refrigerating and Air-Conditioning Engineers: Standards for the energy-efficient design of buildings, including proper cooling and ventilation for energy storage systems to manage heat generated by Lithium-ion batteries.
- NFPA 69, National Fire Protection Association: Provides guidelines for prevention of explosion, focusing on managing gas buildup (e.g., hydrogen release from faulty Lithium-ion batteries) through proper ventilation and explosion venting systems. This standard focuses on preventing the explosion through methods like suppression, containment, inerting, or control of ignition sources.
- UL 9540A, Underwriters Laboratories: Includes testing for heat and gas management in energy storage systems to prevent explosions or fires caused by thermal runaway.

3.11.1 Fire Detection and Suppression

3.12 The fire detection systems shall demonstrate compliance with following standards:

- National Fire Protection Association (NFPA) 855: Provides fire safety requirements for the installation of energy storage systems, including Lithium-ion BESS, such as fire separation distances, suppression system requirements, and emergency planning.
- UL 9540: Focuses on system-level safety for energy storage systems, including fire protection measures for electrical components and enclosures.
- UL 9540A: Tests the system's ability to handle thermal runaway and limit fire propagation within and between battery modules.
- FM Global Datasheet 5-33: Offers guidelines for fire protection and hazard mitigation specific to Lithium-ion battery systems, including guidance on suppression systems for large battery arrays.

- Grid Scale Battery Energy Storage System planning - Guidance for FRS (2022) states that gaseous suppression systems have been proposed in the past. However, it indicates that based on research studies the installation of water-based suppression systems for fires involving cell modules are more effective.
- FM Global Research: States that cooling of the surroundings under a fire event is critical to protect the surrounding infrastructure but as well because it is currently not possible to extinguish a BESS fire with sprinklers. Furthermore, gaseous protection systems do not provide cooling of the BESS or the surrounding occupancy.

3.13 For the selection of the fire suppression system, in addition to the standards and compliance requirements, it is essential to base the choice on thorough risk assessments, environmental considerations, and the specific operational needs of the facility. The following aspects will need to be considered:

- Involvement of Fire Protection Engineer (FPE) who has experience in fire suppression systems.
- Calculation of the water supply requirements to ensure the flow rates and volumes needed for the type of suppression system selected and the potential for fire spread and the required coverage area. It shall be noted that the lack of sufficient water supplies at a particular site location should not be considered as the basis for a suppression system choice. The consideration of alternative solutions would need to be investigated.
- The water run-off management from the suppression system and its impact on the surrounding environment such as water sources, soil and nearby ecosystems. The investigation of measures to minimize potential environmental impacts would need to be assessed, e.g. containment basins or filtration systems.

3.14 Operation and Maintenance

3.14.1 Operational Requirements

3.15 The system operation shall be monitored to ensure optimal performance and identify any potential issues at an early stage. For the proposed BESS, the system shall monitor at least the following:

- Battery Management System (BMS) Operational Monitoring:
  - Ensure that battery cells and modules track the State of Charge (SoC), State of Health (SoH) and operating battery cell temperatures.
  - Ensure the system operates within safe voltage and current limits.
- Energy Management System (EMS) Operational Monitoring:
  - Monitoring of the charge discharge cycling to optimise system efficiency and revenue (e.g. energy arbitrage, frequency regulation, peak shaving).
  - Monitoring and control of the interaction between the BESS and the grid to ensure that the BESS provides the contracted grid services without compromising battery health.
- Remote Monitoring and Alerts: Provision of remote monitoring capabilities so that operators receive real-time alerts and can monitor plant status. This shall include an automatic monitoring system of key safety parameters such as: cell / module

overheating warnings, deep charge/discharges of the battery or system failures (e.g. the cooling system).

