

TYDD BATTERY ENERGY STORAGE SYSTEM

land off Guanockgate Road, Sutton St. Edmund, Cambridgeshire PE13 4PL

(BESS & Solar Farm)

FIRE STRATEGY REPORT – RIBA STAGE 2

Audit Sheet

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Revision	Description	Date	Issued by	Reviewed by
00	Fire Strategy Report - Stage 2 Concept Design	29/02/24	CE	AS
01	Fire Strategy Report - Stage 2 Concept Design	15/05/24	CE	AS
02	Fire Strategy Report - Stage 2 Concept Design	28/05/24	CE	AS

*This document has been
checked by:*

*Alina Scarlat
Ealing Cross
85 Uxbridge Road
London
W5 5BW*

Tel : 07833536416

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1. INTRODUCTION

1.1 Brief

The purpose of this report is to provide a fire engineering assessment and fire safety strategy for the proposed Battery Energy Storage System & Solar Farm facility located near Gorefield and Sutton St Edmund in both Lincolnshire and Cambridgeshire. The proposed site will occupy approximately 141.6 hectares of land. The site will consist of solar panels, a battery storage system and a small transformer station. This report has been developed using the site plan issued by PACE. Please refer to Figure 1 below.

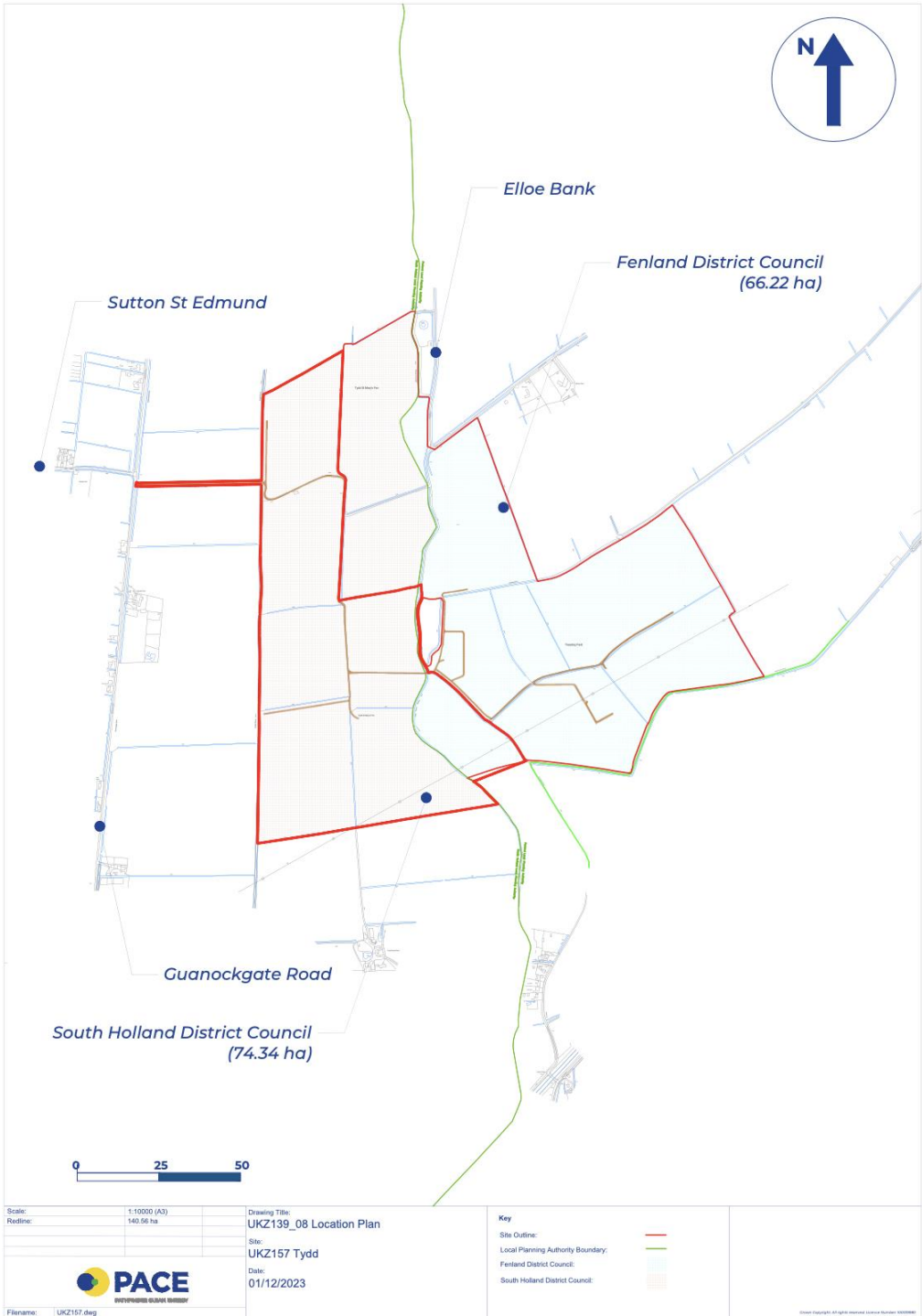


Figure 1 - Site Plan - 30 MW storage BESS and solar panels farm

The site is known as Tydd Battery Energy Storage System (BESS). The BESS is located at the following distances to the nearest structures:

- Property A: 829m
- Property B: 894m
- Property C: 869m
- Property D: 1,192m
- Property E: 1,058m
- Property F: 955m
- Property G: 897m



Figure 2 - Solar PV panels distance to structures

The proposed facility features 35 containers for batteries and transformer station.

The layout of the BESS containers is to be developed in such a way in which the recommended 6m distances is complied with. In the situation in which two containers are installed back-to-back or side-by-side, the dividing wall(s) will be offered with 120 minutes fire performance – this is subject to the local fire brigade agreement.

This report focuses on the mitigation elements added to the facility and the ways in which a possible fire incident is contained within the facility area demise.

1.2 Statutory guidance - Legislation and guidance for fire safety

Solar Panels Farms (SPF) and Grid scale Battery Energy Storage Systems (BESS) are a fundamental part of the UK's move toward a sustainable energy system. The installation of SPFs which have their own BESS systems both in the UK and around the globe is increasing at an exponential rate.

Currently in the UK there is no prescriptive legislation which regulates SPFs and BESS facilities, therefore, most of the fire engineering designers have turned to the American standards issued by the National Fire Protection Association (NFPA). Consequently, this report is based on the guidance described in NFPA 855 - Standard for the Installation of Stationary Energy Storage Systems in conjunction with the guidance issued by the National Fire Chiefs Council (the professional voice of the UK Fire and Rescue Services).

In addition to the guidance mentioned above, the development design will also consider the fundamentals of the Building Regulations 2010 with the latest amendments. However, it is to be noted that both SPFs and BESS facility falls outside of the scope of works described under the Building Regulations and it is classed as being an exempt building (Class 2) under Regulation 9, Schedule 2 of the Building Regulations, as per the extract below:

	SCHEDULE 2	Regulation 9
	Exempt Buildings and Work	
	CLASS 1	
	Buildings controlled under other legislation	
	1. Any building in which explosives are manufactured or stored under a licence granted under the Manufacture and Storage of Explosives Regulations 2005(1).	
	2. Any building (other than a building containing a dwelling or a building used for office or canteen accommodation) erected on a site in respect of which a licence under the Nuclear Installations Act 1965(2) is for the time being in force.	
	3. A building included in the schedule of monuments maintained under section 1 of the Ancient Monuments and Archaeological Areas Act 1979(3).	
	CLASS 2	
	Buildings not frequented by people	
	1. Subject to paragraph 2, a detached building—	
	(a) into which people do not normally go; or	
	(b) into which people go only intermittently and then only for the purpose of inspecting or maintaining fixed plant or machinery.	
	2. The description of buildings in paragraph 1 does not include a building where any point of the building is less than one and a half times its height from—	
	(a) any point of a building into which people can or do normally go; or	
	(b) the nearest point of the boundary of the curtilage of that building,	
	whichever is the nearer.	

1.2.2 The Regulatory Reform (Fire Safety) Order

Figure 3 - Building Regulations Extract - Regulation 9 - Schedule 2

Even though the facility falls outside of the Building Regulations scope, the site will have to comply with the fire risk assessment and fire management procedures in accordance with the Regulatory Reform (Fire Safety) Order. The Regulatory Reform (Fire Safety) Order (the RRO) was introduced to replace some previously applicable fire safety legislation, including the Fire Precautions (Workplace) Regulations and the Fire Precautions Act.

