



**CLEARSTONE
ENERGY**

DARTFORD ENERGY HUB SITE SAFETY REPORT

Prepared by Clearstone Energy | December 2024
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1. EXECUTIVE SUMMARY

- 1.1 The Dartford Energy Hub Site Safety Report aims to provide an overview of the community and environmental safety considerations related to the operation of the Proposed Development. The report will outline the known safety risks for Battery Energy Storage Systems (BESS) and explain how they would be effectively managed through the adoption of best practices in safety systems and site design in collaboration with the Kent Fire and Rescue Service (KFRS).
- 1.2 The risk of a BESS safety incident in the UK is very low, within acceptable levels set by the UK Health and Safety Executive (HSE).
- 1.3 The primary safety concern for BESS is the risk of fire. This risk arises from the possibility that a battery cell failure could result in a thermal runaway event in the affected cell. Thermal runaway causes a rise in temperatures within the cell, leading to production of flammable and toxic gases, smoke, fire or a combination of these. Apart from smoke and toxic gases, potential community and environmental impacts include the potential contamination of water supplies from firefighting water.
- 1.4 The UK National Fire Chiefs' Council (NFCC) has issued guidelines for safe BESS design, which developers must adhere to. Compliance with these guidelines is documented in section 3.
- 1.5 The Applicant consulted with KFRS on the Proposed Development before finalising its Planning Application for the project. More information can be found in section 4 of the report.
- 1.6 The impact assessments contained within this report are based on a worst case scenario of a full battery unit fire. Should the Proposed Development be permitted, evidence of the effectiveness of safety systems in preventing a fire from propagating to other battery units would be demonstrated through the provision of fire test data as part of a Battery Safety Management Plan (BSMP).
- 1.7 The BSMP will also include detailed risk assessments and a full Emergency Response Plan, developed in collaboration with KFRS. It would be subject to approval by Dartford Borough Council (DBC), in consultation with KFRS, before construction can commence.
- 1.8 Plume modelling studies for BESS fires show that the hazard from a battery unit fire is limited to the immediate vicinity of the battery unit, which is less than 12.5 meters. At a distance of 30 meters from a battery unit fire, the concentrations of toxic gases are within safe exposure limits for the workplace in the UK. Smoke visibility impairment is restricted to 25 meters from the affected battery unit, so both Station Road and the A2 to the north would not be affected. This is discussed in Section 5 of the report.
- 1.9 This risk of water contamination is discussed in Section 6 of the report. Risks are minimised as the recommended firefighting strategy is defensive only which reduces the possibility that water will contact battery cells. The site design also includes a water containment system to retain water on site in the event of a fire incident.
- 1.10 In summary, the risks of a fire incident at the Proposed Development are considered to be low and the risks of community or environmental impacts arising from a fire incident are negligible.

2. INTRODUCTION

- 2.1 This Site Safety Overview Report has been prepared by Clearstone Energy Limited (“the Applicant”) and its advisors to accompany a full planning application for the proposed installation of a Battery Energy Storage System (BESS) (“the Proposed Development”) on Station Road, Gravesend, DA13 9PA.
- 2.2 The purpose of this report is to provide an overview of the key community and environmental safety considerations arising from the operation of the Proposed Development. It explains that the risk of a safety incident here in the UK is very low, and within the range of acceptable levels as set by the Health Safety Executive (HSE). The report identifies and evaluates the severity of those risks and explains how these would be effectively managed.
- 2.3 Whilst very rare in UK BESS installations, the key safety consideration to manage is the risk of thermal runaway within the battery units following a battery cell failure. Causes of a battery cell failure are manufacturing defects, physical damage, overheating or overcharging. Cell failure can lead to a rapid increase in cell temperature if not controlled - known as thermal runaway - leading to the venting of gases, smoke or fire or a combination of all. The heat and / or fire created by the failed cell can cause adjacent cells to enter the same process. If not effectively ventilated, the gases produced by multiple cells entering thermal runaway can create the conditions for fire and, potentially, an explosion.
- 2.4 As a consequence of a *fire/explosion*, there is a direct safety risk to emergency first responders attending to control the incident, and members of the public living or working nearby, depending on proximity. As a result of a *fire/explosion*, there is a consequential risk of *smoke emissions and toxic gases* that can present themselves as a plume over the incident area, together with a risk of *water pollution* from contaminated firefighting water run-off.
- 2.5 Each of these safety risks (fire/explosion/air pollution/water pollution) is assessed in this report alongside the means by which risks are managed to ensure the safety of people, property and the environment. Further technical detail can be found in document R012A - The Battery Safety Standards Report.
- 2.6 Successful collaboration with Kent Fire and Rescue Service (KFRS) is key to the safe operation of the Proposed Development and the outcome of pre-application consultation with Kent FRS are presented in this report.

Battery and Fire Safety Experience

- 2.7 The Applicant has been developing BESS projects since 2019 and gas fired power stations since 2016. In that time, it has gained significant expertise in health and safety matters relating to power projects including BESS.
- 2.8 The Applicant has engaged the following external consultants to advise on battery system design, site design matters, fire safety and support on FRS liaison for its BESS projects.

Joe Hassell Command

- 2.9 Joe Hassell Command - Joe Hassell (founder of Joe Hassell Command (JHC)) is a recently retired senior fire officer who completed 31 years of service in both Essex and Devon and Somerset. Joe has extensive experience at all levels of command and retired as the Deputy Chief Fire Officer of Devon and Somerset Fire and Rescue Service in 2022.
- 2.10 Joe is a highly experienced and qualified fire and rescue commander, trainer and assessor, with experience at all command levels dealing with various complex emergencies and major incidents. JHC was established as a training and consultancy company in 2023. JHC provides advice on operational fire fighting matters and consultation with local FRS.

AECOM

- 2.11 AECOM is a global infrastructure consulting company with deep expertise in BESS technologies, site design, risk assessment and mitigation. AECOM co-authored Clearstone Energy's Battery Safety Standards Report.

DNV

- 2.12 DNV is a global assurance and risk management consultancy with deep expertise in BESS safety and risk management. DNV has conducted plume modelling studies for the Applicant.

BST&T Consultancy Services

- 2.13 BST&T is an independent battery safety and testing consultancy which has worked on the safety aspects of lithium-ion battery applications since 2015. It is actively engaged with a number of leading BESS providers on testing programmes and undertaking safety planning for a number of large-scale BESS facilities in the UK. BST&T co-authored Clearstone Energy's Battery Safety Standards Report and provides advice on BESS selection and site design.

UK Battery Safety Track Record

- 2.14 To contextualise the safety record of UK BESS installations, reference is made to the Department for Energy Security and Net Zero (DESNZ), Renewable Energy Planning Database, dated April 2024 and published 01 July 2024.
- 2.15 This database provides concise information on all UK BESS in operation, when they were commissioned and how long they have been operational. The following points are clear:
- As of April 2024, there were 113 BESS sites in operation across the UK.
 - The total energy capable of being delivered to the electricity grid at any one point in time by these projects is estimated at 2,279MW (2.27GW).
 - Since 2006 UK based BESS have operated for approximately 5.8 million hours (data details 5,809,133 hours) which is equivalent to 663 years of operation.

- To date, there has been only one reported UK BESS fire that required FRS attendance, this occurred at Carnegie Road, Liverpool in September 2020. The fire was contained and there was no 3rd party collateral damage or injury to firefighters or the public.
- This equates to 1.7E-07 (0.000000172) failures per hour (fph) for BESS fires in the UK, which aligns with Health and Safety Executive (HSE) expectations and an acceptable level of risk as detailed in the HSE publication 'Reducing Risk Protecting People' (R2P2).
- To date nobody in the UK has been harmed or killed in a BESS incident, be this a first responder or a member of the public.
- No third-party property has been affected by a UK BESS incident,
- No adverse environmental incidents have resulted from a UK BESS incident.

2.16 The key issues and learning from the BESS fire in Carnegie Road, Liverpool in 2020¹ are set out below:

- BESS monitoring systems were not fit for purpose, for example real time data was not available to assess the risk of propagation to adjacent BESS units.
- Active gas detection and explosion prevention systems were not installed.
- Gas suppression systems were installed which increased explosion risk.
- Site specific, operational risk information for fire crews was 'inadequate'.
- The Emergency Response Plans required to inform firefighting tactics had not been produced.
- The unintended consequence of directly applying water onto the fire led to the release of Hydrogen Fluoride which was contained on site.

These learnings have been incorporated into guidance for BESS design and operation produced by the UK's National Fire Chief Council (NFCC) and reflected in this proposal.

UK BESS Regulation

2.17 A BESS is not a hazardous facility as classified under the Planning (Hazardous Substances) Regulations 2015; Part 2 Regulation 3 refers. Hazardous substances are defined as those substances, mixtures or preparations falling within Schedule 1 of the 2015 Regulations. Lithium-ion batteries of any chemistry are not listed in Schedule 1 of the Regulations.

¹ Significant Incident Report, Incident: 018965 - 15092020, Orsted BESS, Carnegie Road, Liverpool, L13 7HY. Merseyside Fire and Rescue Service Ver 1.2, Dec 2021

- 2.18 Further guidance on the safety aspects of BESSs has been provided by the Secretary of State (SoS) for Work and Pensions when asked, in July 2021, if the SoS would review the exclusion of lithium-ion batteries for grid storage from the Control of Major Accident Hazard Regulations 2015 (COMAH). The SoS confirmed:
- Lithium-ion batteries are outside the scope of COMAH;
 - The Health and Safety Executive considers the current regulatory framework to be sufficient and suitably robust in relation to lithium-ion batteries and battery energy storage systems.
- 2.19 Of relevance are the:
- Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) which set minimum requirements for the protection of workers and others from fire and explosion risks;
 - Electricity at Work Regulations which require precautions to be taken against the risk of death or personal injury from electricity in work;
 - Management of Health and Safety at Work Regulations which require risks to be assessed and appropriately managed; and
 - In addition, for large scale battery storage, there are statutory requirements to notify the Fire and Rescue Service to inform their emergency response planning.
- 2.20 In March 2024 DESNZ published its report “Health and Safety Guidance for Grid Scale Electrical Energy Storage Systems”, which provides specific guidance for grid-scale systems across their development, operational and decommissioning life. It is a useful source to understand the numerous existing health and safety standards that govern the industry.
- 2.21 Regulation of BESSs within England is undertaken by several bodies, each with its own remit and expertise and enforcement powers. It includes the Local Planning Authority (LPA) to control spatial land use matters; local authority Environmental Health Departments to protect public and environmental health; and Fire and Rescue Services who advise developers and the Local Planning Authority on fire safety and related environmental protections.

Local Planning Authority

- 2.22 The planning regime seeks to ensure that new development, such as a BESS, is appropriate for its location taking into account its likely effects on the local community and environment. The focus of planning is on whether proposed development is an acceptable use of land, including its proximity to neighbouring uses and its design and layout.
- 2.23 The LPA consults with statutory consultees including Environmental Health and the Fire and Rescue Service and applies planning conditions to any permission that regulate the consented land-use.
- 2.24 Examples of such planning conditions include controlling the layout design of the BESS including the spacing between battery units; the provision of necessary safety infrastructure such as secondary emergency access points and water tanks; and the requirement to prepare and submit a Battery Safety Management Plan (BSMP) for the LPA’s approval in consultation with the FRS.

- 2.25 Any breach of the conditions of the planning permission can be enforced by the LPA using a range of different enforcement powers depending on the nature of the breach, including the requirement for immediate cessation of use/development through issue of a Stop Notice.
- 2.26 Planning decisions do not seek to control the processes or emissions of the consented development where these are subject to separate pollution control regimes. The National Planning Policy Framework makes clear that LPAs should assume that these separate regimes will operate effectively.
- 2.27 As mentioned above, typically planning permissions for BESS projects contain a planning condition requiring the submission and approval by the LPA of a BSMP before any construction of the BESS can commence. This approach is standard and has been used by both the Secretary of State and LPAs when consenting BESS facilities.
- 2.28 As such the Applicant would be supportive of such a planning condition being applied to any planning permission that might be issued for the Dartford Energy Hub:

“Development of the battery storage compound shall not commence until a Battery Safety Management Plan (BSMP) has been submitted to and approved in writing by the Local Planning Authority. The BSMP must prescribe for measures to facilitate safety during the construction, operation and decommissioning of the battery storage facility, including the transport of new, used and replacement battery cells both to and from the authorised development. The Local Planning Authority must consult with the Kent Fire and Rescue Service before approving the BSMP. The BSMP must be implemented as approved.”

Environmental Health Departments

- 2.29 Environmental Health Departments within local councils execute standards for protecting public health and regulate and implement legislation related to environmental health to reduce health and safety hazards. Environmental Health Departments address food, water, land and air and other environmental factors such as noise, protecting the public and ensuring a pollution free environment.
- 2.30 Examples of how Environmental Health Departments assist in the regulation of BESS development including advising on the likely acceptability of noise impacts on the surrounding area, enforcement of noise limits and ensuring public safety by requiring specified buffer distances between residential property and the proposed BESS.

Fire and Rescue Service

- 2.31 The Fire and Rescue Service (FRS) - Kent FRS for the Proposed Development - advises on the safety of the public and emergency responders in the event of a fire at the BESS. The FRS advise on the acceptability of the design and layout from a fire safety and explosion perspective, referring to the National Fire Chief Council's design guidelines.
- 2.32 In addition, for large scale battery storage, there are statutory requirements to notify the FRS to inform its emergency response planning.

3. PROPOSED DEVELOPMENT

3.1 The Applicant seeks full planning permission for the following Description of Development:

“Proposed construction, operation and maintenance of a Battery Energy Storage System (BESS) facility with associated infrastructure and works including highway access, landscaping and biodiversity enhancements”.

3.2 When fully energised the Proposed Development would have the capacity to deliver 300MW of low carbon energy on to the electricity grid for up to two hours.

3.3 It is estimated that the Proposed Development would displace up to 80,000 tonnes of carbon dioxide emissions from gas fired power plants annually, which in turn equates to planting 4 million trees. The primary function of the Proposed Development is to make the electricity network more flexible and resilient as it transitions from highly controllable and centralised electricity generation from fossil fuel power stations to intermittent and dispersed sources of low carbon, renewable energy.

3.4 BESS technology achieves this by storing excess electricity available on the grid when supply outstrips demand, such as at times of high solar radiance levels or high winds, for use at a later point in time when demand outstrips supply. BESSs provide the essential balancing and flexibility services needed to operate a new generation electricity network underpinned by renewables rather than fossil fuels, matching weather dependent renewable wind and solar energy generation to the fluctuations in end user demand.

3.5 This section sets out the Applicant's approach to ensuring the safe operation of the Dartford Energy Hub and explains the different components of the Proposed Development. It explains how the relevant safety design guidelines have been built into the Proposed Site Layout.