3.15.1 Maintenance Requirements

3.16 The preventative maintenance regime shall regularly require at least the following:

- Battery System
  - Visual examination: Periodical visual checks to identify potential damage, leakages or corrosion.
  - Thermal Inspection: Use of infrared thermography to identify potential hotspots, e.g. poor electrical connections.
  - Capacity Testing: This involves regular discharge tests to check the battery capacity and actual performance, ensuring the system still meets the expected energy output. The BS EN 62620 standard specifies the requirements for large scale Lithium-ion BESS in terms of capacity testing, safety, and battery performance. As an example, if a BESS system participates in the UK's Capacity Market, it is a typical requirement to provide yearly capacity tests and performance tests to demonstrate that the system can deliver the capacity for which it has been contracted.
  - Regular cleaning: This is to ensure that that battery terminals and general connections are clean to avoid poor connections.
- PCS
  - Battery inverter testing: The regular testing and recalibration of the inverters to guarantee the system efficiency and operational safety.
  - Firmware Updates: Regular software updates to ensure new releases or bug fixes are applied.
  - Visual examination: Undertake inspections to identify potential damage to connectors, cables, connectors, etc.
- Cooling and HVAC System Maintenance
  - Air filters maintenance: Ensure filters are regularly cleaned or replaced to guarantee optimal cooling performance.
  - Fans and Ventilation System Inspection: Inspect ventilation fans and airflow paths for blockages and ensure proper air circulation.
  - Coolant Levels: For liquid cooling systems, verify coolant levels and test for potential system leaks.
- Fire Suppression System Maintenance
  - Functional System Testing: This involves periodical fire tests to verify that the system performs as expected.
  - Smoke and Gas Detectors Testing: This involves periodical tests to verify early detection of any hazardous situations.
  - Alarm system testing: This involves periodical tests to confirm the alarm notification is triggered under a potential fire event.

4.0 Management / Safety Procedures and Further Consultation

4.1 It is recommended that a Battery Safety Management Plan be developed prior to the construction of the BESS facility. The Battery Safety Management Plan would include within it:

- An Emergency Response Plan;
- Site Plans and Maps;
- Maintenance Overview; and
- A Recovery Plan.

4.2 The content of the Battery Safety Management Plan should be agreed, prior to construction, in consultation with the Local Planning Authority (including input from the Environmental Health Officer) and the local Fire Service.

5.0 Conclusion

5.1 Effort has been made, regarding the BESS within the proposed development, to site the BESS in an appropriate location that adheres to relevant safety guidance (while also considering other environmental constraints).

5.2 It is anticipated that should the proposed development be granted consent, that further detailed design work on the BESS would be required.

5.3 Prior to construction of the BESS, a Battery Safety Management Plan should be agreed in consultation with the Local Planning Authority (including input from the Environmental Health Officer) and the local Fire Service.