This legislation is based on risk-appropriate compliance and requires regular fire risk assessments to be carried out by the building management/owners/occupiers. The Fire Service will conduct inspections of

premises to enforce the Regulations. Whilst guidance documents have been produced by the government to assist in the preparation of the risk assessment, it should be noted that these documents are not intended to be used to design the building – the building design should focus on satisfying the functional requirements of the Building Regulations. The RRO provides Statutory Legislation to ensure that the ongoing maintenance and fire safety management of new premises will be maintained during the life of the building, which is not currently fully addressed under the Building Regulations. Therefore, the fire strategy detailed in this report does not explicitly address all the management requirements of the RRO. It will be necessary for effective fire safety management regimes to be developed by the building occupier, and a risk assessment of the premises to be conducted prior building occupation (and updated on an on-going basis).

Once the site work is finished and the facility will be handed over to the client, the client is required to employ a competent person to undertake the fire risk assessment and to detail the fire management plan for the operation of the facility.

1.2.3 Property Protection

Property Protection is not a requirement of the Building Regulations and, as this report deals only with statutory requirements, property protection is not explicitly addressed, although it is recognized that some fire safety provisions will inherently offer a degree of property protection to the building. As such, it is recommended that the building insurers are consulted at an early stage to ensure that any additional needs are satisfied.

1.2.4 Management Issues

This report primarily relates to the fire safety requirements needed to ensure that the building design satisfies the Building Regulations. However, it is recognised that fire safety management is critical to ensure the safety of the building occupants. Although some management issues may be discussed in this strategy document, it does not explicitly address all of the management needs of the development. **Prior to building occupation, a suitable management strategy should be developed by the relevant building management bodies to cover issues including:**

- Fire management structure;
- Evacuation procedures;
- Staff training;
- Housekeeping and fire prevention;
- Maintenance and control of fire safety systems;
- Conflicts between security and means of escape issues.

1.2.5 Document Limitations

It is important to note that the report does not represent a design or specification; it is a series of principle recommendations that others may consider and relate to the design of the scheme as appropriate. The information contained herein is strategic and does not address detailed aspects of design, such as construction details. The document needs to be updated through each remaining work stage in order to reflect developing and agreed strategies and relate to the design as the scheme progresses.

Note that any diagrams incorporated into this document are illustrative, intended to convey aspects of the

FSS (Fire Safety Strategy) and do not necessarily reflect the latest backgrounds. The diagrams are not a substitute for the architectural general arrangement drawings or the detailed M&E drawings or specifications, which should be referred to in conjunction with this report.

For clarity, the information herein does not specifically address:

- Insurance requirements
- Property or business protection
- Construction / fit-out fire safety

-
- Detailed management procedures or duties under the Regulatory Reform (Fire Safety) Order (RRO)

1.2.6 Certification

Construction materials and products should be provided with appropriate certification through a recognized testing house, to demonstrate compliance with the relevant British Standards, to the satisfaction of the relevant Building Control Authority.

2. FIRE ORIGIN AND PROPAGATION – DESIGN FUNDAMENTALS

Functional Requirements

An extract from “Safety of Grid Scale Lithium-ion Battery Energy Storage Systems” paper produced by Eurling Dr Edmund Fordham MA PhD CPhys CEng FInstP - Fellow of the Institute of Physics, Dr Wade Allison MA DPhil - Professor of Physics, Fellow of Keble College, Oxford University and Professor Sir David Melville CBE FInstP Professor of Physics, former Vice-Chancellor, University of Kent states:

“Li-ion batteries are dominant in large, grid-scale, Battery Energy Storage Systems (BESS) of several MWh and upwards in capacity. Several proposals for large-scale solar photovoltaic (PV) “energy farms” are current, incorporating very large capacity BESS. These “mega-scale” BESS have capacities many times the Hornsdale Power Reserve in S. Australia (193 MWh), which was the largest BESS in the world at its installation in 2017.

Despite storing electrochemical energy of many hundreds of tons of TNT equivalent, and several times the energy released in the August 2020 Beirut explosion, these BESS are regarded as “articles” by the Health and Safety Executive (HSE), in defiance of the Control of Major Accident Hazards Regulations (COMAH) 2015, intended to safeguard public health, property and the environment. The HSE currently makes no representations on BESS to Planning Examinations.”

Therefore, it is clear that the facilities should be provided with systems that will mitigate the risk, prevent a fire starting, mitigating the fire spread and explosion risk and firefighting facilities should also be provided in order to aid the firefighters in their intervention.

2.1 Basis of design - BESS

The proposed design includes PV solar panels and batteries outdoor racks (LFP lithium-ion batteries), central inverters and MV transformers for grid connection.

The containers will include battery racks with a total maximum capacity of 30 MW.

Lithium-ion (Li-ion) batteries are currently the battery of choice in the ‘electrification’ of our transport, energy storage, mobile telephones, mobility scooters etc. Working as designed, their operation is uneventful, but there are growing concerns about the use of Lithium-ion batteries in large scale applications, especially as Battery Energy Storage Systems (BESS) linked to renewable energy projects and grid energy storage. These concerns arise from the simple consideration that large quantities of energy are being stored, which if released uncontrollably in fault situations could cause major damage to health, life, property and the environment.

In accordance with the paper “Safety of Grid Scale Lithium-ion Battery Energy Storage Systems”, the main concerns regarding BESS facilities are as follows:

- 1) The potential for failure in a single cell (out of many thousands) to propagate to neighbouring cells by the process known as “thermal runaway”. Believed to be initiated by lithium metal dendrites growing internally to the cell, a cell may simply discharge internally releasing its stored energy as heat. Even sound Li-ion cells will spontaneously discharge internally if heated to temperatures which can be as low as 150 °C, releasing their stored electrical energy, thus overheating neighbouring cells and so on. Temperatures sufficient to melt aluminium (660 °C) at least have been inferred from analyses of such thermal runaway accidents. Eye-witness reports consistently speak of repeated “re-ignition” which is inevitable, even in the complete absence of oxygen, so long as the temperature anywhere exceeds the thermal runaway initiation threshold.
- 2) The emission of highly toxic gases – principally Hydrogen Fluoride – for prolonged periods, in the event of thermal runaway or other battery fires. At a minimum, respirators and complete skin protection would be required by any fire-fighters. Measures to protect the public from toxic plumes would also be necessary.

- 3) The emission of large quantities of highly inflammable gases such as Hydrogen, Methane, Ethylene and Carbon Monoxide even if a fire suppression system is deployed. These gases will be evolved from a thermal runaway accident regardless of such measures, with explosion potential as soon as they are mixed with air and in contact with hot surfaces. Such an explosion was the cause of the “deflagration event” at McMicken, Arizona in 2019 in a 2 MWh BESS, which critically injured four fire-fighters and was triggered simply by opening the cabin door.
- 4) The absence of any adequate engineering and regulatory standards to prevent or mitigate the consequences of “thermal runaway” accidents in Li-ion BESS.
- 5) The potential for thermal runaway in one cabin propagating to a neighbouring cabin. In Arizona [3] there were reports of “fires with 10-15 feet flame lengths that grew into 50 - 75 feet flame lengths appearing to be fed by flammable liquids coming from the cabinets”.
- 6) The significant volumes of water required to thoroughly cool the system in the event of a “fire”, and how this water will be contained and disposed of (since this will be contaminated with highly corrosive hydrofluoric acid and, therefore, must not be allowed to drain into the surrounding environment).

Such incidents are routinely and repeatedly described in the Press as “battery fires” though they are not “fires” at all in the usual sense of the word; oxygen is completely uninvolved. They represent an electrochemical discharge between chemical components that are self-reactive. They do not require air or oxygen at all to proceed.

Hence the traditional “fire triangle” of “Heat, Oxygen, Fuel” simply does not apply, and conventional fire-fighting strategies are likely to fail (Figure 10, over).

Thermal runaway events are uncontrollable except by cooling all parts of the structure affected – even the deepest internal parts – below 150 °C. This basically requires water, in large volumes.



Figure 11 The fire triangle and its relationship to thermal runaway

Figure 10: The traditional “fire triangle” does not apply to “thermal runaway”.

Figure 4 - Diagram of Fire Triangle -Figures 10 and 11 of Safety of Grid Scale Lithium-ion Battery Energy Storage System paper

2.1.1 Thermal runaway

Li-ion batteries are sensitive to mechanical damage and electrical surges, both in over-charging and discharging. Most of this can however be safeguarded by an appropriate Battery Management System (BMS) and mechanical damage (unless deliberate and malicious) should not be a hazard. Internal cell failures can arise from manufacturing defects or natural changes in electrodes over time; these must be regarded as unavoidable in principle. Subsequent escalation into major incidents can propagate from such apparently trivial initiation.