Commitment to Safety

3.6 The Battery Safety Standards Report (Document Ref: R022 accompanying the Application) outlines the Applicant's commitment to safety, ensuring that the Dartford Energy Hub will incorporate the following principal safety objectives:

- To minimise the likelihood of a fire, deflagration or explosion event in BESS equipment by:
 - Specifying BESS equipment that conforms to the latest UK and International safety standards and has undergone real world testing to prove the efficacy of safety systems; and;
 - Designing a BESS facility that conforms to the latest UK and International guidance on safe BESS site design.
- To minimise the consequences, should an incident occur by:
 - Designing a BESS facility that restricts the propagation of a fire beyond a single battery cabinet;
 - Developing an Emergency Response Plan and providing live incident information to first responders in a way that enables them to safely manage the incident; and
 - Ensuring that the site design minimises the risks of fire, smoke and the spread of toxic gases or substances impacting the local community or the environment.

Development Components

3.7 The Proposed Development includes the following equipment:

- A battery storage compound surfaced with non-compacted gravel containing:
 - Strings of battery units (72 no.) arranged in rows of three units;
 - ACC/DCC panels positioned at the end of each row of battery units;
 - MV Twin Skid units (38 no.);
 - Inverter units (72 no.);
 - Spare equipment containers;
 - Five emergency water tanks; and
 - Fire hydrants with a pumped distribution system (9 no.).
- Associated infrastructure including:
 - A single substation building and switchgear compound;
 - Internal access roads;
 - Two access roads for each section of the site from Station Road, one for construction and operational traffic and a secondary emergency access road, four in total
 - A steel palisade fence and double gates around the battery storage compound;
 - CCTV and infrared cameras mounted on steel poles.

3.8 Drawings and dimensions for all equipment can be found in the Planning Application Drawing Pack Schedule and Drawings accompanying the Application.

3.9 There is no lighting associated with the operation of the Proposed Development, other than a manually operated or passive infrared sensor lighting system in the event of a night-time incident.

3.10 To connect the BESS facility to the electricity network, cables would link the onsite substation to the existing Northfleet National Grid Substation located approximately 450m to the north-east of the site. Please see the Proposed Development Zone plan in the Planning Application drawing pack for the cable route and substation location.

Battery Technology Provider

3.11 The Applicant has not, at this point, selected a provider of battery equipment for the project. It is likely that construction of the project will not commence until 2026, at which point there will have been advances in battery technology, which means that the latest BESS will offer enhancements in both performance and safety systems. The battery equipment provider ultimately selected for the project will meet all existing and future safety regulations and guidance and will be subject to final approval by the Dartford Borough Council, in consultation with KFRS, through the submission of a Battery Safety Management Plan.

- 3.12 The Application includes an indicative site design based on the Gridsolv Quantum BESS from Wärtsilä. This system is being deployed at a number of UK BESS projects and being specified by the Applicant for projects with near term construction dates. It is considered to be the market leader for safety. It is described below to provide an understanding of current best practice in designing BESS facilities for safe operations and illustrate the level of supporting information and testing data that would be provided to Dartford Borough Council and KFRS as part of the Battery Safety Management Plan.
- 3.13 The Gridsolv Quantum BESS is a lithium iron phosphate (LFP) system and complies with all relevant BESS safety guidance, test certifications and codes. A compliance list is included at Appendix 1. Further, Wärtsilä has conducted a series of full-scale burn tests of the BESS and extensive Fire Dynamics Simulation (FDS) modelling to understand the potential outcomes from likely fire scenarios, validate the performance of safety systems and provide best practice advice to developers, operators and first responders.
- 3.14 The Wärtsilä battery unit is shown on Figure 3.1 below and provided at scale in the Planning Application Drawing Pack Schedule and Drawings accompanying the Application.

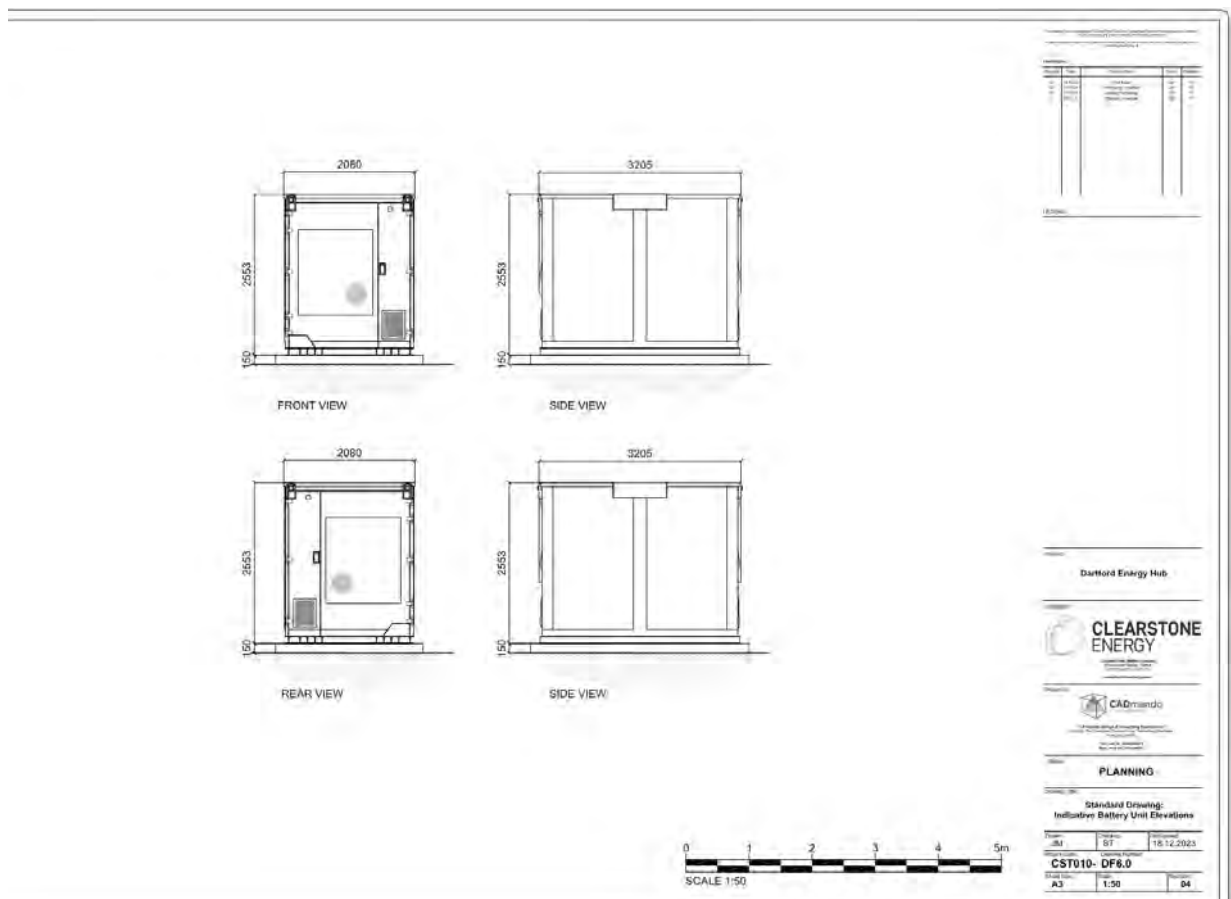


Figure 3.1: Proposed Battery Unit Elevations Plan

Site Design

- 3.15 The Indicative Site Layout Plan for the Proposed Development is provided within Document R002 Planning Application Drawing Pack Schedule and Drawings and shown at Figure 3.2 for ease of reference.

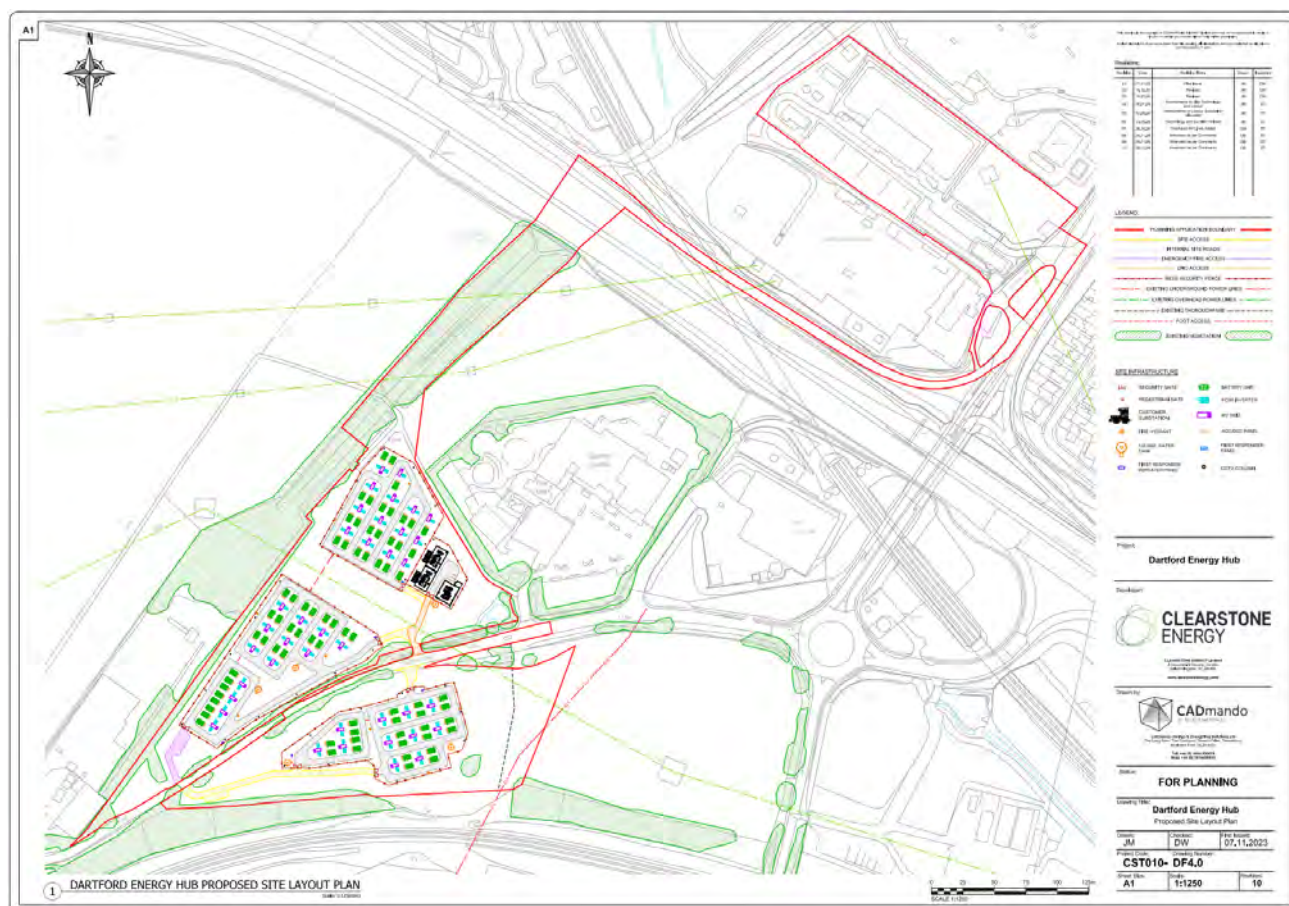


Figure 3.2: Indicative Site Layout Plan

- 3.16 The design has been subject to consultation with KFRS, the outcomes of which are explained in detail in Section 4 below.
- 3.17 A summary of how the Dartford Energy Hub complies with the current NFCC guidelines is set out in the table below and within the NFCC Design Compliance plan in the drawing pack (included below as figure 3.3). The proposal is also compliant with all updates proposed in the new NFCC Guidance that is currently out for consultation.

NFCC GUIDANCE	DARTFORD ENERGY HUB
Site Design	
Minimum 10 metres clearance from battery units to combustible materials	- Confirmed. All surfaces within the BESS compound will be made with compacted gravel to inhibit vegetation growth. There is a minimum of 10 metres from battery units to existing or new planting as shown by the hashed green line in figure 3.3
At least 25 metres clearance from battery units to occupied buildings / site boundaries	- Confirmed. Battery units are located no less than 25m from the nearest publicly accessible spaces - Millbrook Garden Centre car park and Station Road

Minimum 6 metre spacing between batteries unless closer spacing supported by manufacturer testing	- Battery spacing will be confirmed post planning at the detailed design stage and approved by Kent Fire & Rescue Service as part of the Battery Safety Management Plan for the project. Any reduction below 6m will be designed by a competent fire engineer and supported by full scale fire testing and / or modelling. The indicative layout is based on the Wartsila Gridsolv Quantum BESS which is designed and tested at 3m spacing and provides for 4m spacing between battery rows. (supporting testing data provided at Appendix 6)
No stacking of battery units	- Confirmed. Battery units are not stacked
Site Access	
Minimum of two access points to account for wind conditions	- Confirmed. As the site is split in two by Station Road, we have provided primary and secondary access points for each section of the site. These are shown in figure 3.3.
Passing places on perimeter road	- Confirmed. Passing places provided on all access roads.
Road access to all areas of the facility, sized appropriately for KFRS vehicles	- Confirmed. Access roads are a minimum of 4.5m wide. Swept path analysis conducted for a medium fire appliance.
No extremes of grade on internal roads	- Confirmed
Water Supply / Containment Features	
Minimum 1,900 litres per minute for 2 hours (228,000 litres)	- Confirmed. Each section of the site will provide access to 228,000 litres of water stored in tanks, feeding a pump driven system of fire hydrants across the site. Volumes validated through firefighting scenario planning (paragraphs 4.30 - 4.38 in this report)
Minimum 10 metres from battery units to water storage tanks	- Confirmed. Minimum 10 metres
Management of fire water run off within site design	- Confirmed. Containment is provided for each section of the site for a minimum of 228,000 litres of water within the onsite drainage system. This is equivalent to emergency water supplies stored on site.

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4. FIRE SAFETY

- 4.1 This section of the report assesses fire risks and potential impacts on people, property and the environment and describes their mitigation through technology selection, site design and emergency response planning.

Engagement with Kent Fire & Rescue Service

- 4.2 The NFCC recommends that planning applicants engage early and supply appropriate information to the local Fire and Rescue Service (FRS) to allow an initial fire safety appraisal to be made and gain input into emerging draft proposals.
- 4.3 Prior to preparing the Application, the Applicant appointed fire consultancy Joe Hassell Command (JHC) in an advisory role to co-design the site layout in accordance with NFCC and other relevant guidance, and to engage with KFRS to ensure that the emerging draft proposals reflected its operational requirements.
- 4.4 JHC contacted the Fire Engineering team at KFRS on 1 November 2024 to request a pre-application consultation briefing. The request was accompanied by a briefing pack that included: FRS briefing document (Appendix 2), Battery Safety Standards Report (Document Ref: R022) and draft versions of the NFCC Design Compliance plan (In Drawing Pack) and Sensitive Receptors Plan (In drawing pack).
- 4.5 Following a review of the documentation, KFRS provided a pre-planning response (Appendix 3) on 11 November 2024 with requests for further clarification on water supplies, suppression systems and procedures for using the annunciation panels specified by the Applicant.
- 4.6 In response, the site layout was updated to include an additional emergency water tank in the most northerly section of the site. An updated Fire Strategy Plan was sent to KFRS on 19 December 2024 alongside responses to questions raised in the pre-planning response (Appendix 4).
- 4.7 If the proposed development receives planning consent KFRS will be consulted on final site designs, BESS technology selection and the creation of an emergency response plan as part of the project's Battery Safety Management Plan.