Figures

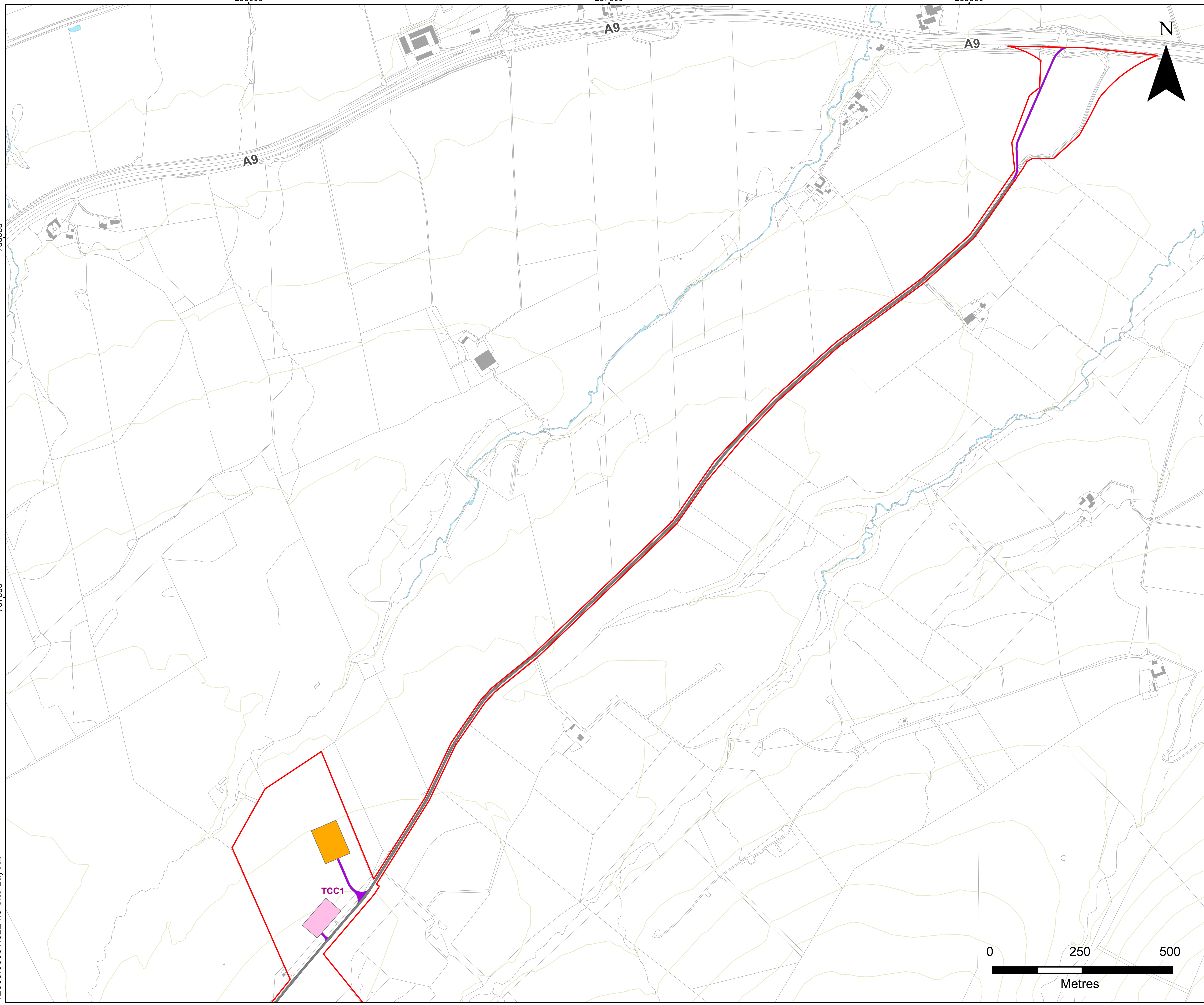
BESS Fire Risk Statement

Windburn Wind Farm

Wind 2 Limited

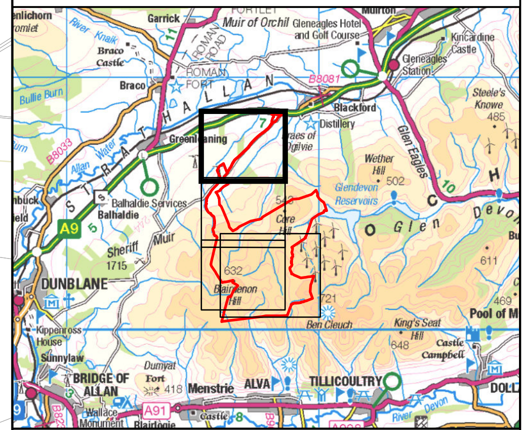
SLR Project No.: 428.V12959.00001

2 June 2025



LEGEND

- Application Boundary
- Proposed Substation Compound
- Proposed Temporary Construction Compound (TCC)
- Proposed Access Track
- Existing Road (To Be Upgraded)