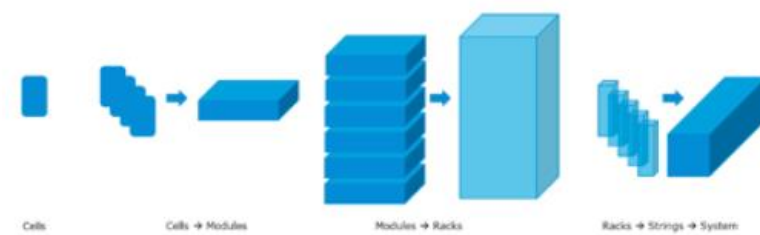


Figure 11: Cells stack into Modules; Modules into Racks; Racks into Strings; Strings into Systems.

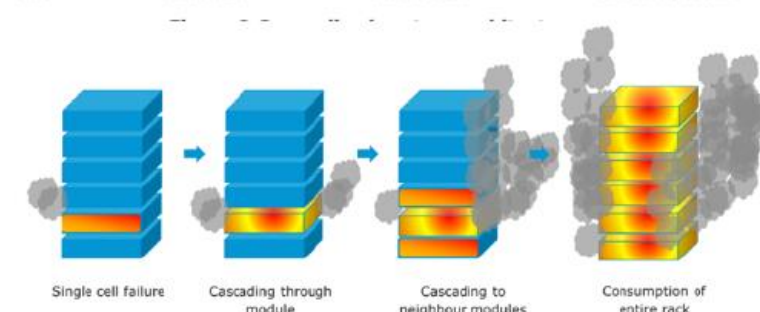


Figure 12: Propagation of single Cell failure through Module; cascade to entire Rack.

Figure 25 A single cell failure propagated through Module 2, then consumed the whole rack, releasing a large plume of explosive gases. This process could have occurred without visible flame, which would explain why the gases were not burned as they were emitted.

Figure 5 - Diagrams showing the Thermal Runaway - extract of the paper "Safety of Grid Scale Lithium-ion Battery Energy Storage System"

2.2 Basis of design – Solar panels

There are two principal types of PV system: roof top and ground mount systems. Rooftop systems range in size from a few PV modules (1 kWp) on a single dwelling, up to 5 MWp (several thousand PV modules) on larger warehouse-type applications.

Ground mount systems can range from a few kW up to several hundred MW and can cover huge expanses of land.

In the Tydd BESS site case, the latter type of PV panels are to be installed over 140 ha. The plant capacity is approximated to provide 30 MW which will be stored in the incorporated BESS, as described in the earlier sections.

2.2.1 Fire risk elements

In accordance with BRE National Solar Centre, "Where PV systems have been the cause of fires, some themes emerge. Much attention is paid to the phenomenon of electrical arcing, where a current flows across an air gap by ionising the air. High voltage arcs are extremely hot and can cause combustion of surrounding materials in less than a second. Arcing can occur where conducting parts become physically separated by mechanical movement or mis-alignment. Also, a build-up of contaminants (e.g. oxide) on electrical contacts can cause resistive heating, resulting in the breakdown of materials and subsequent arcing. Certain components, if incorrectly specified, poorly installed or contain manufacturing faults, are typical locations of electrical arcs:

- DC connectors
- DC isolators
- Inverters
- PV modules, including by-pass diodes and junction boxes

The majority of incidents (approximately 36%) that were caused by PV systems were attributed to poor installation practices. 12% were attributed to faulty products and 5% to system design errors. The causes of the remainder were unknown."

Based on the literature available on the Solar Panels Farms fire incidents, it is observed that most of the

fires have resulted from electrical faults in the system components. Therefore, it is considered that with a high level of management and regular checks in addition to a location of the panels that is remote from other buildings, the risks can be mitigated.

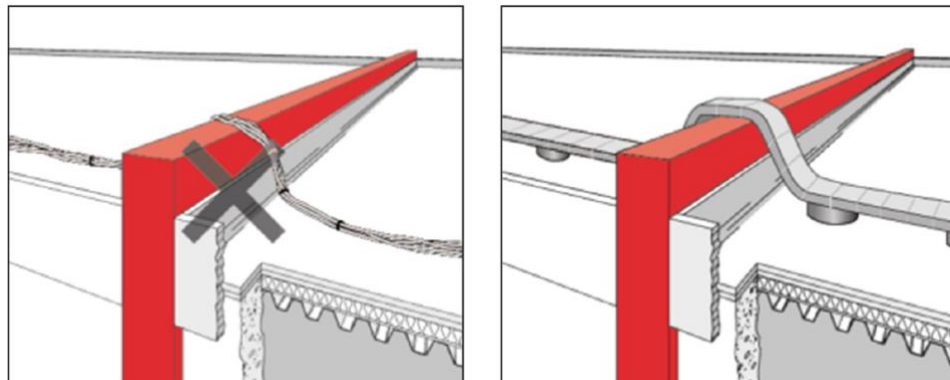
2.3 Design recommendations

In accordance with the advice of the Fire and Rescue Service, the SPF and BESS facilities should be designed to provide:

- Adequate separation between containers.
- Provide adequate thermal barriers between switch gear and batteries,
- Install 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.
- Install a very early warning fire detection system, such as aspirating smoke detection/air sampling.
- Install Carbon Monoxide (CO) detection within the BESS containers.
- Install sprinkler protection within BESS containers. The sprinkler system should be designed to adequately contain and extinguish a fire.
- 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 120 minutes (2 hours). Further hydrants should be strategically located across the development. These should be tested and serviced at regular intervals by the operator. If the site is remote from a pressure fed water supply, then an Emergency Water Supply (EWS) meeting the above standard should be incorporated into the design of the site e.g. an open water source and/or tank(s). If above ground EWS tanks are installed, these should include facilities for the FRS to discharge (140/100mm RT outlet) and refill the tank.
- The site design should include a safe access route for fire appliances to manoeuvre within the site (including turning circles). An alternative access point and approach route should be provided and maintained to enable appliances to approach from an up-wind direction.
- As the majority of BESS are remotely monitored, consideration should include the fixing of an Information Box (IB) at the FRS access point. The purpose of the IB is to provide information for first responders e.g., Emergency Response Plan, to include water supplies for firefighting, drainage plans highlighting any Pollution Control Devices (PCDs) / Penstocks etc for the FRS.
- The fire and rescue services are aware that large scale BESS is a fairly new technology, and as such risks may or may not be captured in current guidance in pursuance of the Building Regulations (as amended) and the Regulatory Reform (Fire Safety) Order 2005. This will highlight challenges the FRS have when responding to Building Regulations consultations. For this reason, we strongly recommend applying the National Fire Protection Association (NFPA) 855 Standard for the Installation of Stationary Energy Storage Systems along with guidance from the NFCC Grid Scale Battery Energy Storage System Planning.
- PV panel systems should be selected to have a low propensity for fire spread, with no or minimal propensity to produce burning droplets following ignition. Research is in process to develop a suitable UK fire test specification and standard for property protection, for PV modules. In the meantime, suitability should be based on assessment of fire-classification of (PV modules) materials of construction and available test data (e.g. UL 1703, UL 790, PD CLC/TR 50670:2016, BS EN 61730-2:2007, ASTM E108-20a).
- Determine whether the addition of DC disconnection switch technology and interfacing with the existing fire systems is mandatory according to UK legislation (BS EN 7671).
- Subject to risk assessment, determine if the inverter arc fault circuit interrupter is acceptable if fitted and, if not fitted, whether a stand-alone arc fault interrupter is required, mandatory, or not required.
- Windblown litter and leaves should not be allowed to accumulate, especially around or beneath PV panels.
- When there are no or few staff present, it is paramount that careful consideration be given to the fire safety management implications of a PV system that will operate at a fully or partially unattended location.
- PV installations shall be serviced and maintained in accordance with the installer's instructions and to BS EN IEC 62446-2 (2020). The schedule of maintenance should follow the service contract,

warranty conditions, and/or performance guarantees.