Inbuilt Fire Risk Mitigation and Management

Battery Equipment

- 4.8 The BESS units ultimately selected for the project will comply with all relevant BESS safety guidance, test certifications and codes including NFPA 855, NFPA 69, NFPA 68, UL 1973, UL 9540, UL 9540A, BS EN IEC 62619, and BS EN IEC 62933 (2-1, 5-1, 5-2). Key features and safety systems include the following:
- **Cell:** The basic building block of the BESS. The standard BESS cell today is a prismatic lithium iron phosphate (LFP) cell. Each cell has a nominal capacity of 280 or 306-amp hours (Ah) and a nominal voltage of 3.2 volts (V).

- **Module:** Cells are arranged in modules typically comprising around 50 cells and equipped with venting fans and communication connections for remote monitoring and switch off in response to abnormal cell behaviour that indicates a potential fault. Both cell and module casing are designed to inhibit the propagation of fire between cells within a battery unit.
- **Rack:** Modules are held in racks, typically containing around 8 modules and 400 cells. Each rack contains a Battery Management System (BMS) controller. The BMS controls battery operation and provides multiple safety mechanisms including overcharge protection, over-discharge protection, overcurrent protection, and temperature protection. The BMS ensures that the battery operates within safe parameters.
- **Unit:** A complete battery unit typically contains between 4 and 12 racks of modules (depending on whether cabinet or container sized system). The unit will be provided with a cooling system for cell, module and rack level cooling. Today's standard is liquid cooling using a closed loop chiller system. The fire detection solution will be a fully addressable system (as per NFCC guidelines) integrating detectors including carbon monoxide, smoke, heat and hydrogen.
- **Enclosure:** A rigid metal enclosure which is designed to house the BESS unit. The BESS enclosure will include a minimum 1-hour fire resistance rating on the front, rear, and sides of the enclosure. The BESS enclosure helps to protect the BESS from mechanical damage, animals, and general weather conditions.

- 4.9 For reference, the Wartsila Gridsolv BESS system used for the indicative site layout is a cabinet sized BESS containing 4 racks of battery modules. Each enclosure measures 2.1m (w), 3.3m (d) and 2.6m (h). Up to eight enclosures can be installed in a row and interconnected to achieve the desired energy storage capacity.
- 4.10 Each battery enclosure will include a NFPA 69 compliant flammable gas ventilation system. The system will be capable of preventing flammable gases produced by a battery fire from exceeding 25% of the Lower Explosive Limit (LEL) within the enclosure. This reduces the risk that a battery fire could lead to an explosion. Performance testing would be provided as part of the Battery Safety Management Plan, an example is provided in Appendix 5 to this document.
- 4.11 Each battery enclosure will also integrate a NFPA 68 compliant deflagration panel on the roof of the unit. If other safety systems have failed and there is an explosion the deflagration panel will open and direct the force of the explosion upwards minimising risk to site operatives and first responders.
- 4.12 A visual overview of the safety systems integrated into the Gridolv Quantum BESS units is contained in Appendix 6 of this document for illustration.
- 4.13 As an example of the continual improvements being introduced by BESS equipment providers it is expected that the fire resistance rating on enclosures will be increased from 1-hour to 4-hour in equipment supplied from 2025.

Suppression systems

- 4.14 Battery unit enclosures will be fitted with a suppression system for extinguishing an electrical fire so that it cannot propagate to battery cells. The standard today is a gas-based system that displaces oxygen from the battery unit through the introduction of another non-flammable gas.

- 4.15 Battery unit enclosures will also be fitted with a dry-pipe water sprinkler system as standard. This is controlled by attending first responders with guidance from a manufacturer-trained subject matter expert. Latest guidance from manufacturers and NFCC recommends against using the water sprinkler to directly tackle a BESS fire, due to the risk from contacting electrified components, and instead to use as a means of extinguishing a BESS unit fire once the batteries have burnt out and it is safe to apply water to extinguish the remaining fire. FRS crews would charge the water sprinkler using onsite water supplies and fire service vehicles. Connections for each BESS unit sprinkler system will be a minimum of 25 metres from the BESS unit.
- 4.16 The applicant confirms that any suppression system proposed for the final site design will comply with NFCC guidelines and be appropriate to the BESS unit ultimately selected for the project. It will be subject to approval by KFRS as part of the proposed battery safety management plan condition.

Additional Safety Systems

- 4.17 **First Responder Panel** - A fully addressable fire alarm system will be installed on site, accessible through a first responder panel. The master digital display will be located at the main access gate with repeater panels at the entrance to each section of the site. Panel locations are included in the fire strategy plan (Figure 4.1). In the event of a fire incident, the first responder panels will provide live information on the location of the affected battery unit; the status of battery modules and fire suppression systems within the cabinet; and temperature data for that cabinet and adjacent cabinets so that KFRS personnel can monitor and deploy defensive firefighting tactics if required to manage the situation. Primary responsibility for managing the system lies with the BESS Subject Matter Expert assigned to an incident. Training on the fire alarm system will also be provided to KFRS as part of emergency response planning.



Figure 4.1: Location of first responder panels (red dots)

Facility Fire Risk Mitigation and Management

Distance to Combustibles

- 4.18 It is important that the Site is kept free of vegetation and other combustible materials that could catch fire in the event of an incident. All equipment on site will be placed on 15cm deep concrete pads, internal roads and the areas between equipment will be surfaced with crushed aggregate to restrict vegetation growth. Battery units will be located a minimum of 10 metres away from existing and new planting as per NFCC guidance.

Distance to Public Spaces

- 4.19 The Proposal follows NFCC guidance on safe distances between battery units and public spaces to ensure that people are protected from heat, flames, smoke and toxic substances in the event of a fire. The NFCC guidance currently suggests a minimum of 25 metres between battery units and site boundaries or occupied buildings.
- 4.20 The Proposed Site Layout Plan provides for a minimum of 25 meters to occupied buildings within the Milbrook Garden Centre, or to Station Road. The adequacy of these arrangements in protecting members of the public from the effects of heat, smoke and toxic emissions in the event of a fire is demonstrated in section 5 of this report.

Battery Spacing

- 4.21 The NFCC guidance recommends a standard minimum spacing between units of 6 metres unless *“suitable design features can be introduced to reduce that spacing. If reducing distances a clear, evidence based, case for the reduction should be shown.”* The applicant confirms that battery spacing in the final site design will conform to NFCC guidance and that any reduction in spacing below 6 metres will be supported by evidence from fire testing of battery units.
- 4.22 As an example, the Wärtsilä Gridsolv Quantum BESS units shown in the indicative site plan are designed to be installed and connected together in rows (often referred to as strings) containing a maximum of 8 units with a separation of 10cm between units. The manufacturer recommends a minimum spacing of 3 metres between strings of battery units. Recommendations are supported by outcomes from full scale free burn tests conducted by the Energy Safety Response Group in February 2023 and further FDS modelling undertaken by the Fire and Risk Alliance. The Indicative Site Layout provides for a spacing of 4 metres between rows of batteries.
- 4.23 The tests conducted by Wartsila are described in more detail in Appendix 7 and 8 of this report. No defensive firefighting tactics, such as boundary cooling, were undertaken during the tests. Post-fire inspection of the units demonstrated that the fire did not propagate into the adjacent units and there was no observable damage to the battery modules within the non-initiating units, indicating that the risk of propagation is low.

Fire and Rescue Service Response Planning

Around the clock access to BESS Fire Subject Matter Expert

4.24 In the event of a safety incident at the facility, first responders from KFRS would be supported by a BESS Fire Subject Matter Expert (SME) who would be trained and certified by the equipment manufacturer. The SME would play a critical role in alerting and guiding members of the fire services through the response posture associated with a BESS emergency. The SME will fall under the Unified Command structure where they will collaborate with members of the FRS to bring the incident under control. The SME will be responsible for coordinating the following:

- Review Fire Alarm Control Panel (FACP);
- Review and interpret Battery Management System and Fire Alarm System data, such as gas alarms, module isolation and cell temperature;
- Operation of Rapid System Shutdown/Process Stops and Disconnect switches;
- Operation of the MV Skid Process Stop and operation of Disconnect switches;
- Coordinate Field Switching and isolation of auxiliary power supply;
- Advise if and when BESS unit doors should be opened;
- Advise on requirement for use of internal suppression systems water sprinklers; and
- Post-Incident Operations.

Emergency Response Planning and Execution

4.25 NFCC guidance recommends that site operators develop an Emergency Response Plan (ERP) in collaboration with the local FRS to help facilitate effective and safe emergency response, including emergency procedures for all hazards. The ERP is finalised in the detailed design phase of the project, once the BESS equipment provider has been selected and a site operator has been appointed and included within the Battery Safety Management Plan.

4.26 An outline of the incident response plan follows and includes details of potential fire risk scenarios and recommended approaches.

4.27 Upon arrival, KFRS personnel will contact the BESS SME to obtain a status briefing which should provide a snapshot of existing conditions and lead to the following set up actions:

- **Accountability of ALL site personnel:** Only essential employees should be allowed into the site during emergency conditions.
- **Staging of apparatus:** All apparatus should be staged uphill/upwind on arrival. Scene size-up will determine apparatus placement; and

- **FRS Exclusion Zone:** Establish a 30.5m exclusion zone around the involved BESS (dashed red at Figure 3.2). This is a conservative method employed in parallel with an explosion protection system (NFPA 68 and NFPA 69) to ensure the safety of personnel and department members operating at the scene.
- **Public Exclusion Zone:** Establish a 61m exclusion zone around the involved BESS for members of the general public (dashed orange at Figure 3.2). This has been established as a safe distance to ensure that the local community are not put at any risk from smoke or toxic gases from a BESS fire. It may mean temporarily closing Station Road.

4.28 The annotated site layout below (Figure 4.2) shows exclusion zones and FRS staging for an incident involving a BESS in the area of the site closest to the Garden Centre:

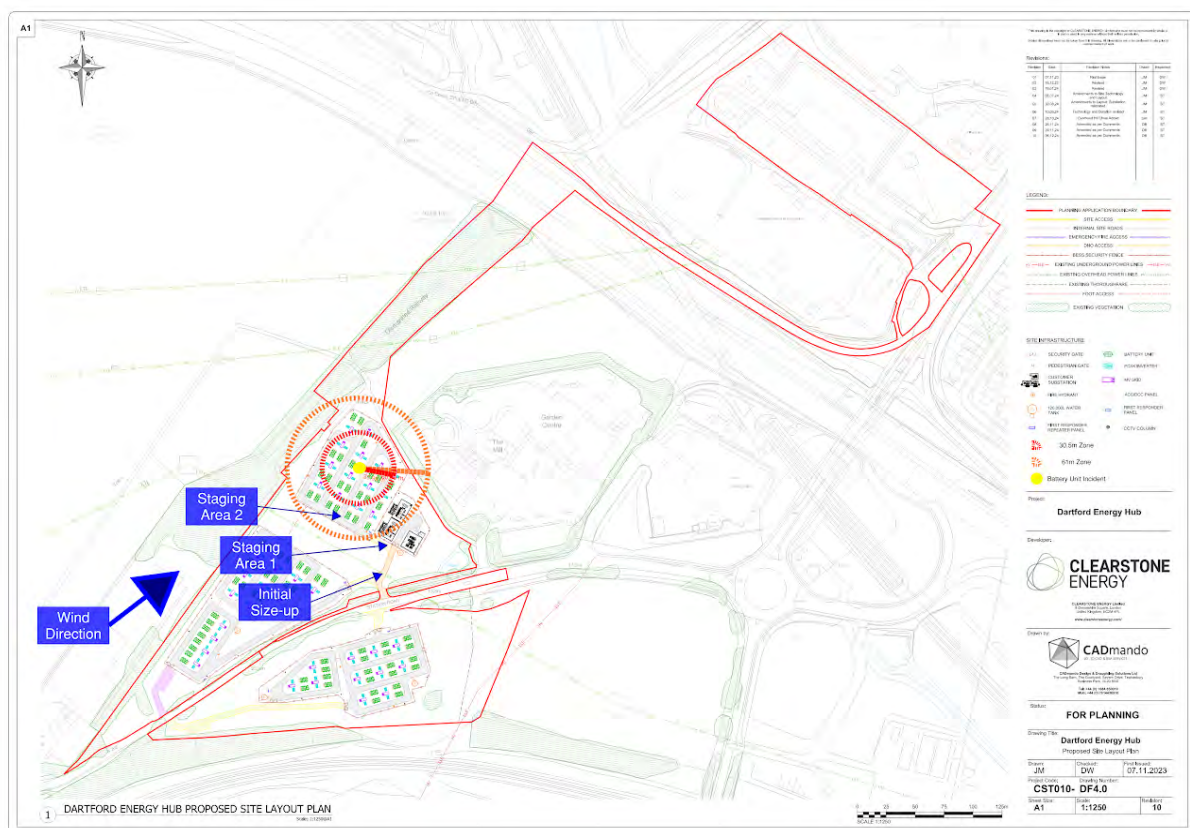


Figure 4.2 Annotated site layout plan showing exclusion zones and FRS staging in relation to a fire incident in the centre of the Site

4.29 Guidance from the NFCC, leading manufacturers and other international fire services organisations² is that firefighters attending a BESS fire would adopt a controlled burn approach with the involved battery unit and monitor the condition of adjacent units. KFRS and the BESS SME will work together to evaluate the status of the involved BESS and adjacent units:

- **Fire Alarm Control Panel Info:** The FACP should be reviewed to determine which, if any, of the safety systems within the enclosure have been activated;

² Battery Energy Storage System Emergency Response Plan Guide 2023, International Association of Fire Chiefs (IAFC) Bulletin 2022

- **Battery Management System:** The battery management system will be monitored continuously to identify changing conditions. Conditions within the involved BESS enclosure container and exposures of adjacent containers will be captured and recorded in 15-minute intervals for trending analysis. Data would include enclosure temperatures, cell temperatures with focus on cells/module surrounding the troubled modules, state of charge and H2 gas detection;
- **Exposures:** The involved BESS string should be evaluated with a thermal imaging gun. For comparison an uninvolved string should also be evaluated to develop a baseline temperature;
- **Electrical Hazards:** The Battery Management System operates in an autonomous manner and isolates troubled equipment in a timely manner. The BESS SME shall verify that all switching to isolate the trouble equipment has been completed; and
- **Chemical Hazards:** The hazards found during the response to a BESS system failure can be appropriately managed by wearing a structural firefighting ensemble along with an SCBA for respiratory protection.