WINDBURN WIND FARM LTD

SLR

WINDBURN WIND FARM

BESS FIRE RISK STATEMENT

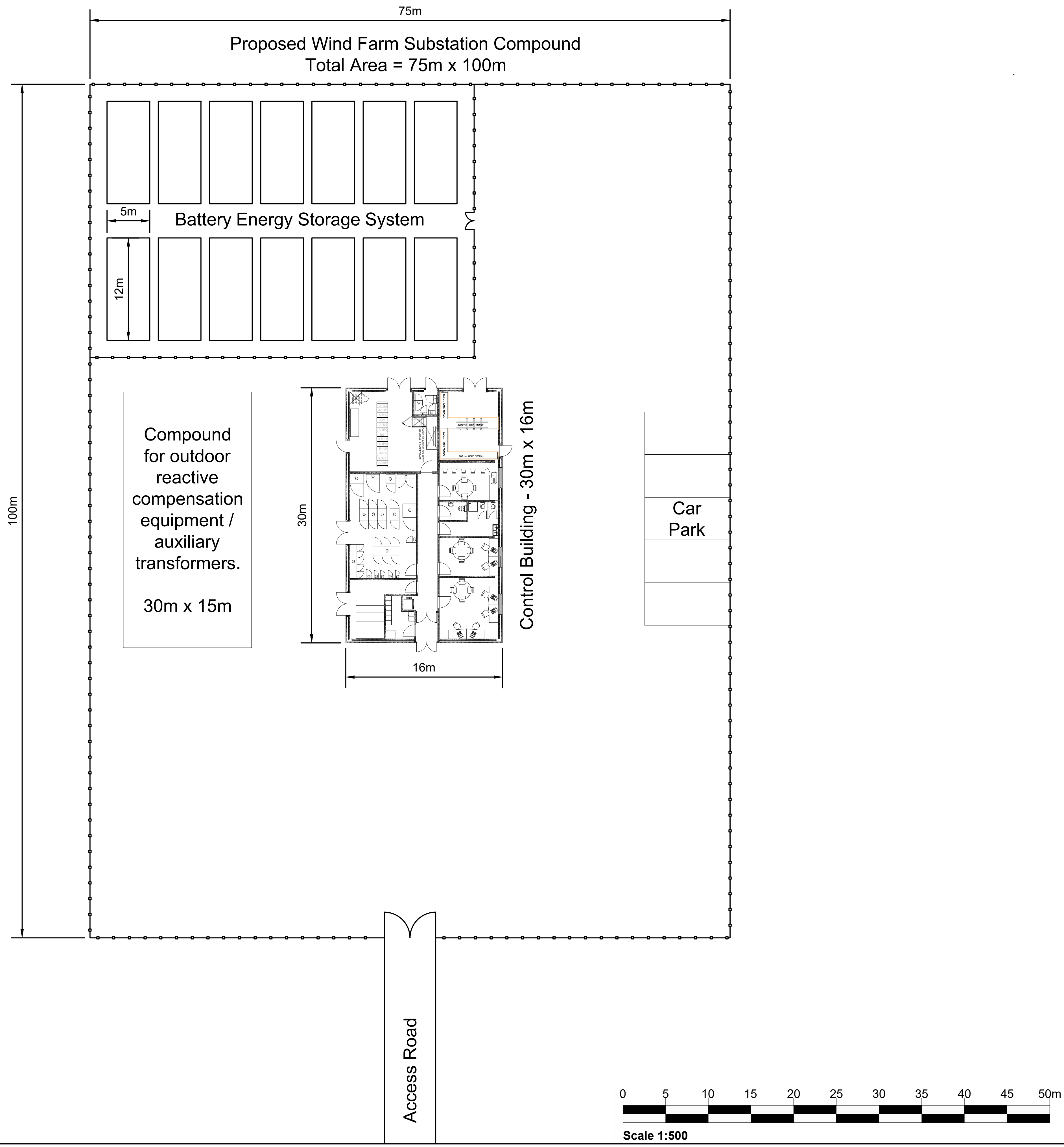
SUBSTATION COMPOUND

FIGURE 1

Scale 1:10,000 @ A3

Date MAY 2025

12959.00001.0224.0 Site Layout



LEGEND

Rev	Date	Comments	Drawn	Reviewed	Approved
0	April 2024	Preliminary Issue.	KW	MM	AS

WINDBURN WIND FARM LTD

SLR

WINDBURN WIND FARM

BESS FIRE RISK STATEMENT

INDICATIVE SUBSTATION COMPOUND AND BESS LAYOUT

FIGURE 2

Scale	Date
1:500 @ A3	MAY 2025

428.12959.00001.FIG-3.7.0_Ind_Substation_Compound.dwg

Making Sustainability Happen