- In addition to the PV panels themselves, there is typically a notable amount of copper and aluminium on a PV installation. This increases the attraction for theft, and there is an expectation of additional security measures proportionate to this risk. There have also been reported incidences of the use of catapults and air rifles to deliberately vandalise PV modules. The risk is higher for commercial and industrial buildings that are not staffed.
- Robust on-site controls for staff who access PV installation areas (such as maintenance operatives) should be implemented – e.g. absolutely no smoking (even though the area might be outdoors) and caution with vehicle exhaust systems over long dry grasses.
- Electrical compliance with BS EN 7671 is a core requirement. Subject to any particular identified risks, the measures including arc suppression, module level power electronics, and DC disconnection systems, should be considered for incorporation into the design to address the mitigation requirements defined by the Fire Risk Assessment.
- The design should minimise the risk of product failure over the expected design life of the system, not the warranty period alone. This should include the long-term impact of temperature variation, weather, and humidity. Thermal duty cycles and ratings of equipment, especially transformers, should be given correct consideration. A PV system would be expected to have a design life of 30 to 35 years.
- Components of PV systems often contain combustible materials. In order to effectively limit the spread of fire via components of PV systems, the following measures are necessary (CFPA-E Guideline No 37:2018 F):
 - i. Components of PV systems with combustible elements, e.g. cables, are not allowed to be passed over a compartment/fire wall. If this cannot be avoided, they should be installed in fire-resistant cable ducts and shafts (Figure 5.5.1).



- Rodents, squirrels, and nesting birds (and, for ground mount systems, farm and wild animals) can all cause harm and alter the fire safety properties of a PV system. Consideration should be given to the potential impact, and suitable mitigation measures put in place.¹

The aforementioned recommendations should be able to mitigate the thermal runaway risk for the Battery Containers. In the case in which the thermal runaway cannot be avoided, the very early warning system will be able to announce the local fire brigades and the site management.

As in any case, a risk can be mitigated but in this situation, the risk cannot be eliminated. Therefore, the design team will propose a design intent that will address the main concerns and will develop a solution which will mitigate the risk of fire and fire spread.

In the later sections of this report, the proposed design solutions are detailed.

¹ Recommendations in accordance with the FPA RC 62: Recommendations for fire safety with PV panel installation

3. DESIGN SOLUTION

3.1 Very Early Warning and Remote Energy Management System

The proposed design includes CATL outdoor racks (LFP lithium-ion batteries), central inverters and MV transformers for grid connection. The system will be constantly monitored and controlled through an energy management system (EMS) that will monitor the energy dispatch of the system but also the temperature of the cells and the containers.

The EMS will trigger the alarm at the detection of smoke, heat, gas or in the situation in which the suppression system has started to operate.

The EMS is a central system that coordinates all the signals coming from the detection sensors and the operation of the suppression system.

The Battery Management System (BMS) shall include both operational functions and safety functions.

The BMS shall have at least the following operational functions:

- Charge and discharge monitoring and management of all cells, modules, and racks.
- Monitoring of maximum and minimum voltage, current and temperature at all relevant levels in the BESS.
- Calculation of the State of Charge (SOC) of each rack.
- Calculation of the maximum usable charging and discharging power for each rack.
- Passive or active balancing SOC between cells in a module.
- Passive or active balancing SOC between modules in a rack.
- Internal communication between parts of the BMS hierarchy.
- Interfacing with the BESS master control system (i.e., an Energy Management System (EMS), and any application-specific external system.
- Reporting faults related to any accessory devices of the BMS (such as module/rack/BMS fans, rack-integrated cooling system etc.)
- All applicable safety related and operational alarms to be sent to EMS.
- The BMS shall have a direct communications link to stop charging or discharging on receipt of a positive signal from the fire detection system.

A heat detection system or an infrared thermal detection system should also be considered for each container. In addition each container should be provided with smoke and gas detection.

If any detection is triggered in either of the containers, the container of origin must be isolated from the rest of the BESS.

In the case in which the BMS is picking up changes in any container, the fire and rescue services must be announced immediately, as well as the management staff.

3.2 Monitoring

Each rack is equipped with temperature, voltage and current sensors. Temperature monitoring of each container is provided, which is fed back to the centrally monitored control station located off-site. This is monitored 24 hours a day, 365 days a year. The Battery Management System (BMS) samples voltage, current, as well as temperature and alerts the operator to possible faults automatically.

In addition to the thermal, voltage and current sensors, it is recommended that carbon monoxide (CO) detection within the BESS containers.

In the event of a fire, the remote team will alert the local Fire and Rescue Service to the specific container or rack issue and provide accurate information about the initial source of the fire.

Additionally, a physical inspection of the cells is made on a periodic basis by the operations and maintenance team as part of routine preventative maintenance.

3.3 Aspirating Smoke Detection

In accordance with NFPA 855, the recommended smoke detection is the aspirating smoke detection system. Please refer to the extract below:

“Fire events in LIB ESS must be detected as early as possible to ensure personnel safety, asset protection, and uninterrupted business operation. Aspirated smoke detection mitigates the risk of fire and the consequences of downtime in an ESS in the following ways:

- (1) Aspirated smoke detectors detect fires at their incipient stage, allowing early intervention for investigation and action before smoke and corrosive gases affect equipment and personnel. Early detection can prevent the spread of fire from one rack to another.
- (2) Early intervention reduces the reliance on active fire suppression or fire department intervention.
- (3) Aspirated smoke detectors monitor all fire stages from incipient to fully developed, providing multiple alarms for staged response. Later stages assure prompt evacuation for life safety of building occupants.
- (4) An aspirated smoke detection system can be designed to reliably detect diluted smoke due to its very sensitive sensing chamber and cumulative sampling (e.g., smoke drawn through multiple sampling holes).
- (5) The system can be designed to accommodate temperature and humidity extremes.
- (6) The aspirated smoke detection system can monitor HVAC outside air intakes and adjust smoke readings to avoid nuisance alarms from outside sources. This feature is particularly important for high sensitivity levels.
- (7) Where a gaseous or sprinkler fire suppression system forms part of the overall fire protection solution, the system can be designed to actuate the release mechanisms flexibly with various systems, from non-interlocked to double-interlocked systems, by different detection schemes, including coincidence detection.
- (8) Aspirated smoke detectors can be mounted in easily accessible areas. This allows for easy and safe system maintenance when sampling in awkward locations such as inside cabinets, above cable trays, under raised floors, in ceiling voids, and in underground cable tunnels/vaults; and will not disrupt operations or cause a security breach of secure areas.”

3.4 Automatic Fire Suppression Systems - Drenchers

Thermal runaway cannot be controlled like a regular (air-fuel) fire. The only way to mitigate “reignition” (a regular report of eye-witnesses) is by thorough cooling. Water is the only fire-fighting material with the necessary thermal capacity. Sprinkler systems, though with good records in conventional building fires, are likely to be completely inadequate. The purpose of the water is absorbing a colossal release of energy. The Hill/DNV report [8] called for so-called “dry pipe” systems allowing first responders to connect very large water sources to the interior without having to access the interior.

It is critical to appreciate that all parts of the battery system must be cooled down. Applying water on a battery “fire” may cool the surface, but so long as Li-ion cells deep inside the battery remain above about 150°C, “re-ignition” events will continue. It is not sufficient to estimate water requirements on the basis of calculations assuming water reaches everywhere, uniformly.

As general guidance, the Local Authorities have suggested that water supplies of 1900 litres per minute for 2 hours (228 m3) will be needed.

Therefore, based on the research, precedent and design guidance, it is proposed that each container is provided with a drencher system capable of a minimum capacity of 1900 litres / minute for a minimum time of 2 hours (228 m3 water storage required).

3.5 Manually Operated Fire Suppression Systems – Hydrants

Further from the automatic fire suppression systems provided to the containers, public or private hydrants must be provided around the site.

As the site is situated in a remote location, public hydrants might not be close enough to the site itself. Therefore, a private hydrant system must be provided to aid the firefighters intervention.

The hydrants will be designed and installed in accordance with BS 9990. “Where fire hydrants are to be installed, they should be included as part of a ring fire main system and be positioned not more than 90 m from an entry to any building on the site and not more than 90 m apart. They should preferably be sited immediately adjacent to roadways or hard-standing facilities suitable for fire and rescue service appliances. To ensure that they remain usable during a fire, they should be sited to take into account the effect that falling debris and other possible occurrences during a fire might have on the continuing viability of the location and should be not less than 6 m from the building or other risk.

If the water supply is not sufficient to serve a hydrant, and there is no possibility in increasing the water supply coming from the utilities provider, a private underground or surface water storage tank will be provided to ensure the minimum water supply provision for a hydrant system.

The recommended flow rate for a hydrant system provided for an industrial site with an area larger than 3 ha, is 4500 litres / minute.