Fire and Rescue Service Response Scenarios

4.30 Thermal runaway cell-to-cell propagation can lead to four primary BESS hazards:

- Multiple cells venting flammable gases without an ignition source or significant temperature for ignition.
- Multiple cells venting flammable gases with delayed ignition resulting in a deflagration (explosion).
- Multiple cells venting flammable gases without an ignition source or significant temperature for ignition until after flammable gas concentrations have exceeded the Upper Flammable Limit (UFL). Introduction of fresh oxygen can cause a fireball or deflagration; however, a jet fire is more likely if BESS units integrate explosion prevention and protection systems as the Wartsila Gridsolv Quantum units do.
- Rapid or immediate ignition of cell gases, which can lead to sustained propagation resulting in a fire that partially or fully consumes battery modules within the battery unit.

Scenario 1: Battery Module Venting or Burning Thermal Runaway within a Single Battery Module

4.31 A cell failure leads to a fire within a single module within a unit. Gas exhaust and / or fire protection systems restrict thermal runaway propagation to that individual module. Situation monitored by FRS and BESS SME but no emergency firefighting intervention required.

Scenario 2: Partial Battery Unit Fire - Controlled Burn

4.32 A burning thermal runaway incident propagates to further modules within the BESS unit but not all. Data from adjacent units satisfies attending FRS personnel and BESS SME that there is no risk of further propagation and they allow the fire to burn out in a controlled manner without any emergency firefighting intervention.

Scenario 3: Full Battery Unit Fire – Controlled Burn

- 4.33 A burning thermal runaway incident fully propagates to all modules within a BESS unit. Data from adjacent units satisfies attending FRS personnel and BESS SME that there is no risk of further propagation, and they allow the fire to burn out in a controlled manner without any emergency firefighting intervention.

Scenario 4: Single Battery Unit Fire - Boundary cooling of adjacent units

- 4.34 As with scenario 3 however battery temperature monitoring systems indicate to attending FRS and BESS SME that the burn time has exceeded the thermal protection rating of the battery enclosures and adjacent units are reaching temperatures high enough to trigger cell failure and consequent fires.
- 4.35 Firefighters wearing breathing apparatus would use appropriate defensive tactics to reduce internal temperatures within adjacent units. Tactics would include directly applying water spray to adjacent units using adjustable firefighting branches (nozzles) or deploying defensive spray plates that form a water curtain between the affected unit and adjacent units. These boundary cooling tactics would likely be applied intermittently in 15-minute application periods with temperature changes measured between application periods. The potential exists to contact energised electrical components in battery enclosures so fog patterns and water stream strategies will be agreed by FRS and BESS SME.
- 4.36 Water requirements for boundary cooling will vary depending on branch/spray plate manufacturer, with likely application rates per water jet/ spray plate used between 450-800 litres per minute. If the involved battery unit is in the middle of a string and cooling is required for two adjacent units this equates to a maximum of 1,600 litres per minute, or 96,000 litres per hour if boundary cooling is applied continuously.
- 4.37 Factors such as wind speed and direction will influence the temperatures reached in adjacent units so two hours of continuous boundary cooling is used as a conservative estimate. At 1,600 litres per minute, two hours of continuous boundary cooling would require 192,000 litres of water to be available on site.
- 4.38 If boundary cooling is applied intermittently with 15-minute application periods followed by 15-minute non-application periods to monitor temperature changes then 192,000 litres of water would suffice for four hours of boundary cooling.

Fire Response Safety Provisions

Access

- 4.39 The Applicant can confirm that access for Fire Service vehicles is in accordance with B5, Approved Document B of the Building Regulations. The access gates have a minimum width of 3.1m, the road has a minimum width of 3.7m, the minimum turning circle between kerbs is 16.8m, the minimum height clearance is 3.7m and the minimum carrying capacity is 12.5 tonnes.
- 4.40 A secondary access point is included to both sections of the site, as per NFCC guidance, and the internal road layout gives fire service access to all battery units from both primary and secondary access points.

- 4.41 Passing places have also been included within both primary and emergency access roads to allow multiple vehicles to attend an incident if required.
- 4.42 The swept path analysis for all access roads have been considered and can be seen in full in the Construction Traffic Management Plan (CTMP).
- 4.43 Foot Access between different site levels is provided, for instances where wind is blowing access across the primary plateau access points.

Water Supply

- 4.44 Ensuring the availability of adequate water supplies for firefighting and the containment of any water used in response to a battery failure is a key element of risk management and emergency response planning for battery energy storage facilities.
- 4.45 The Applicant can confirm that a system of water hydrants fed by static water tanks and pump will be installed as an Emergency Water Supply (EWS). The water hydrants will be installed at 45M radius coverage in line with approved document Part B Fire Safety. Water tanks will be located at the primary and secondary site access points with direct hose access provided, through a 4" BSP female outlet connection and isolating valve, as redundancy for water access.
- 4.46 There will be three water tanks in the northern section of the site each containing 76,000 litres of water, a total of 228,000 litres. The southern section of the site will include two water tanks each containing 114,000 litres of water, a total of 228,000 litres. Each tank will be sited at least 10 metres away from any battery unit. The complete system will be capable of delivering no less than 1,900 litres of water per minute (lpm) for at least 2 hours for each of the two sections of the site, equivalent to a minimum of 228,000 litres of water, as per NFCC guidance. Due to the split nature of the site, the applicant can confirm that the full provision of 228,000 litres of water is stored on either side of Station Road. Fire hydrants will be compliant with BS9990 and BS3251 and capable of delivering a minimum 25 litres per second flow rate as per draft Updated NFCC guidance.
- 4.47 With the controlled burn approach to managing a fire incident (as described in 4.30 - 4.38) water requirements are likely to be less than 228,000 litres. In these scenarios the maximum water requirement is 192,000 litres of water. This is in line with the draft version of the updated NFCC Guidance released in July 2024 which reduces its guidance to a minimum of 180,000 litres.

Water containment

- 4.48 Each section of the Site is designed with a drainage system capable of containing a minimum of 228,000 litres of water (equivalent to emergency water supplies) in addition to surface water runoff already in the system from a 48-hour rainfall event. In the event of a fire, penstock valves are used to close the drainage system and contain water on site. Once the fire has extinguished, water will be tested for contamination and either taken away by tanker for treatment or released through the drainage system. The risks presented by contaminated water and their mitigation through the drainage system are covered in detail in Section 6 of this report.

Battery Safety Management Plan and other Fire Safety Plans

4.49 This section explains how safety aspects of the BESS facility will be managed and documented through specific plans. The plans described below will be in place at different phases of construction however all will be completed and signed off prior to the BESS facility becoming operational.

4.50 There are four key plans that are integral to the safe operation of the BESS:

Battery Safety Management Plan Required as a condition of planning permission Describes all safety measures during construction, operation and decommissioning of the BESS		
Risk Management Plan Proactive fire risk mitigation plan and advice to FRS in relation to a potential incident	Emergency Response Plan Reactive internal plan should an emergency occur	Fire Risk Assessment May be required by FRS to identify fire risks and mitigation

Battery Safety Management Plan (BSMP)

4.51 A site-specific BSMP for a standalone battery energy storage system is essential to ensure the safe operation and maintenance of the system. The BSMP must prescribe safety measures during the construction, operation and decommissioning of the battery storage facility, including the transport of new, used and replacement battery cells both to and from the authorised development. The Local Planning Authority must consult with the Health and Safety Executive and the local Fire and Rescue Service before approving the BSMP which must be implemented as approved. It is the overarching plan that includes details that are required for other plans such as Emergency Response Plan and the Risk Management Plan.

4.52 The plan will be tailored to the unique characteristics and risks of the standalone battery energy storage system and periodically updated to reflect changing circumstances and new safety information. Below is an example of a BSMP Table of Contents.

	Content	Detail
1.	Site Description	- Location of the BESS. - Site layout and design. - Environmental considerations.
2.	Battery System and Fire and Explosion Protection system Information	- Battery technology and operation specifications. - Capacity and voltage. - Battery manufacturer and model. - BMS and EMS specifications. - Thermal Management System specifications. - Date of installation and expected lifespan. - Fire and gas detection system specifications. - Fire and explosion protection system specifications.

	Content	Detail
3.	Safety Policies and Objectives	Clearly defined safety policies and objectives for the BESS construction, operation and decommissioning.
4.	Roles and Responsibilities	- Identification of personnel responsible for safety management. - Duties and responsibilities of each role (RACI matrix).
5.	Safety Training and Education	- Requirements for personnel training in battery system safety. - Training programs and certification procedures. - Frequency of safety training.
6.	Safety Equipment	- List of safety equipment on-site. - Personal Protective Equipment (PPE) guidelines. - Details of provision of firefighting water and guidelines for operational use (including water capture and testing). - Maintenance and inspection procedures for safety equipment. - Equipment testing and calibration schedules.
7.	Hazard Identification and Risk Assessment	- Analysis of potential hazards associated with the BESS (FMEA and HMA reports). - Assessment of the risks associated with these hazards (Fire Risk Analysis, Explosion Risk Analysis, HAZOP, etc.) - Procedures for continuous risk assessment and mitigation.
8.	Emergency Response and Evacuation Plan	- Procedures for responding to fires, thermal runaway event scenarios, or other emergencies. - Evacuation plans, assembly points, and communication methods. - Contact information for emergency services.
9.	Incident Reporting and Investigation	- Protocol for reporting and documenting safety incidents. - Procedures for incident investigation and root cause analysis. - Corrective actions and preventive measures.
10.	Security Measures	- Access control measures to prevent unauthorised entry. - Cybersecurity. - Surveillance and monitoring systems. - Security personnel responsibilities.
11.	Battery Storage and Handling	- Guidelines for the safe storage and handling of batteries, including charging and discharging procedures. - Decommissioning procedures. - Safe transportation procedures. - Suitable storage conditions (temperature, ventilation, etc).
12.	Ventilation and Environmental Controls	- Information on ventilation systems and environmental controls to prevent the build-up of hazardous gases. - Details on testing and maintenance schedule.
13.	Electrical Safety	- Protocols for working with electrical systems. - Lockout/tagout procedures.
14.	Inspection and Testing	- Regular inspection and testing schedules for the BESS and its components. - Records of inspections and test results.

	Content	Detail
15.	Record Keeping and Documentation	- Documentation of safety procedures, inspections, maintenance, and incidents. - Record retention policies.
16.	Regulatory Compliance	- Information on applicable regulations and standards. - Procedures to ensure compliance.
17.	Communication Plan	- Procedures for communicating safety information to employees, contractors, and relevant stakeholders. - Emergency communication plan.

Risk Management Plan (RMP)

4.53 The NFCC guidelines recommend that a Risk Management Plan (RMP) should be developed by the operator, which provides advice in relation to potential emergency response implications including the following, the majority of which would be drawn from the BSMP:

- The hazards and risks at and to the facility and their proposed management;
- Any safety issues for firefighters responding to emergencies at the facility;
- Safe access to and within the facility for emergency vehicles and responders, including to key site infrastructure and fire protection systems;
- The adequacy of proposed fire detection and suppression systems on-site; and
- Natural and built infrastructure and on-site processes that may impact or delay effective emergency response.

Emergency Response Plan (ERP)

4.54 NFCC guidelines state that an ERP should be developed to facilitate effective and safe emergency fire service response, and should include:

- How the fire service will be alerted;
- A facility description, including infrastructure details, operations, number of personnel, and operating hours;
- A site plan depicting key infrastructure: site access points and internal roads; firefighting facilities (water tanks, pumps, booster systems, fire hydrants, fire hose reels etc); drainage; and neighbouring properties;
- 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 and first aid;
- Up-to-date contact details for facility personnel, and any relevant off-site personnel that could provide technical support during an emergency;

- A list of dangerous goods stored on site;
- Site evacuation procedures; and
- Emergency procedures for all credible hazards and risks, including building, infrastructure and vehicle fire, grassfire and bushfire.

Fire Risk Assessment (FRA)

- 4.55 The Regulatory Reform (Fire Safety) Order, often referred to as the Fire Safety Order or RRO, is a piece of legislation in the United Kingdom that places requirements on the responsible person (usually the building owner or occupier) to take general fire precautions in commercial and non-domestic premises. While the RRO primarily applies to buildings, due to the low life risk during normal occupation the RRO is limited in its application to BESS sites. The majority of the information required will already be in the BSMP and RMP therefore the operator would liaise with KFRS prior to development of the BESS commencing to determine if a Fire Risk Assessment (FRA) is required.
- 4.56 If an FRA is required, it would be carried out by a competent person and would identify potential fire hazards, evaluate the risk, and establish appropriate control measures. At BESS sites, fire risk assessments should consider the unique risks associated with the storage and operation of batteries.
- 4.57 If required, the FRA should include:
- Fire prevention measures;
 - Escape routes and evacuation plans;
 - Fire detection and alarm systems;
 - Firefighting equipment;
 - Staff training information and record keeping; and
 - Regular reviews and updates.

5. AIR QUALITY

- 5.1 In the unlikely event of a fire, it is important to understand the resultant thermal effects and toxic gas and smoke impacts on neighbouring areas. This is typically presented in a plume impact Study and assessed using 3D Computational Fluid Dynamics (CFD) modelling.
- 5.2 Studies model the generation of smoke and toxic gases by a BESS fire and consequent dispersal into the atmosphere in different wind conditions. Modelling is based on the worst-case scenario of a full battery container fire at peak fire conditions. Results are presented in terms of recognised hazardous and safe exposure thresholds. The hazardous threshold is known as Immediately Dangerous to Life and Health (IDLH). The safe threshold is based on the UK HSE Workplace Exposure Limits (Ref) for recommended maximum short term (15 minutes) and long term (8 hour) exposure.

- 5.3 There have been a number of plume impact studies conducted in the UK and US. The findings have informed Emergency Response Planning guidance, such as the 61m (100ft) public evacuation zone for smoke, pollution and explosion risk contained in the NFPA 855 standard.
- 5.4 This section of the site safety reports presents the findings of those plume impact studies. It compares studies of two different BESS form factors - cabinet and container-based systems - and draws conclusions on how nearby sensitive receptors - residential properties, local roads and public footpaths - would be impacted by the air emissions arising from a fire. Cabinet-based systems like the Wartsila Gridsolv Quantum BESS string together smaller units with individual units measuring approximately 2m x 3.2m x 2.5m (L X W X H). Container based systems use larger units measuring approximately 6m x 2.5m x 2.6 m (L X W X H).

Cabinet based systems

- 5.5 A plume modelling study of air quality impacts from a fire within a Wartsila Gridsolv battery unit - the BESS used for the indicative design on this proposal - was undertaken in May 2024. The study was conducted by DNV, an independent risk management and assurance consultancy with experience in the fire risks associated with BESS projects.
- 5.6 A 3D model of a battery unit was created and used to build a full 3D model of the facility, site boundaries and nearby buildings. The 3D CFD code Kameleon FireEX (KFX) was used to run a series of fire simulations. Gas composition data obtained from both cell level and unit level fire tests of the Wartsila Quantum Gridsolv BESS was used to generate results.
- 5.7 The modelling was undertaken with worst case assumptions, where safety systems and barriers to prevent escalation were assumed to have failed, and a worse case (full battery unit) fire was modelled. In simple terms, this is the worst-case event.
- 5.8 The study considered the full range of toxic gases produced by a battery fire using gas emission data collected by Wartsila during full scale fire tests. Gases measured included Hydrogen Fluoride (HF), Carbon Monoxide (CO), Hydrogen Chloride (HCl), Hydrogen Cyanide (HCN) and Nitrogen Dioxide (NO₂). Peak fire conditions and, hence, gas release rates, were used to plot concentration levels for smoke and toxic emissions.
- 5.9 The main findings from the simulations were:
- Visibility impairment due to smoke is restricted to the locality of the affected battery unit. At 11m from the battery unit visibility is 100 metres, only reducing closer to the battery unit.
 - The concentrations measured of toxic gases in the full-scale fire test shows that the hazard posed by a battery unit fire is confined to the immediate surrounds of the battery unit, i.e., less than 5m. This is due to the low concentrations of the toxic gases produced in the fire which means that a high concentration of smoke is required to reach the hazardous IDLH thresholds which is limited to the proximity of the fire;
 - Larger distances were observed for the long term 8 hour exposure limits which are the safe exposure limits for the workplace in the UK. These limits do not exceed 30m from the battery unit, at 2m above the ground.

5.10 The following table documents the distance from the affected BESS at which exposure limits were reached for each toxic gas. It should be noted that the plume is typically above 2 metres high (the height of a battery unit is 2.5m) as is illustrated in figure 5.1 below.

Toxic Gas	Short term exposure limit threshold (15 mins)	Long term exposure level threshold (8 hours)
Hydrogen Fluoride (HF)	9.9 metres	14.5 metres
Carbon Monoxide (CO)	24.4 metres	60 metres
Hydrogen Chloride (HCl)	1.6 metres	5 metres
Hydrogen Cyanide (HCN)	0.6 metres	2.5 metres
Nitrogen Dioxide (NO ₂)	0 metres	0 metres

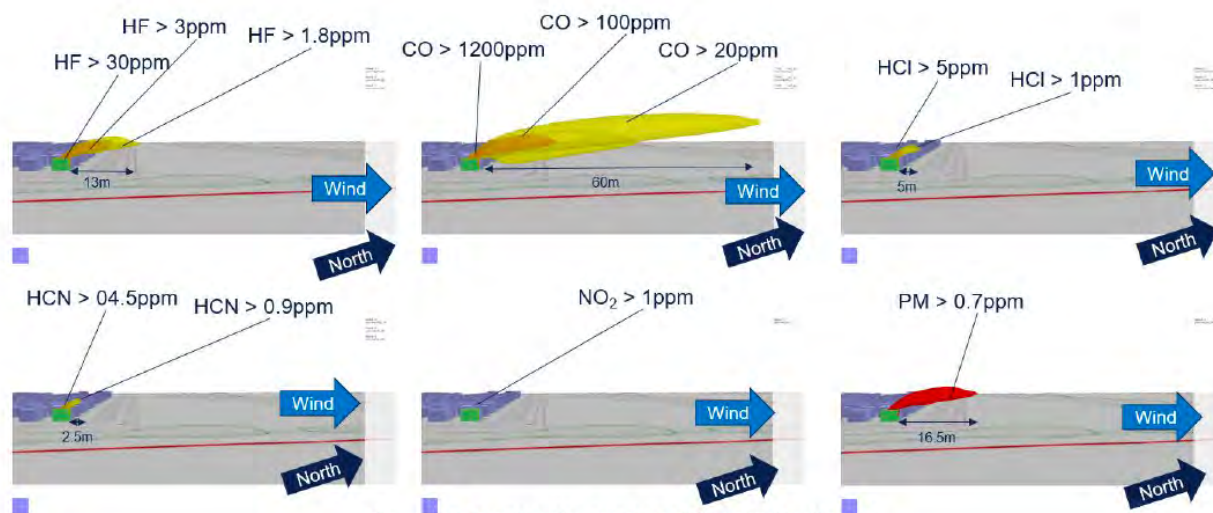


Figure 5.1 Toxicity contour plots from 2.2m/s (5mph) wind

Container based systems

- 5.11 A plume modelling study of air quality impacts from a fire within a containerised battery unit was undertaken in March 2023. The study was conducted by DNV, an independent risk management and assurance consultancy with experience in the fire risks associated with BESS projects.
- 5.12 A 3D model of a battery unit was created and used to build a full 3D model of the facility, site boundaries and nearby buildings. The 3D CFD code Kameleon FireEX (KFX) was used to run a series of fire simulations. Gas composition data was based on publicly available data from previous tests.
- 5.13 The modelling was undertaken with worst case assumptions, where safety systems and barriers to prevent escalation were assumed to have failed, and a worse case (full battery unit) fire was modelled.

- 5.14 Toxic gas measurements were limited to Hydrogen Fluoride (HF). Safety thresholds focused on the area where concentrations of HF would be of immediate danger to life and health (IDLH). The impact of smoke on visibility was also considered.
- 5.15 The main findings from the simulations were:
- While the greatest impairment to visibility is restricted to the area within 20 metres of the battery unit. There is a minor impact to visibility up to 70m from the BESS for the full BESS fire. At an average wind speed (6m/s) the smoke plume rises and disperses to the atmosphere with any smoke impairment at ground level limited to within 25 metres of the BESS.
 - The concentrations measured of toxic gases in the full scale fire test shows that the hazard posed by a battery unit fire (concentrations above IDLH threshold) is confined to the immediate surrounds of the battery unit, less than 12.5m.

Sensitive Receptors

- 5.16 The Applicant has produced a Sensitive Receptors Site Location plan for the Proposed Development in line with the updated guidance from the NFCC published in draft form in 2024. This identifies homes, businesses, major roads, hospitals, schools and care homes within 1 kilometre of the proposed Site.
- 5.17 The Site is set back from publicly accessible areas. The nearest public road is Station Road, which intersects the site, a minimum of 25m away at its closest point to the proposed Battery Units.
- 5.18 There is a mainline railway (High Speed 1) passing to the south of the site boundary, 40 metres from the nearest Battery Unit, and to the west of the site, 270 metres from the nearest Battery Unit. The A2 runs parallel to the northern boundary of the site and is 220 metres away at its closest point.
- 5.19 The nearest dwelling to the site is Station House located to the east of the site and 150 metres away from the nearest battery unit. There are no hospitals, schools, or similar establishments within 1 kilometre of the site.
- 5.20 The nearest business to the site is the Milbrook Garden Centre, with the building occupied by Swallow Aquatics being 33m from the nearest battery unit.
- 5.21 Dale Mount Residential home is situated 450m to the south-west of the site.
- 5.22 The Sensitive Receptors plan is included below for ease of reference and can be found in the drawing pack that accompanies this application.

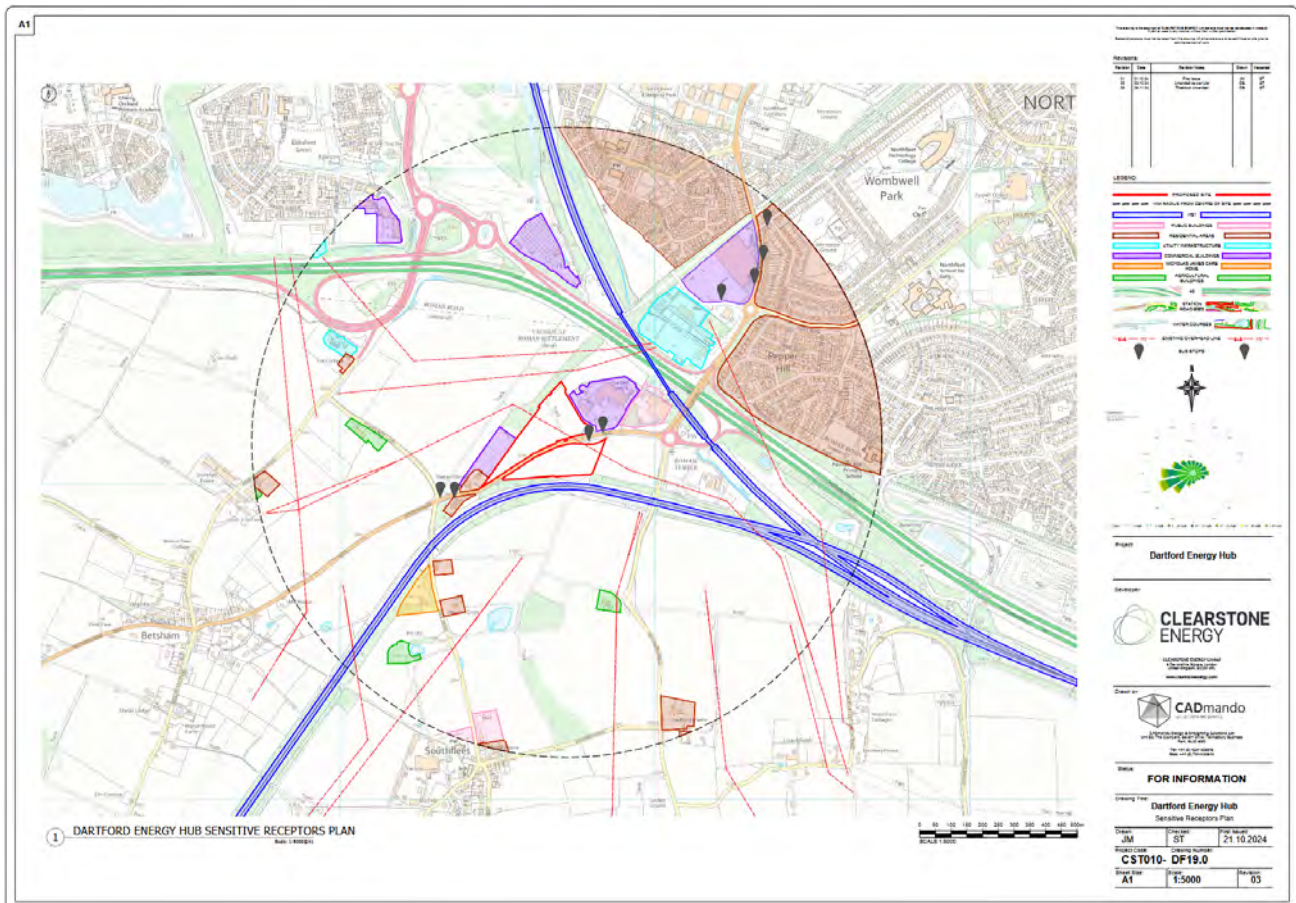


Figure 5.2 Sensitive receptors plan

Summary

5.23 The plume modelling studies indicate that visibility impairment due to smoke is restricted to 70 metres. A wind rose for the location is provided below (Figure 5.3).

5.24 The primary concerns for smoke impairment are nearby roads and railways.

- The A2 road runs parallel to the northern boundary of the site. Located a minimum distance of 220 metres from the nearest battery unit it is highly unlikely to be impacted by smoke.
- The main High Speed 1 railway line (HS1) runs parallel to the eastern boundary of the site. Located a minimum of 270 metres from the nearest battery unit it is highly unlikely to be impacted by smoke.
- The Ebbsfleet branch of HS1 runs along the southern boundary of the site. Located a minimum distance of 40 metres from any battery unit and upwind of the site it is unlikely to be impacted by smoke.
- The Emergency Response Plan developed in collaboration with KFRS would include engagement with HS1 and National Highways as a precaution.
- Station Road runs between the two sections of the site. Located a minimum distance of 25 metres from the site, the Emergency Response Plan will include provisions to close the road in the event of a fire.

- 5.25 The plume modelling studies indicate that hazards from toxic gases are limited to the immediate area surrounding the affected BESS unit (12.5 metres). Guidance for first responders in the Emergency Response Plan is to set up an FRS exclusion zone at 30.5 metres from the affected battery area. If FRS personnel needed to approach closer, they would need to be wearing appropriate safety equipment and breathing apparatus.
- 5.26 The nearest publicly accessible area to the BESS facility is Milbrook Garden Centre, with the closest point of carpark situated approximately 30m to the east of the battery compound. If the wind was blowing from the west, then the plume studies indicate that at this distance concentrations of most of the toxic gases generated by the fire would have fallen below the long-term exposure threshold. Carbon Monoxide levels could remain higher, but below the short-term exposure threshold.
- 5.27 The southeastern section of the Garden Centre car park would fall within the 61 metre exclusion zone specified in the Emergency Response Plan so would likely be closed to the public by Kent FRS on attending a fire incident at the site as a precaution. The Emergency Response Plan will contain a provision for the evacuation of the garden centre based on wind conditions at the time of the incident.
- 5.28 There are no dwellings that sit within the safety exclusion zones. Station House is located 150 metres upwind of the site so highly unlikely to be impacted by a fire incident.

Dartford

51.45°N, 0.21°E (8 m asl).
Model: ERA5T.