3.6 Thermal barriers

One of the recommended methods of preventing the thermal runaway by design is to prevent thermal barriers as follows:

- Thermal barriers (i.e. Low thermal conductivity barriers, not merely refractory barriers, ideally with water cooling, between all cells, so that propagation from cell to cell cannot occur.
- Separation of modules by similar barriers to Prevent module-to-module cascade.
- Separation of Racks to prevent rack-to-rack cascade, even with ejection of molten metals.
- Spacing of BESS cabins such that even with “75 foot flame lengths” cabin to cabin escalation is impossible. This is probably the most critical of all, since cabin-to-cabin escalation could turn a major fire incident into an unprecedented catastrophe, on the scale of the Beirut explosion or a small nuclear weapon.

Based on the CATL liquid cooling containers, the thermal barriers are achieved via the liquid cooling technology. Every module is provided with integrated frequency conversion liquid cooling system. The system helps limit the temperature difference among cells within 3 °C.

In terms of separation of “cabins”, the design has been developed in such a way in which a distance of 6m will be provided between the containers. Therefore, the distance provided will limit the fire spreading from one container to the other.

3.8 Ventilation

All containers should be provided with ventilation to outside.

The generation of Carbon Monoxide is very toxic and inflammable. Nevertheless, the generation of Hydrogen Fluoride will also continue until the batteries are completely cooled off. Both of the gases are acute toxic by skin exposure.

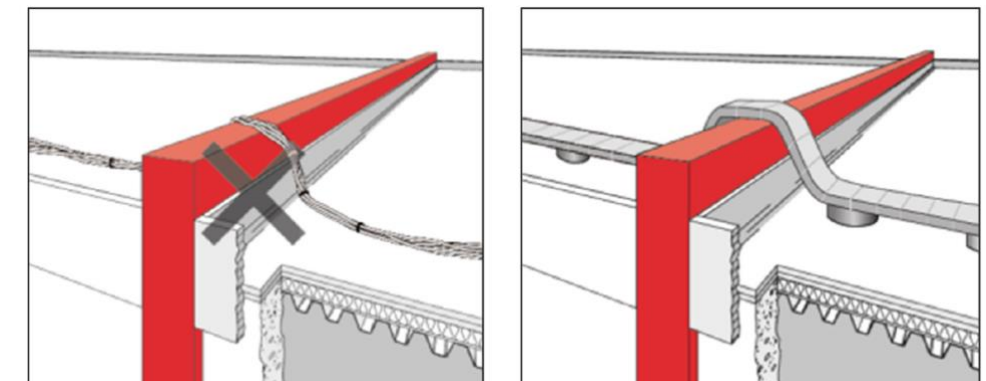
3.8 Solar panels management

In accordance with the Fire Protection Association, the following elements should be considered for solar panel farms, as follows:

- PV panel systems should be selected to have a low propensity for fire spread, with no or minimal propensity to produce burning droplets following ignition. Research is in process to develop a suitable UK fire test specification and standard for property protection, for PV modules. In the meantime, suitability should be based on assessment of fire-classification of (PV modules) materials of construction and available test data (e.g. UL 1703, UL 790, PD CLC/TR 50670:2016, BS EN 61730-2:2007, ASTM E108-20a).
- Determine whether the addition of DC disconnection switch technology and interfacing with the

existing fire systems is mandatory according to UK legislation (BS EN 7671).

- Subject to risk assessment, determine if the inverter arc fault circuit interrupter is acceptable if fitted and, if not fitted, whether a stand-alone arc fault interrupter is required, mandatory, or not required.
- Windblown litter and leaves should not be allowed to accumulate, especially around or beneath PV panels.
- When there are no or few staff present, it is paramount that careful consideration be given to the fire safety management implications of a PV system that will operate at a fully or partially unattended location.
- PV installations shall be serviced and maintained in accordance with the installer’s instructions and to BS EN IEC 62446-2 (2020). The schedule of maintenance should follow the service contract, warranty conditions, and/or performance guarantees.
- In addition to the PV panels themselves, there is typically a notable amount of copper and aluminium on a PV installation. This increases the attraction for theft, and there is an expectation of additional security measures proportionate to this risk. There have also been reported incidences of the use of catapults and air rifles to deliberately vandalise PV modules. The risk is higher for commercial and industrial buildings that are not staffed.
- Robust on-site controls for staff who access PV installation areas (such as maintenance operatives) should be implemented – e.g. absolutely no smoking (even though the area might be outdoors) and caution with vehicle exhaust systems over long dry grasses.
- Electrical compliance with BS EN 7671 is a core requirement. Subject to any particular identified risks, the measures including arc suppression, module level power electronics, and DC disconnection systems, should be considered for incorporation into the design to address the mitigation requirements defined by the Fire Risk Assessment.
- The design should minimise the risk of product failure over the expected design life of the system, not the warranty period alone. This should include the long-term impact of temperature variation, weather, and humidity. Thermal duty cycles and ratings of equipment, especially transformers, should be given correct consideration. A PV system would be expected to have a design life of 30 to 35 years.
- Components of PV systems often contain combustible materials. In order to effectively limit the spread of fire via components of PV systems, the following measures are necessary (CFPA-E Guideline No 37:2018 F):
 - Components of PV systems with combustible elements, e.g. cables, are not allowed to be passed over a compartment/fire wall. If this cannot be avoided, they should be installed in fire-resistant cable ducts and shafts (Figure 5.5.1).

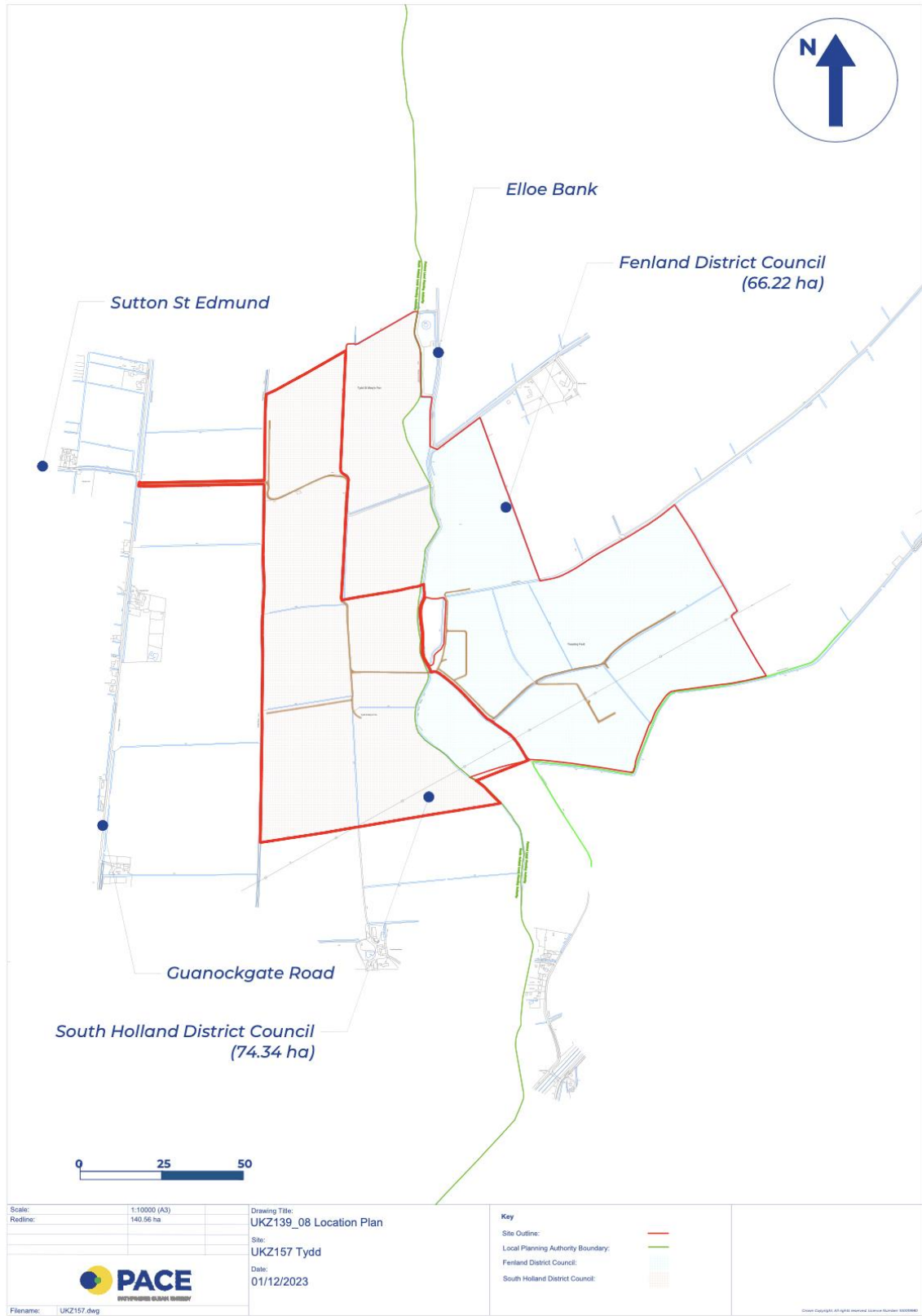


- Rodents, squirrels, and nesting birds (and, for ground mount systems, farm and wild animals) can all cause harm and alter the fire safety properties of a PV system. Consideration should be given to the potential impact, and suitable mitigation measures put in place.²

² Recommendations in accordance with the FPA RC 62: Recommendations for fire safety with PV panel installation

4. SITE LOCATION AND PLAN

The site is located in a remote area on a land off Guanockgate Road, Sutton St. Edmund, Cambridgeshire PE13 4PL, located within both South Holland and Fenland District councils.