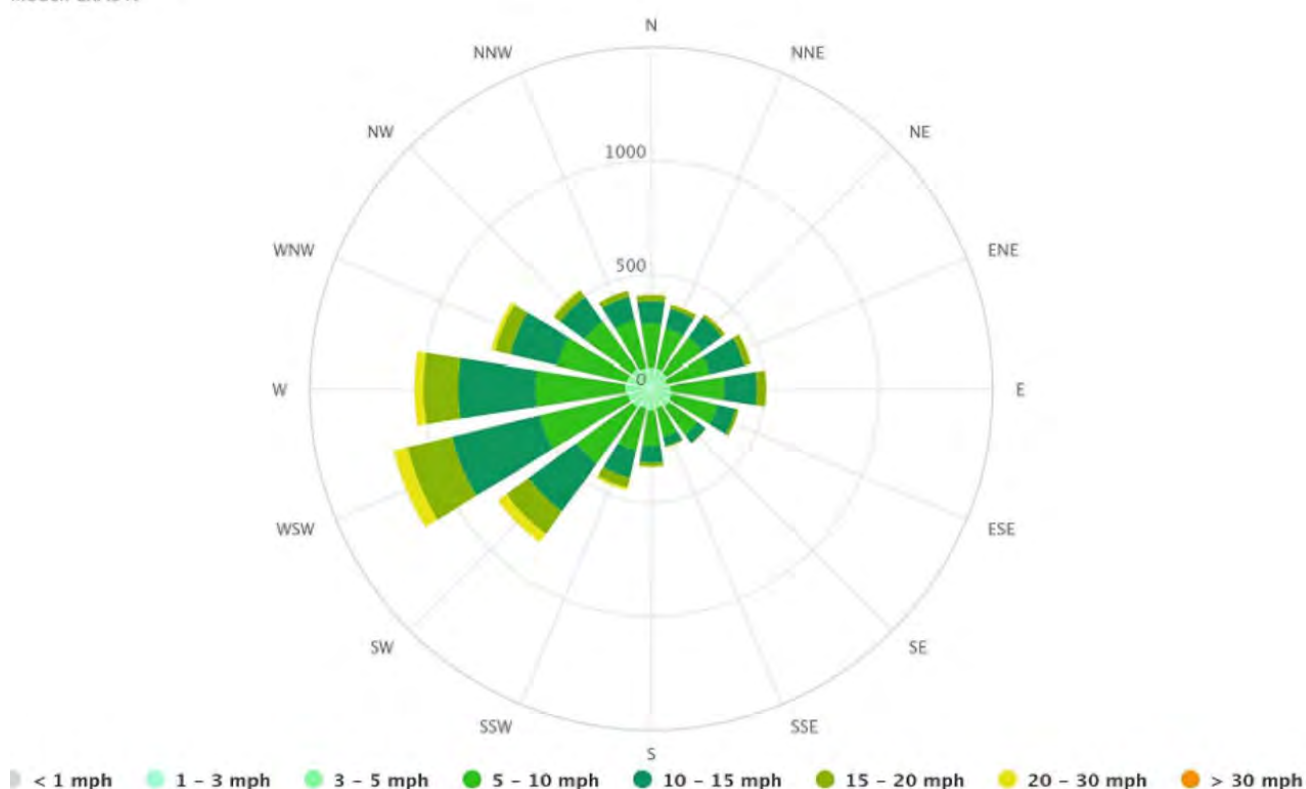


Figure 5.3 Wind rose for Dartford, plotting recorded wind directions and speeds

6. WATER SAFETY

Introduction

- 6.1 The construction and operation of the Proposed Development creates the risk that local water sources and water supplies, for households and businesses relying on boreholes or wells, could be contaminated. This section of the report evaluates the associated risks and their mitigation through good construction and operational practices.

Nearby water resources

- 6.2 The only Statutory Main River within 500 m radius of the Site is the source of the River Ebbsfleet, a tributary to the River Thames, located 246m north of the site. The River Ebbsfleet generally flows north and ultimately joins the River Thames approximately 2.6km to the north of the Site. There are also two unnamed watercourses located 91m east and 107m east of the site.
- 6.3 The Site is located within the EA's Thames River Basin District and is part of the Medway Management Catchment, the Medway Lower Operational Catchment and the Ebbsfleet Water Body.
- 6.4 Data provided by the EA and presented in the Groundsure Report for the site identify 15 licensed groundwater abstraction points within 1.5 km of the Site (Table 8). Four licences (five abstraction points) are large abstraction licences for public water supply and are licensed to abstract up to 144 Million litres per day (ML/d) in total (87.6 ML/d as an annual average). Other abstractions in the area are for agricultural and industrial uses amounting to 25.7 ML/d (16.9 ML/d as an annual average). The nearest abstraction point to the site is around 200 m to the west at Joyce Hall Farm and is used for spray irrigation. The nearest potable water supply abstraction to the site is at Southfleet Pumping Station around 640 m to the northwest of the site.
- 6.5 Water resources are therefore classified as a High Sensitivity receptor.

Groundwater vulnerability

- 6.6 Bedrock geology beneath the site is comprised of both the White Chalk Subgroup and the Thanet Formation (silt and sand). The Thanet Formation is designated as a Secondary A Aquifer. Secondary A aquifers comprise permeable layers that can support local water supplies and may form an important source of base flow to rivers. The White Chalk Subgroup is designated as a Principal Aquifer. Principal aquifers provide significant quantities of drinking water and water for business needs and may also support rivers, lakes and wetlands.
- 6.7 The site is considered to have high or medium-high groundwater vulnerability to surface pollution due to the limited superficial cover and generally high infiltration capacity of the Chalk bedrock³.

Drainage Strategy

- 6.8 Due to a lack of suitable discharge locations for rainwater run-off from the site, controlled infiltration will be utilised for drainage with soakaway pits directing water into the bedrock geology beneath the site.

³ [Groundwater Vulnerability Maps \(2017\) on MAGIC - data.gov.uk](#), accessed September 2024

Impact Assessment and Mitigation Measures

6.9 There are four potential impacts associated with controlled waters as a result of the proposed BESS which are as follows:

- Sediment mobilisation during construction;
- Contamination from construction equipment and/or materials;
- Changes in flow characteristics; and
- Contamination of the surface water drainage system in the event of a fire impacting water resources and controlled water environment.

Sediment Mobilisation During Construction

6.10 There is the potential that the proposed works on Site, including some limited site levelling and foundation works could result in an increase in surface water runoff, and ultimately promote sediment mobilisation within the groundwater.

6.11 There are no direct works associated with the watercourses. Good construction practice would minimise the impact on sediment mobilisation during the works and will be secured by a detailed Construction Environmental Management Plan (CEMP) required by condition of any planning permission.

6.12 This would result in an overall Negligible impact on controlled waters.

Contamination from Construction Equipment

6.13 The operation of construction equipment could give rise to controlled waters being contaminated with hydrocarbons, silt or other contaminated materials.

6.14 Construction equipment will be properly maintained to reduce the risk of hydrocarbon contamination and will only be active when required. Drip trays and spill kits will be used to limit the possibility of oil contamination and any mechanical faults will be reported to the site manager immediately. Spill kits will be carried on vehicles and will be available at all times; drip trays will be used if the refuelling of plant is necessary. This will be secured by a detailed CEMP required by planning condition on any planning permission,

6.15 This would result in an overall Negligible impact on controlled waters.

Changes in Flow Characteristics

6.16 Given that the Site is greenfield, during the construction and operational phases there would be an increase in impermeable area from the inclusion of construction compounds etc. and the BESS site itself. This would result in an increase in surface water runoff to the surrounding area, if not managed appropriately.

6.17 During construction the Site would comply with BS6031:2009 'The British Standard Code of Practice for Earthworks', which details methods that should be considered for the general control of drainage on construction sites. As well as this, all necessary drainage works would be installed to ensure that any

increases in surface water runoff as a result of construction of the Proposed Development are controlled and discharged appropriately.

- 6.18 During the operational phase, a suitable surface water drainage strategy will be in place (approved under planning condition in the event planning permission is granted) which will limit surface water runoff. This will ensure there is no change in flow characteristic when compared to the existing site and a Negligible impact.

Surface Water Contamination in Event of Fire

- 6.19 Should a fire event occur on Site, and without suitable measures in place, there is risk that sensitive receptors such as licenced abstractors and wider groundwater resources could be contaminated with fire-water runoff should it be able to enter the hydrological system.
- 6.20 The proposed surface water drainage strategy has been carefully designed to include penstock valves and impermeable membranes to ensure that fire-water would be contained on Site without infiltrating into the ground or entering into controlled water catchments.
- 6.21 The drainage system uses the voids in the layers of aggregate underlying the Site, referred to as a drainage blanket, to collect and direct water towards soakaway pits. The aggregate layer will be lined with an impermeable membrane, capable of resisting chemical concentrations and temperatures potentially generated by fire-water runoff.
- 6.22 Water is carried from the drainage blankets to the soakaway pits via underground pipes. There are penstock valves positioned at each point that the drainage system discharges into a soakaway pit to enable the system to be closed in the event of a fire.
- 6.23 Tanker take off valves are included before the penstock valves to enable contained water to be tankered away for treatment if tests show that it is contaminated. The location of the penstock valves and tanker take off valves is shown in Figure 6.1 below.



Figure 6.1: Location of penstock and take off valves (yellow dots)

- 6.24 The drainage system is designed in three sections with the site area north of Station Road split into two sections with a soakaway pit between them. With its penstock valve closed, each section would have capacity to store the 228,000 litres of emergency water supplies provided for firefighting.
- 6.25 The storage capacity of each section of the site will be affected by water that is already in the drainage system from recent rainfall. Modelling has also been carried out to demonstrate that each of three sections of the site would have capacity to store 228,000 litres of water in the event that a 1 in 2 year 48 hour rainfall event preceded a fire incident
- 6.26 Contaminated water would be removed from the surface water drainage system as soon as possible following an incident if contaminated (and disposed of appropriately), so that the penstocks can be re-opened to allow the drainage system to accept further rainfall.
- 6.27 More information on the drainage strategy can be found in the Surface Water Drainage Strategy that accompanies the application (Document Ref: R018).
- 6.28 Wartsila has conducted both direct and indirect (boundary cooling) firefighting suppression exercises during full-scale BESS burn tests. Testing was conducted in the US with reference to US water quality standards and established that pollution levels only exceed US aquatic life and reportable quantity limits for a small number of substances and then only from water used for direct suppression of battery units rather than boundary cooling, where water does not enter the involved battery unit.
- 6.29 When assessed against US aquatic life limits, water runoff could contain levels of Iron (1 mg / litre) and Zinc (0.12 mg / litre) exceeding reportable limits.

- 6.30 When assessed against US reportable quantity pollution limits, levels of phosphorus only exceeded reportable quantity component loads in water used for direct suppression. Tests of water used for indirect, boundary cooling suppression showed negligible levels of phosphorus.
- 6.31 It should also be noted that in a range of previously documented global BESS thermal runaway incidents, water runoff from FRS boundary cooling has not contained significant levels of pollution.
- 6.32 With these mitigation measures in place the risk of contamination of the hydrological and hydrogeological environment including water resources from fire-water runoff would be 'Negligible'.

7. CONCLUSION

- 7.1 The purpose of this report is to provide an overview of the key community and environmental safety considerations arising from the operation of the Proposed Development. To do so it has examined operational risks; detailed the systems and processes that will be employed to mitigate and manage these risks; and quantified the risk of a safety incident at the site.
- 7.2 The key safety consideration to manage is the risk of thermal runaway within the battery units following a battery cell failure. This can lead to the venting of flammable and toxic gases, smoke or fire or a combination of all.
- 7.3 Evidence suggests that the risk of a BESS safety incident here in the UK is very low and within the range of acceptable levels as set by the Health Safety Executive (HSE).
- 7.4 The BESS ultimately selected for this project would meet all existing and new fire safety regulations and guidance and include a comprehensive set of safety systems that mitigate the risk of a thermal runaway event taking place. Evidence of the effectiveness of these systems would be demonstrated through the provision of both laboratory and real-world fire test data as part of the Battery Safety Management Plan, for approval by Dartford Borough Council in collaboration with KFRS.
- 7.5 The Applicant has designed the BESS site and safety procedures in consultation with KFRS and BESS fire safety experts to ensure that - in the unlikely event that there is a battery fire - it can be safely managed without putting fire service personnel, the local community or environment at risk.
- 7.6 The analysis of findings from plume modelling studies conducted for two kinds of BESS systems demonstrates that in the unlikely event of a full battery unit fire there would be no impact on air quality or visibility at the closest residential receptors and that it is unlikely that a fire would impact either the A2 to the north or the railway line to the South. The Emergency Response Plan will contain a provision for the temporary closure of Station Road in the event of a fire.
- 7.7 The assessment of the risks presented to controlled waters from contaminated water exiting the site during construction or as the result of a fire incident concludes that the risks are negligible.

8. GLOSSARY OF TERMS

Applicant: Clearstone Energy Limited

Application: The planning application submitted by Clearstone Energy (the Applicant) applying for planning permission to construct, operate and decommission the Dartford Energy Hub

BESS: Battery Energy Storage System, describes all equipment, hardware and software that makes up a working system

Battery Cell: The basic functional unit of a BESS contains an assembly of electrodes, electrolyte, separators, and terminals in a container. It is a source of electrical energy by direct conversion of chemical energy.

Battery Module: A battery module comprises up to 52 cells and is equipped with venting fans and communication connections for remote monitoring and switch off in response to abnormal cell behaviour that indicates a potential fault.

Battery Unit: The main functional unit of a battery energy storage system (BESS). The battery unit holds racks of battery modules (typically 32 modules per unit, 1664 cells) and includes a Battery Management System (BMS) controller at the top of each rack. The battery unit is typically a 2.5m cube and housed in a rigid metal enclosure which provides protection from weather, animal and mechanical damage.

Battery String: Battery units are designed to be installed and connected together in rows (often referred to as strings)

BMS: The Battery Management System (BMS) monitors and controls the operation of the BESS triggering alarms and the shutdown of individual battery modules in the event of abnormal conditions.

BSMP: The Battery Safety Management Plan will be prepared by the Applicant, as required by a planning condition in the event planning permission is granted and submitted to the Local Planning Authority (Dartford Borough Council) for approval in consultation with Kent FRS.

Burn Test: Full scale fire testing of battery units undertaken by the BESS manufacturer to measure levels of heat, smoke and gas emissions produced by a fire and validate the performance of safety features in real world conditions.

CFD: Computational Fluid Dynamics modelling uses computers to simulate the flow of liquid and gases in three dimensions and measure concentrations of different elements within the flows.

Dartford Energy Hub Battery Energy Storage System (BESS): The proposed BESS compound within the Dartford Energy Hub planning application

Dartford Energy Hub: The entirety of the development proposed within the Dartford Energy Hub redline planning application area.

DESNZ: The government Department for Energy Security and Net Zero

ERP: Emergency Response Plan, prepared post any planning permission in consultation with Kent Fire & Rescue Service and for approval by Dartford Borough Council as part of the BSMP

LFP: Lithium Iron Phosphate, the battery chemistry most commonly used for BESS projects.

HVAC Units: Heating, ventilation and air conditioning (HVAC) units control the temperature, humidity and chemical composition of the air contained within the battery unit, there are two units for each battery unit.

IDLH Values: Immediately Dangerous to Life and Health (IDLH) values set a threshold for concentrations of airborne chemicals above which exposure without suitable breathing apparatus is likely to cause immediate ill effects. IDLH values were created by the National Institute for Occupational Safety and Health (US) but are used globally.

MW: Megawatt (MW) is a measure of power level - in this case electrical - at a point in time, one megawatt is equal to one million watts. For comparison a boiling kettle requires 1000 watts of electricity or 1 kilowatt (kW) when switched on.

MWh: A Megawatt Hour (MWh) is a measure of power volume. A 1MWh battery is capable of delivering 1MW of power for an hour.

Offgas: Chemicals emitted in gaseous form as the by-product of a chemical process.

Particulate Matter: Particulate matter (PM) is everything in the air that is not a gas. It consists of microscopic solids or liquid droplets that are so small that they can be inhaled and enter the bloodstream.

Penstock valves: A penstock is a type of valve used to control the flow of water. The valve incorporates a sliding door that is operated by hand or with a motor. When the valve is closed water is retained within the drainage system until the valve is opened again.

Planning application: See Application definition above.

PPM: Parts per million (ppm) is a unit commonly used to express the concentration of a substance in the air. A concentration of 1ppm means that there is one unit of a substance present in 1 million units of air. PPM is used to set safe levels for air quality.

Proposed Development: The Dartford Energy Hub

Site: The location of the Dartford Energy Hub on Station Road, Gravesend, DA13 9PA.

Thermal Runaway: A battery cell failure can lead to a rapid increase in cell temperature if not controlled - known as thermal runaway - leading to the venting of gases, smoke or fire or a combination of all. The heat and / or fire created by the failed cell can also cause adjacent cells to enter the same process.

UK HSE Short Term Workplace Exposure Limit (WEL): The UK Government Health & Safety Executive threshold for concentrations of airborne chemicals above which short term exposure - 15 minutes - is likely to cause ill effects.

UK HSE Long Term Workplace Exposure Limit (WEL): The UK Government Health & Safety Executive threshold for concentrations of airborne chemicals below which long term exposure - 8 hours, a working day - is considered unlikely to cause ill effect.

UL 9540A: Standard test for the safety of energy storage systems and equipment and was developed by UL as a test method for evaluating thermal runaway fire propagation in battery energy storage systems.

Kent FRS: The Fire and Rescue Service responsible for advising on the fire safety aspects of the Dartford Energy Hub application.

9. APPENDICES

APPENDIX 1 - Gridsolv Quantum BESS Compliance Chart

Compliance Chart for Wärtsilä GridSolv Quantum

Safety	
UL 9540¹	Standard for Energy Storage Systems and Equipment
NFPA 70²	National Electric Code
NFPA 855²	Standard for the Installation of Stationary Energy Storage Systems
NFPA 68	Standard on Explosion Protection by Deflagration Venting
CE mark	European conformity – Low voltage and EMC directives
UKCA mark	United Kingdom conformity – Low voltage and EMC directives
IEC 61439-1³	Low-voltage switchgear and controlgear assemblies – Part 1: General
IEC 61439-2³	Low-voltage switchgear and controlgear assemblies – Part 2: Power switchgear and controlgear assemblies
IEC 62933-2-1³	Electrical energy storage (EES) systems – Part 2-1: Unit parameters and testing methods – General specification
IEC 62933-5-1³	Electrical energy storage (EES) systems – Part 5-1: Safety considerations for grid-integrated EES systems – General specification
IEC 62933-5-2³	Electrical energy storage (EES) systems – Part 5-2: Safety requirements for grid-integrated EES systems – Electrochemical-based systems
IEC 60364²	Low-voltage electrical installations
Battery Safety	
UL 1973⁴	Standard for Batteries for Use in Stationary and Motive Auxiliary Power Applications
UL 9540A⁵	Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems
IEC 62619⁴	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications
UN 38.3	UN Recommendations on the Transport of Dangerous Goods Manual of Tests and Criteria

¹ Certified by MET Labs and CSA

² Applicable to site installation and field wiring.

³ Tested by Certification Entity for Renewable Energies

⁴ Applicable to battery cell and rack.

⁵ Cell, module and unit level testing.

Enclosure Integrity

IEC 60529	Degree of Protection Provided by Enclosure (IP Code) – IP 55
UL 50E	Enclosures for Electrical Equipment, Environmental Considerations – 3R
IEC 62262	Degrees of Protection Provided by Enclosure for Electrical Equipment Against External Mechanical Impacts (IK code) - IK10

Fire Resistance of Enclosure Wall

EN 13501-2:2016	Fire classification of construction products and building elements - Part 2: Classification using data from fire resistance tests, excluding ventilation services – (E60 / EI15 with single wall, EI60 with double wall)
EN 1364-1:2015	Fire resistance tests for non-loadbearing elements – Part 1: Walls

Seismic Integrity

IEEE 693⁶	IEEE Recommended Practice for Seismic Design of Substations
IEC 60068-3-3⁶	Environmental testing – Part 3-3: Supporting documentation and guidance – Seismic test methods for equipment

Electromagnetic Compatibility

IEC 61000-4-2	Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test
IEC 61000-4-3	Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency electromagnetic field immunity test
IEC 61000-4-4	Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test
IEC 61000-4-5	Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test
IEC 61000-4-6	Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields
IEC 61000-4-8	Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test
IEC 61000-6-2	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments
IEC 61000-6-4	Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments
IEC CISPR 11	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics – Limits and methods of measurement – Conducted emissions and Radiated emissions tests

⁶ Performed on switchbox and control components only.

Power Conversion System (Grid Interconnect)⁷

UL 1741	Standard for Safety Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources
IEEE 1547	IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
CSA C22.2 No. 107.1:16	Power conversion equipment
IEC 62109-1	Safety of power converters for use in photovoltaic power systems – Part 1: General requirements
IEC 62109-2	Safety of power converters for use in photovoltaic power systems – Part 2: Particular requirements for inverters
IEC 62477-1	Safety requirements for power electronic converter systems and equipment – Part 1: General
IEC 61000-6-2	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments
IEC 61000-6-4	Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments
IEC CISPR 11	Industrial, scientific, and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement
IEC 62909-1	Bi-directional grid-connected power converters – Part 1: General requirements
IEC 62909-2	Bi-directional grid-connected power converters – Part 2: Interface of GCPC and distributed energy resources

⁷ Only common standards for Power Conversion Systems (PCS) are listed here. Different standards may apply depending on brand and type of PCS used. Refer to the datasheets of PCS used for complete list of standards.

APPENDIX 2 - KFRS Briefing Document

DARTFORD ENERGY HUB - FRS BRIEFING DOCUMENT

FRS: Kent Fire & Rescue Service
PROJECT: Dartford Energy Hub
DATE: 25th October 2024
KEY CONTACT: Joe Hassell, JHC - Joe@joe Hassellcommand.co.uk

KEY PROJECT INFORMATION	
Project	Dartford Energy Hub
Developer	Clearstone Energy
Location	Land adjacent to Station Road Station Road Gravesend DA13 9PA TQ 61696 72104
Size	300MW/300 MWh
BESS Manufacturer	To be confirmed closer to construction (2026 for 2028 operational go live)
Battery Chemistry	LFP (Lithium iron phosphate battery)
Designer	Clearstone Energy, with support from - Joe Hassell, JHC - operational fire safety consultant - AECOM and BST&T - technical fire safety consultants

Choice of BESS OEM

Clearstone Energy has not yet selected a provider of battery equipment for the project. Construction is likely to commence in 2027, and the procurement of BESS providers is expected to take place in early 2026. By that time, there will likely have been advances in battery technology, resulting in the latest BESS offering improvements in both performance and safety systems.

The battery equipment provider ultimately selected for the project will comply with current safety regulations and guidance at the time of specification. These will be shared for final endorsement by Dartford BC, in collaboration with Kent FRS, through the submission of a

Battery Safety Management Plan (BSMP). We will be requesting that the development and approval of the BSMP in advance of construction is a condition of planning consent.

The planning application will include an indicative site design based on the Gridsolv Quantum BESS from Wärtsilä. This system is being deployed at a number of UK BESS projects and being specified by the Applicant for projects with near-term construction dates.

The Gridsolv Quantum BESS is a lithium iron phosphate (LFP) system and complies with all relevant BESS safety guidance, test certifications and codes. It is considered to be the market leader for safety. It is referred to in the information provided below to illustrate the level of supporting information and testing data that would be provided to Dartford BC and Kent FRS as part of the Battery Safety Management Plan.

A major factor in Clearstone Energy choosing to work with Wärtsilä is that it has conducted a series of full-scale burn tests of the Gridsolv Quantum BESS and undertaken further Fire Dynamics Simulation (FDS) modelling to understand the potential outcomes from a thermal runaway event.

Thermal event / deflagration

- How will the proposed BESS perform in the event of a thermal event / deflagration and what proactive / reactive systems are proposed to mitigate this?

The chosen BESS will be designed to inhibit the propagation of thermal runaway between individual cells within a battery unit. If propagation between cells does occur, the design of the battery unit enclosures and separation between battery units will ensure that a thermal event is contained within the affected battery unit. In this scenario the BESS is designed to undergo a steady, controlled burn consuming all cells within the battery unit over a period of 4 - 5 hours. The fire would typically burn for a further 4 hours as the plastic cell casings are consumed.

Cell, module and unit level test results will be provided as part of the BSMP to support this approach and the proposed separation distances between battery units.

The primary concern is to avoid a thermal event in the first place and, when operational, battery units will be continuously monitored for signs that a thermal runaway event could be about to take place or is taking place. The Battery Management System (BMS) will monitor battery cells for raised temperatures and other indications that a cell may be about to fail. The fire detection solution will be a fully addressable system (as per NFCC guidelines) integrating detectors including carbon monoxide, smoke, heat and hydrogen.

If a potential thermal runaway event is detected, the affected battery unit will be automatically isolated from the BESS power system. Additionally, Cell and module casings will inhibit propagation between cells within the battery unit while the battery unit cooling system will work to reduce temperatures within the unit.

Each battery unit will include a NFPA 69 compliant flammable gas ventilation system. If cells are producing offgas, the ventilation system will be capable of preventing gas volumes exceeding 25% of the Lower Explosive Limit (LEL) within the enclosure to reduce the risk of a deflagration / explosion. Performance testing of the ventilation system would be provided as part of the Battery Safety Management Plan.

The battery unit enclosures will also integrate a NFPA 68 compliant deflagration panel which, in the event that ventilation systems fail, will mitigate the explosion risk, provide for additional structural integrity if a deflagration does occur and direct flames away from first responders and other battery units.

- How will the thermal event be contained to the BESS of origin without the radiant heat to others?

The thermal event will be contained to the BESS of origin through a combination of heat resistant battery unit enclosures and physical separation of battery units. Battery enclosures will have a minimum 4-hour fire rating. Separation distances between battery units will be no lower than the minimum distances recommended by the BESS manufacturer. Manufacturers' recommendations will be supported by full-scale burn testing of units and/or heat flux modelling using a platform such as Fire Dynamics Simulator (FDS).

As an example, the Wärtsilä Gridsolv Quantum BESS units shown in the indicative site plan are designed to be installed and connected together in rows (often referred to as strings) containing a maximum of 8 units with a separation of 10cm between units. Battery unit enclosures have a one hour fire rating and the manufacturer recommends a minimum spacing of 3 metres between strings of battery units. These recommendations are supported by outcomes from full scale free burn tests conducted by the Energy Safety Response Group in February 2023 and further FDS modelling undertaken by the Fire and Risk Alliance. Burn tests were conducted without fire service intervention to reflect a controlled burn approach to managing a battery unit fire.

- How has the performance of the BESS in a thermal runaway event influenced site design?

The Indicative Site Layout is based on Wärtsilä Gridsolv Quantum BESS units. Wärtsilä recommends a minimum spacing of 3 metres between strings of units and a maximum of 8 units in each string. The indicative layout has a maximum of 3 units in each string and provides for a spacing of 4 metres between strings of batteries.

The deflagration panels for the Wärtsilä Gridsolv Quantum BESS units are on the top of the enclosures so battery units are not stacked.

Site plans

- What are the assumptions about active firefighting, within the emergency response plan and what measures are in place to reduce the scale of an incident?

Assumptions are that a controlled burn approach would be taken in the event of a thermal runaway incident within a battery unit on the site. Active firefighting is not recommended due to the risk of water contacting energised battery cells and evidence that direct water application within units can prolong a battery unit fire.

Minimum spacing between battery units will be based on manufacturers guidance and conform to NFCC guidance to minimise the risk of fire propagating between units. Similarly, areas within 10 metres of a battery unit will be surfaced with tarmac, concrete or crushed aggregate to restrict vegetation growth and no combustible materials will be stored on site.

- What is the provision for firefighting access to, around and within the site?

Access for Fire Service vehicles is in accordance with B5, Approved Document B of the Building Regulations. The access gates have a minimum width of 3.1m, the road has a minimum width of 3.7m, the minimum turning circle between kerbs is 16.6m, the minimum height clearance is 3.7m and the minimum carrying capacity is 18 tonnes.

The site is split into northern and southern sections by Station Road. Each section has both primary and emergency access points from Station Road to ensure that the site is accessible regardless of the location of a BESS unit fire. Primary access points are to the east of the site and emergency access points to the west.

The site is separated into plateaus to account for the west to east sloping topography of the site, with three levels in the northern section and two levels in the southern section. Each plateau has a perimeter road. Access roads between plateaus are designed to ensure that there are no extremes of gradient. All access roads are 4.5 metres wide and surfaced with crushed gravel. A swept path analysis will be provided to demonstrate the suitability of site access and roadways for KFRS vehicles that would attend a fire incident

There is the possibility that a fire in a BESS unit close to the road access point to a plateau could prevent vehicles from accessing the plateau. It is proposed that on-foot access with hoses between plateaus be provided through the inclusion of steps or ladders where appropriate to safely traverse between site levels.

- Are the incident assumptions realistic? What is the role of the FRS at an incident? Are they realistic? What is the expectation of the FRS in terms of the fire strategy at a thermal event?

The incident assumptions will be based on the results of battery unit fire testing and subsequent FDS (or similar) modelling.

KFRS personnel attending a thermal incident at the site would be advised by a BESS Subject Matter Expert (SME) who would be trained and certified by the equipment manufacturer. As per NFPA 855, the SME will fall under the Unified Command structure where they will collaborate with members of the FRS to safely manage the incident.

Upon arrival, KFRS personnel will contact the BESS SME to obtain a status briefing which would provide a snapshot of existing conditions and lead to the following set up actions:

- *Accountability of ALL site personnel:* Only essential employees should be allowed into the site during emergency conditions.
- *Staging of apparatus:* All apparatus should be staged uphill/upwind on arrival. Scene size-up will determine apparatus placement.
- *FRS Exclusion Zone:* Establish a 30.5m exclusion zone around the involved BESS. This is a conservative method employed in parallel with an explosion protection system (NFPA 68 and NFPA 69) to ensure the safety of FRS personnel operating at the scene.

- *Public Exclusion Zone:* Establish a 61m exclusion zone around the involved BESS for members of the general public. This has been established as a safe distance to ensure that the local community are not put at any risk from smoke or toxic gases from a BESS fire. It may mean temporarily closing local footpaths and Bullen Lane.

Based on full scale BESS burn testing conducted to date, it is assumed that the fire would burn steadily for around 8 - 9 hours. Attending FRS personnel would monitor conditions within the involved unit and adjacent units using diagnostic information accessed via annunciation panels (referred to as first responder panels in plans) and only adopt defensive firefighting tactics - boundary cooling of adjacent units - if data suggests there is a risk of propagation between units.

Conditions within the involved BESS unit and adjacent units should be captured and recorded in 15-minute intervals for trending analysis. Data would include enclosure temperatures, cell temperatures with focus on cells/modules surrounding the troubled modules, state of charge and H2 gas detection. The involved BESS unit should also be evaluated with a thermal imaging gun and compared with an uninvolved BESS unit for benchmarking purposes.

Each battery unit would be equipped with a dry pipe water sprinkler system. Once the battery cells have burned out and the unit is de-energised (typically after 4-5 hours) then the KFRS team may decide, in consultation with the BESS SME, to charge the unit sprinkler and extinguish the remaining fire, which will be primarily plastic cell casings.