A number of 8 fire brigades are within a 19 miles radius. Please refer to the diagram below.

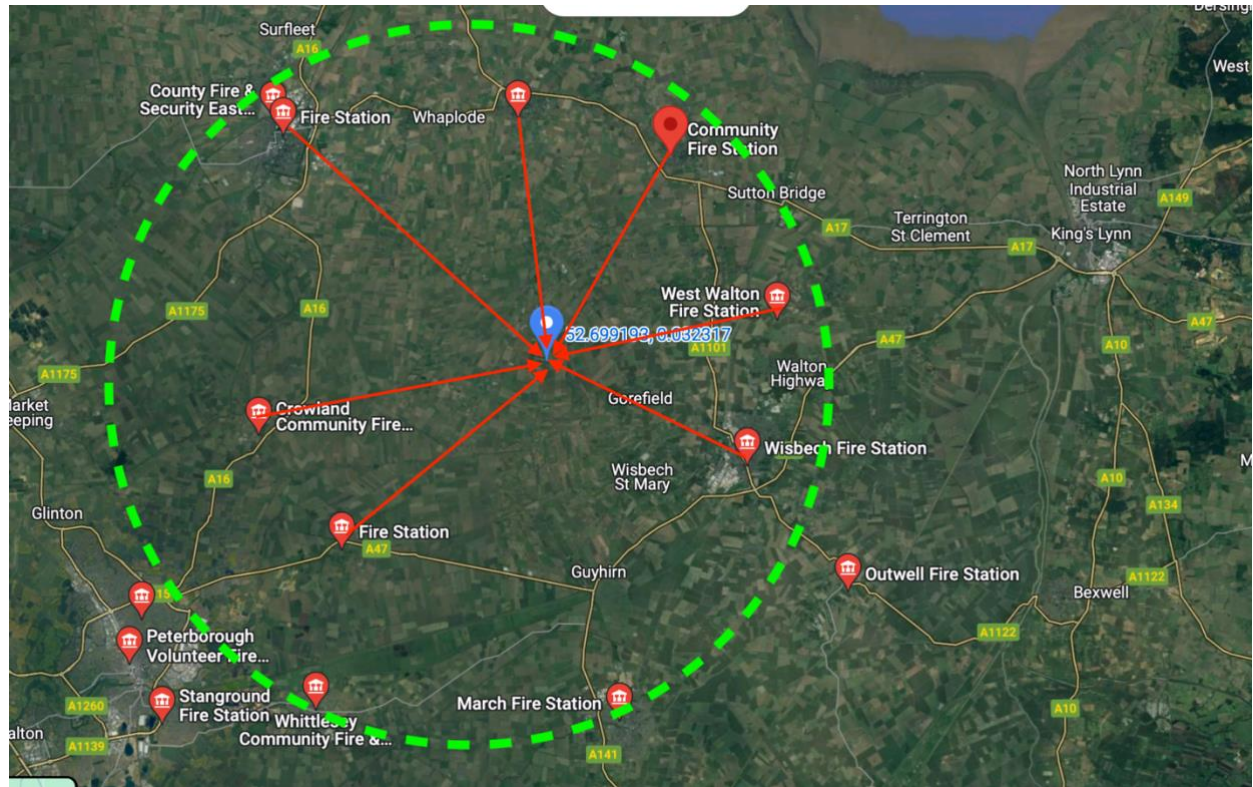


Figure 7 - Fire brigades in proximity of the site

The nearest 8 fire brigade stations are identified as:

Name of Fire and Rescue Station	Distance from site	Attendance time to site from station
County Fire & Security East Anglia Ltd, 146 Pinchbeck Rd, Spalding PE11 1QN	14.8 miles	27 minutes
Fire Station, W Elloe Ave, Spalding PE11	14.4 miles	27 minutes
Holbech Community Fire Station, 21-23 Hall Gate, Holbeach, Spalding PE12 7LG	9 miles	15 minutes
Longton Community Fire Station, 266 Community Fire Station, 82 West St, Long Sutton, Spalding PE12 9BN	8.3 miles	16 minutes
West Walton Fire Station, Ingleborough Farm, Wisbech PE14	17 miles	29 minutes
Wisbech Fire Station, Fire Station, Churchill Rd, Wisbech PE13 2DN	8.6 miles	20 minutes
Fire Station, Thorney, Peterborough PE6 0QE	10.3 miles	18 minutes
Crowland Community Fire Station, Thorney Rd, Crowland, Peterborough PE6 0LF	10.9 miles	19 minutes

The site layout is comprised of 38 containers spread out in order to retain the 6m distance required for the fire spread risk mitigation. In the situation in which two containers are installed back-to-back or side-by-side, the dividing wall(s) will be offered with 120 minutes fire performance – this is subject to the local fire

brigade agreement.
Please refer to the diagram below for the proposed layout.

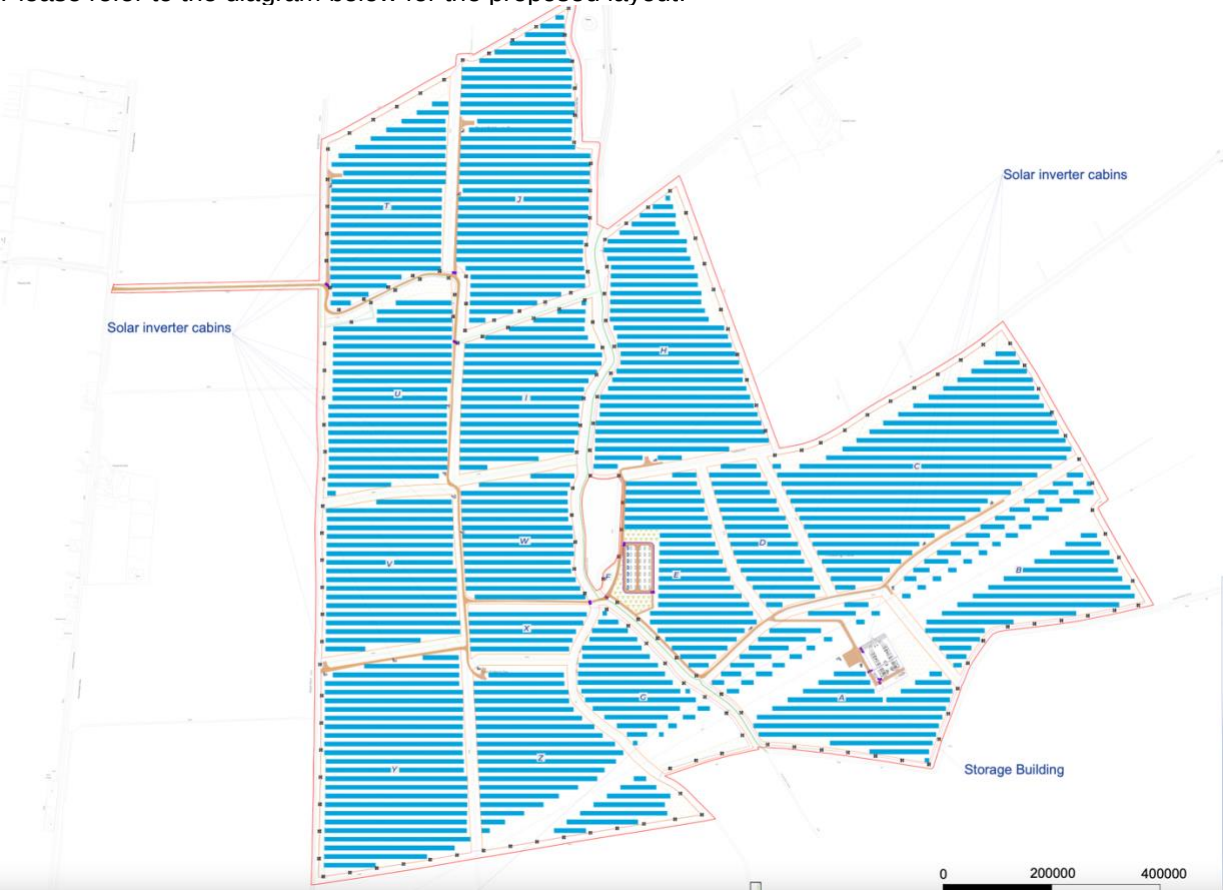


Figure 8 – BESS containers layout and Transformer

5. SITE DESIGN – BUILDING REGULATIONS CONSIDERATIONS

The Building Regulations 2010 – Approved Document B including the 2022 amendments details the imposed requirements for buildings as follows:

- B1 (Means of warning and escape)
- B2 (Internal fire spread (linings))
- B3 (Internal fire spread (structure))
- B4 (External fire spread)
- B5 (Access and facilities for the fire service)

As demonstrated in the earlier sections of this report, the BESS facility is exempt from following the building regulations, however, as the facility will be visited by personnel for maintenance and inspection purposes, section B1 and section B5 have been considered and are described in the following sections of this report.

5.1 Means of warning and escape

Functional Requirements

“The building shall be designed and constructed so that there are appropriate provisions for the early warning of fire, and appropriate means of escape in case of fire from the building to a place of safety outside the building capable of being safely and effectively used at all material times.”

5.2 Overview of Means of Warning and Escape Strategies

The escape strategy has been developed on a simultaneous evacuation model. Any person that is located on site at the moment of a fire incident is to evacuate the site immediately.

5.3 Fire Alarm and Detection

As described in the earlier section, the entire site is provided with smoke, heat and gas detection throughout. The detection systems will also be provided sounders and beacons which will announce the occupants to evacuate in case of a fire incident.

The alarm systems are to be designed and installed by a specialist and competent contractor and will align with:

- BS5839-1:2017 Fire detection and fire alarm systems for buildings - Part 1: Code of practice for design, installation, commissioning, and maintenance of systems in non-domestic premises.
- BS EN 54 Fire detection and fire alarm systems.
- BS EN 12094 Fixed firefighting systems - Components for gas extinguishing systems.

The detection systems are to be linked the BMS and EMS. Therefore, in case of a fire, the detection systems will trigger the BMS which will ultimately announce the fire and rescue services for intervention.

The detection systems must be subject to regular tests which are to be logged in the Fire Safety Log Book.

5.4 Automatic Fire Suppression System

As described in the earlier sections all of the containers are to be provided with a drencher system. The drencher system will be designed and installed to have a minimum flow rate of 1900 litres / minute.

The suppression system must be subject to regular tests which are to be logged in the Fire Safety Log Book.

5.5 Emergency Lighting and Escape Signage

Suitable lighting should be provided to enable the safe movement of persons along escape routes to a place of relative or ultimate safety. For an industrial premise, Approved Document B – Table 5.1 recommends that emergency escape lighting should be provided, in accordance with BS 5266-1, as follows:

- 1) Underground or windowless accommodation
- 2) Stairways in a central core or serving storey(s) more than 18 m above ground level
- 3) Internal corridors more than 30 m long
- 4) Open-plan areas of more than 60 m²

For the BESS facility, neither of the points above are applicable. Therefore, it is proposed that emergency lighting is provided on each of the containers providing visibility in case of smoke and / or dark for means of escape and intervention.

The emergency lighting system will be designed and installed in accordance with BS 5266 and will be provided with battery back-up for a duration of 3 hours.

The emergency lighting system must be subject to regular tests which are to be logged in the Fire Safety Log Book.

6 FIRE SERVICE ACCESS AND FACILITIES

Functional Requirements

The building shall be designed and constructed so as to provide reasonable facilities to assist fire fighters in the protection of life. Reasonable provision shall be made within the site of the building to enable fire appliances to gain access to the building.

6.1 Fire Access

Fire service can access the site from Sutton St. Edmund Road and it is provided with a secondary access route via the junction between Elloe Bank and Broad Drove W roads, thus providing a secondary access route to the firefighters in the case in which the primary access route is compromised by smoke.

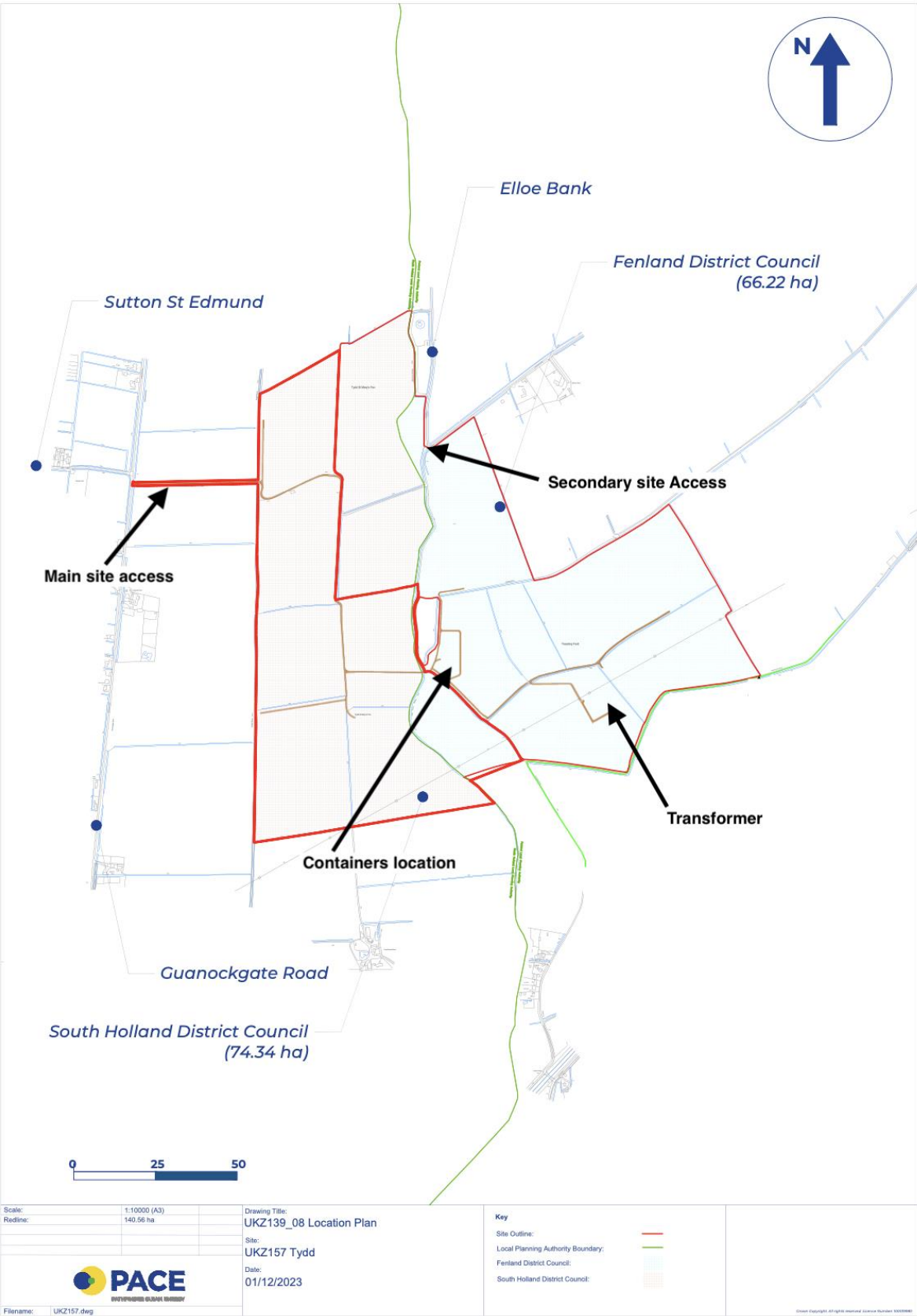
The Fire vehicle reversing distances should be a maximum of 20m otherwise a turning provision is needed. The vehicle access to the development is required to have a clear width of at least 3.1m, whilst the road between kerbs is required to have a minimum width of 3.7m to comply with the guidance recommendations for fire-fighting vehicle access.

The route for fire vehicles needs to be hard-standing, capable of withstanding the carrying capacity of a fire vehicle. The standard for this would be 14 tonnes for a pump appliance.

Table 20 Example of measurements for a typical vehicle access route

Appliance type	Min. width of road between kerbs	Min. width of gateways	Min. turning circle between kerbs	Min. turning circle between walls	Min. clearance height	Min. carrying capacity
	m	m	m	m	m	t
Pump	3.7	3.1	16.8	19.2	3.7	12.5
High-reach ^{A)}	3.7	3.1	26.0	29.0	4.0	17.0

^{A)} Because the weight of high-reach appliances is distributed over a number of axles, their infrequent use of a carriageway or route designed to 12.5 t is not likely to cause damage. It would therefore be reasonable to design the road base to 12.5 t, although structures such as bridges should have the full 17 t capacity.



6.2 Secure information boxes

Consideration should be given to fixing of an Information Box (IB) at the FRS access point. The purpose of the IB is to provide information for first responders e.g., Emergency Response Plan, to include water supplies for firefighting, drainage plans highlighting any Pollution Control Devices (PCDs) / Penstocks etc for the FRS.

A secure information box provides a secure facility to store information about a building for use by the fire service during an incident.

The box should meet all of the following conditions.

- a. Sized to accommodate all necessary information.
- b. Easily located and identified by firefighters.
- c. Secured to resist unauthorised access but readily accessible by firefighters.
- d. Protected from the weather.

Best practice guidance can be found in Sections 2 to 4 of the Code of Practice for the Provision of Premises Information Boxes published by the Fire Industry Association (FIA).

6.3 Emergency Response Plan

As a critical element in the safe management of an incident of fire at this site, the client will produce an Emergency Response Plan. The plan will include necessary information that will assist the Fire and Rescue Service should they be required to attend an incident of fire at this site. The information contained within the plan will include, but not be limited to, the following:

- How the Fire and Rescue Service will be alerted to an incident of fire on site.
- A facility description, including infrastructure details, operations, number of personnel, and operating hours.
- A site plan depicting key infrastructure:
 - o site access points and internal roads.
 - o firefighting facilities (water tanks, pumps, booster systems, fire hydrants, fire hose reels etc); drainage; and,
 - o neighbouring properties.
- Details of emergency resources, including:
 - o fire detection and suppression systems and equipment.
 - o gas detection.
 - o emergency eyewash and shower facilities; spill containment systems and equipment.
 - o emergency warning systems.
 - o communication systems.
 - o personal protective equipment.
 - o first aid.

6.4 Fire and Rescue Service Liaison

During the pre-planning and post-planning design period of time, Magnus Opifex will liaise with the local fire and rescue services and will agree a plan of emergency response. The firefighters and the emergency

response teams must be familiar with the development plans, access, layout, suppression systems and firefighting facilities provided.

The consultation process with the local Lincolnshire and Cambridgeshire Fire and Rescue Services has been undertaken during the RIBA Stage 2 design process and agreement has been achieved based on the fire strategy proposal.

6.5 Contaminated water run-off containment

Following the consultation with the local Fire and Rescue Service, it has been established that part of the development, a water run-off drainage containment system will be provided in order to collect the contaminated water resulting from the firefighting process in the situation of a fire incident.

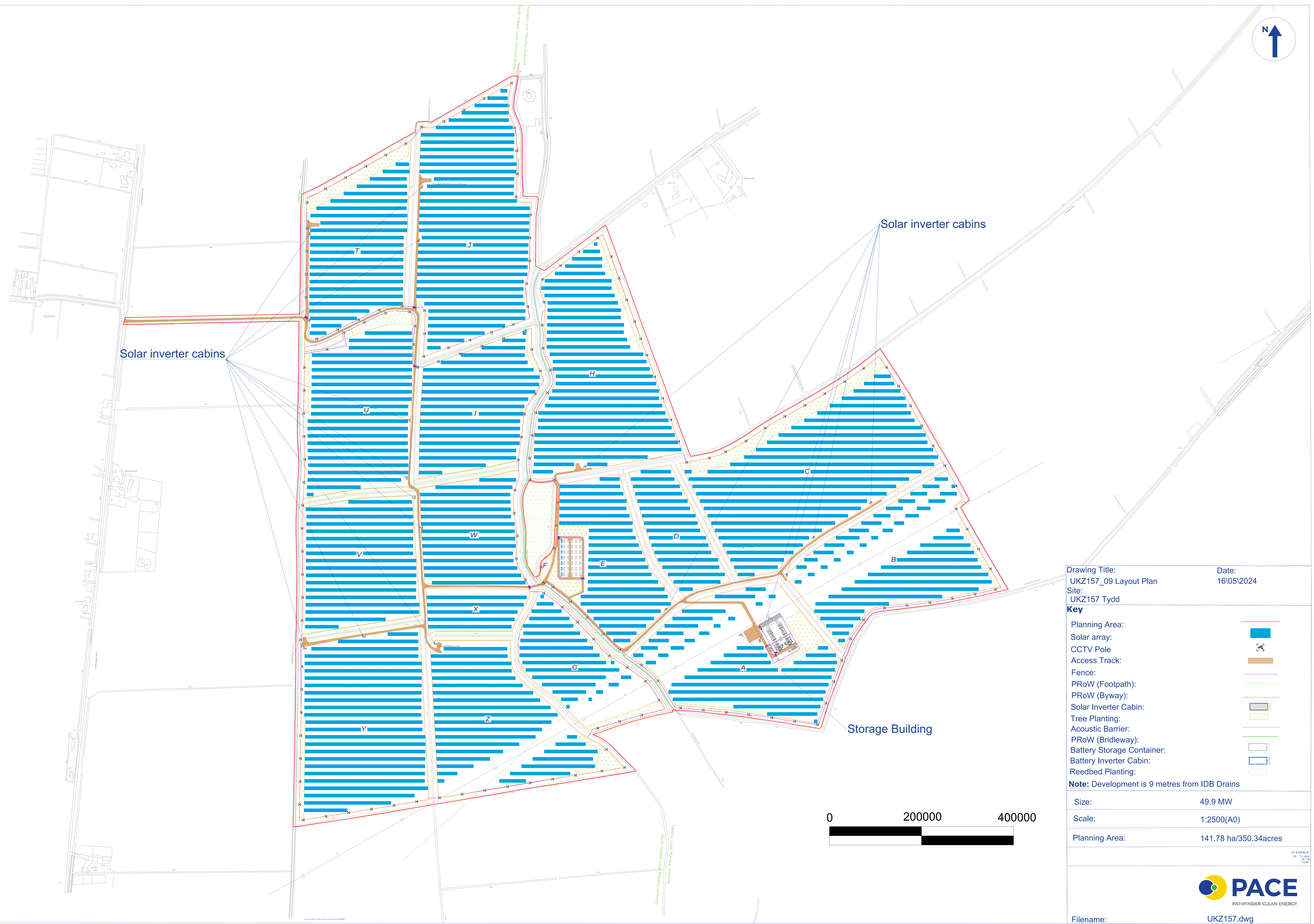
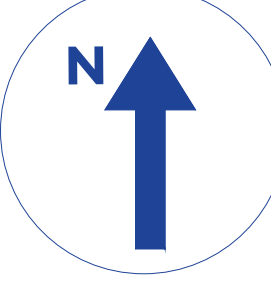
As the water used for firefighting will be directed to the battery containers, the resulting water run-off will be contaminated with toxic acids and other chemical residue.

It is therefore proposed that a collection system is installed under the site surface area accommodating the battery containers. The collection system will be then connected to the collection tanks which will be spread across the site and will be buried.

The contaminated water following the firefighting process will be shipped to a specialised water treatment facility.

The contaminated water collection system will be designed in detail at further stages. The final storage capacities will be subject to negotiation with the local Fire and Rescue Service and the Environmental Agency.

APPENDIX B – SITE PLAN



Drawing Title:
UKZ157_09 Layout Plan
Site:
UKZ157 Tydd

Date:
16\05\2024

Key

Planning Area:

Solar array:

CCTV Pole

Access Track:

Fence:

PRoW (Footpath):

PRoW (Byway):

Solar Inverter Cabin:

Tree Planting:

Acoustic Barrier:

PRoW (Bridleway):

Battery Storage Container:

Battery Inverter Cabin:

Reedbed Planting:

Note: Development is 9 metres from IDB Drains

Size:

49.9 MW

Scale:

1:2500(A0)

Planning Area:

141.78 ha/350.34acres

Filename:

UKZ157.dwg

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PACE
PATHFINDER CLEAN ENERGY