Water supply / Suppression systems

- What is the type, purpose and effect of any fire suppression system installed?

Battery unit enclosures will be fitted with a dry-pipe water sprinkler system as standard. This is controlled by attending first responders with guidance from the SME. Latest guidance from manufacturers and NFCC recommends against using the water sprinkler to directly tackle a BESS fire, due to the risk from contacting electrified components, and instead to use as a means of extinguishing a BESS unit fire once the batteries have burnt out and it is safe to apply water to extinguish what is at that point primarily a plastics fire. The local FRS would charge the water sprinkler using onsite water supplies and pumped vehicles. Connections for each BESS unit sprinkler system will be a minimum of 25 metres from the BESS unit to enable the local FRS to connect safely.

Any suppression system proposed for the final site design will comply with NFCC guidelines and be appropriate to the BESS unit ultimately selected for the project. It will be subject to approval by KFRS as part of the battery safety management plan.

- What is the purpose of the water supply provision on site? Boundary cooling / defensive firefighting or active suppression?

The purpose of on site water supplies is to support a boundary cooling / defensive firefighting approach to managing a thermal event.

A system of water hydrants fed by static water tanks and pump will be installed as an Emergency Water Supply (EWS). The water hydrants will be installed at 45M radius coverage in line with approved document Part B Fire Safety. Hydrants will be fitted at all Primary and Emergency site access points. Water tanks will be distributed across the site with direct hose access provided for redundancy.

Tanks will be sited at least 10 metres away from any battery unit, in line with NFCC guidance. Both northern and southern sections of the site will have an individual water total supply of 228,000 litres and be capable of delivering no less than 1,900 litres of water per minute (lpm) for at least 2 hours, as per NFCC guidance. Fire hydrants will be compliant with BS9990 and BS3251 and capable of delivering a minimum 25 litres per second flow rate as per draft Updated NFCC guidance.

If system diagnostic data suggests there is a risk of propagation between battery units through heat induced thermal runaway then defensive firefighting tactics would be used to reduce internal temperatures within adjacent units. Tactics would include directly applying water spray to adjacent units using adjustable firefighting branches (nozzles) or deploying defensive spray plates that form a water curtain between the affected unit and adjacent units. These boundary cooling tactics would likely be applied intermittently in 15-minute application periods with temperature changes measured between application periods. The potential exists to contact energised electrical components in battery enclosures so fog patterns and water stream strategies will be agreed by KFRS and BESS SME.

Water requirements for boundary cooling will vary depending on branch/spray plate manufacturer, with likely application rates per water jet/ spray plate used between 450-800 litres per minute. If the involved battery unit is in the middle of a row (or string) and cooling is required for two adjacent units this equates to a maximum of 1,600 litres per minute, or 96,000 litres per hour if boundary cooling is applied continuously.

Factors such as wind speed and direction will influence the temperatures reached in adjacent units so two hours of continuous boundary cooling is used as a conservative estimate. At 1,600 litres per minute, two hours of continuous boundary cooling would

require 192,000 litres of water to be available on site. If boundary cooling is applied intermittently with 15-minute application periods followed by 15-minute non-application periods to monitor temperature changes then 192,000 litres of water would suffice for four hours of boundary cooling.

This is in line with the draft version of the updated NFCC Guidance released in July 2024 which reduces its guidance to a minimum of 180,000 litres.

BESS design

- What is the size, quantity and capacity of each BESS unit?

The BESS manufacturer and system specification will be confirmed closer to the construction date of 2027, likely to be 2026. Full details will be provided as part of the Battery Safety Management Plan (BSMP) and subject to approval by Dartford Borough Council and KFRS.

The Wartsila Gridolv Quantum unit included for reference in the indicative site plan uses prismatic lithium iron phosphate (LFP) cells. Each cell has a nominal capacity of 306-amp hours (Ah) and a nominal voltage of 3.2 volts (V). Each battery unit enclosure measures 2.1m (w), 3.3m (d) and 2.5m (h). Up to eight enclosures can be installed in a row (also referred to as a string) and interconnected to achieve the desired energy storage capacity. The indicative site layout is designed with rows of three battery enclosures.

Each battery unit has a nominal capacity of 1.33 MWh. There are a total of 216 battery units equating to a total storage capacity of 300MWh.

- Is the BESS design appropriate for the weather at the proposed location i.e. prevention of water ingress and impact of temperature range on cooling systems?

The selected BESS will be suitable for weather conditions on site. Information will be provided as part of the BSMP.

- Does the applicant / developer have relevant competence and experience in the field of BESS design and deployment on the scale of the proposed development?

Clearstone Energy has been developing BESS projects since 2019 and gas fired power stations since 2016. In that time, it has gained significant expertise in health and safety matters relating to power projects including BESS. Two of our smaller BESS projects (50MW) are about to start construction. We have gained planning permission for a further two projects (200MW and 400MW respectively) and have a further five BESS projects (150 - 400 MW) either in the planning system or soon to be submitted.

We have employed external consultants to advise on battery system design, site design matters, fire safety and support on FRS liaison for our BESS projects.

Joe Hassell Command - Joe Hassell (founder of Joe Hassell Command (JHC)) is a recently retired senior fire officer who completed 31 years of service in both Essex and Devon and Somerset. Joe has extensive experience at all levels of command and retired as the Deputy Chief Fire Officer of Devon and Somerset Fire and Rescue Service in 2022. Joe is a highly experienced and qualified fire and rescue commander, trainer and assessor, with experience at all command levels dealing with various complex emergencies and major incidents. JHC was established as a training and consultancy company in 2023. JHC provides advice on operational fire fighting matters and manages consultation with local FRS teams.

AECOM - AECOM is a global infrastructure consulting company with deep expertise in BESS technologies, site design, risk assessment and mitigation. AECOM co-authored Clearstone Energy's Battery Safety Standards Report.

BST&T Consultancy Services - BST&T is an independent battery safety and testing consultancy which has worked on the safety aspects of lithium-ion battery applications since 2015. It is actively engaged with a number of leading BESS providers on testing programmes and undertaking safety planning for a number of large-scale BESS facilities in the UK. BST&T co-authored Clearstone Energy's Battery Safety Standards Report and provides advice on BESS selection and site design.

- What are the arrangements for ongoing monitoring of the BESS and what is the response time for onsite technical assistance in the event of an incident?

The BESS will be remotely monitored 24/7. The Battery Management System (BMS) will monitor battery cells for raised temperatures and other indications that a cell may be about to fail. The fire detection solution will be a fully addressable system (as per NFCC guidelines) integrating detectors including carbon monoxide, smoke, heat and hydrogen. Alerts generated by the BMS and alarms will be automatically assigned to a SME (described earlier) who will alert KFRS if required and work remotely with the KFRS team dispatched to the site to manage the incident.

Response times for onsite technical assistance will be specified as part of the BSMP for approval by KFRS.

Annunciation

- What remote annunciation panels are available for monitoring an event from the site?

A fully addressable fire alarm system will be installed on site, accessible by fire service personnel through a first responder panel. The master digital display will be located at the access point to the lowest plateau on the north section of the site (the largest plateau) with four further repeater panels located across the site. Panel locations are included in the fire strategy plan.

- What data is available from these remote annunciation panels?

The first responder panels will provide live information on the location of the affected battery unit; the status of battery modules and fire suppression systems within the cabinet; and temperature data for that cabinet and adjacent cabinets so that FRS personnel can monitor and deploy defensive firefighting tactics if required to manage the situation.

Environmental receptors

A sensitive receptors plan is provided in line with the draft update to NFCC guidance.

Prevailing wind for the location is from the West South West direction. Existing plume modelling studies suggest that the hazard posed by toxic gases produced by a single battery unit fire (concentrations above the Immediate Danger to Life and Health threshold) is confined to the immediate surrounds of the battery unit, less than 12.5 metres. At 30 metres concentrations have fallen below the short term workplace exposure limits (15 minutes) as specified by the UK Health and Safety Executive. While at 60 metres concentrations have fallen below the long term 8 hour exposure limits which are the safe exposure limits for the workplace in the UK.

- The nearest publicly accessible space is the Millbrook Garden Centre car park located 30 metres east of battery units at its closest point
- The entrance / exit from the garden centre car park is located 85 metres east of battery units
- Pepper Hill Community Recycling centre is located 210 metres west of battery units
- The nearest educational or care facility is Dale Mount and Dale Lodge, assisted living residences, located 500 metres south west of the site
- The nearest residential property is 140 metres to the west of the site

There is a risk that local water sources and water supplies could be contaminated by fire water run off from a fire event. Taking a controlled burn approach to managing a fire incident will reduce the possibility that water will be used to manage an incident and it should also be noted that in a range of previously documented global BESS thermal runaway incidents, water runoff from FRS boundary cooling has not contained significant levels of pollution.

However, each of the two sections of the Site is designed with a drainage system capable of containing a minimum of 228,000 litres of water in addition to surface water runoff already in the system from a 48-hour rainfall event.

The drainage system uses the voids in the layers of aggregate underlying the Site to collect and direct water towards soak away points. The aggregate layer will be lined with an impermeable membrane, capable of resisting chemical concentrations and temperatures potentially generated by fire-water runoff.

Penstock valves will be positioned at the outlet from the drainage system to the soakaways to enable the system to be closed in the event of a fire. A tanker take off valve will be included before each penstock valve to enable contained water to be tankered away for treatment if tests show that it is contaminated.

In the event of a fire, the penstock valve is used to close the drainage system and contain water on site. Once the fire has been extinguished water will be tested for contamination and either taken away by tanker for treatment or released through the drainage system.

APPENDIX 3 - KFRS Pre-Planning Consultation Response



Kent Fire &
Rescue Service

together

To	Contact	Our ref
Joe Hassell Command (JHC)	Jon Tuttlebury	CAS-246582
On behalf of	Direct line	Your ref
Clearstone Energy	01622 212421	N/A
	Email	Date
	FET@kent.fire-uk.org	11 Nov 2024

FAO: Joe Hassell

Dear Joe,

Pre-planning consultation

Re: Land adjacent Station Road, Southfleet, Kent, DA13 9PA.

This pre-planning consultation is for a Battery Energy Storage Site (BESS) with total storage capacity of 300 MWh. Please be aware that the principles discussed within this pre-planning advice letter should not be used as a precedent for justification for future developments. Each Battery Energy Storage Site (BESS) is unique and should be evaluated on its own merit.

Kent Fire Rescue Service (KFRS) has no authority to approve or decline planning permission for Battery Energy Storage Systems (BESS) sites. This decision, in the majority of cases, lies with the Local Authority or National Infrastructure Planning. KFRS will endeavour to provide consultation during this process, however there is no statutory requirement to do so. Information requested and received will be able to support our observations during the planning process, but also provide a basis for design/build stage. I acknowledge that KFRS are also learning and developing along with this evolving area of technology & approaches to risk mitigation at BESS sites.

Documents provided at pre-planning stage.

- Battery Safety Standards Report
- Site Plan with related NFCC Guidance
- Sensitive Receptor Site Plan
- FRS Briefing document aligned to new draft NFCC Guidance

Confidential Information

Information requested by KFRS will be used to both aid in the design process and influence the emergency response at an incident. It is acknowledged that some specific details may be commercially sensitive, and the information provided is kept in confidence throughout the consultation process.

Building Safety, Fire Engineering Team, Canterbury Fire Station, Upper Bridge Street, Canterbury, Kent, Ct1 2NH. FET@kent.fire-uk.org 01622 212421



**Kent Fire &
Rescue Service**

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Specific Planning Observations

BESS Consultation Overview

Due to the potential hazards of BESS; careful consideration to the design, layout and management is required. Past BESS incidents, both within the UK and abroad, must be considered and all efforts made to ensure safe practices both during daily use and emergency response, for workers, emergency service personnel and the public alike.

Water supplies

I note that your provision of fire-fighting water supply is based on the draft version of the NFCC Grid scale guidance document. The quoted water volumes in your 'FRS briefing' document will require some further review in due course. Consideration for the provision of firefighting water should be with regard of the current requirements until the draft version has been formally released as a guidance document. In addition, where on site water provisions are also proposed to support the container sprinkler system (for end-stage container suppression) higher volumes will be required.

I note there are no water tanks in the upper (most northerly) section of the plan drawings, with two tanks being in the westerly/upper section. This would require pumping of water of a considerable distance into the upper section to support the fire hydrants. Please confirm if a tank will be provided to the upper section. Please also confirm how the water tanks will be replenished i.e. via a permanent water feed into the proposed site. According to our records there are no fire hydrants within 300 metres of this site.

However, I note from paragraph 4.5.5 of the 'Corporate Battery Safety Standard' document that water supply requirements will be fully agreed with the FRS. Certainly further discussion should be had to find a reasonable approach

Gaseous Fire Suppression

I note there is no commentary in the briefing document with regard to internal "gaseous" suppression systems, designed to deal with other potential fires other than those originating from an event of thermal runaway. Please confirm if this will be present in the final design.

Battery testing criteria

Evidence-based testing criteria that your proposed BESS installation meets the fire safety requirements should be provided for such installations. We are happy to discuss and review this with yourself or your clients design team when you have finalised the procurement of your battery technology.

**Building Safety, Fire Engineering Team, Canterbury Fire Station, Upper Bridge Street,
Canterbury, Kent, Ct1 2NH. FET@kent.fire-uk.org 01622 212421**



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Fire Management Plan (FMP) and Emergency response Plan (ERP)

As noted in your briefing and outline battery safety document a finalised Battery Management Safety Plan (BMSP) and Emergency Response Plan (ERP) will be provided with the planning application or towards project completion. These documents should reflect the client's intent of designing and installing the site in line with the NFCC Grid Scale BESS guidance and other international design codes and industry best practise. I am cognisant that some key features of the design may not be currently finalised due to evolving technology and/or procurement of equipment. As such these "evolving documents" are required to assist KFRS in helping your design team develop a finalised BMSP and robust ERP.

Annunciation Panels

I note the provision of on-site first responder panels in your FRS briefing document, further discussion is required with regard to the expectation of crews operating this equipment and interpreting readings. With no training and limited knowledge of this equipment this may inhibit effective monitoring in the event of fire. I note that a Subject Matter Expert (SME) will also be in attendance at an incident therefore, please confirm that monitoring of such annunciation panels will be the responsibility of the SME. Alternatively, suitable awareness training should be provided to KFRS crews.

Important points about this consultation

Currently, as you are aware no British Standard (BS) or Approved Document (AD) specifically addresses the installation of BESS. Importance is therefore placed on evidence-based justification to support the design. In lieu of this the following guidance has been adopted to provide the basis for our observations.

- **National Fire Chiefs Council (NFCC) published guidance: Grid Scale Battery Energy System Planning, Guidance for FRS – published April 2023***
- **Department for Energy Security & Net Zero: Health and Safety Guidance for Grid Scale Electrical Energy Storage Systems- Published March 2024***

*Please note that this detailed document should not be considered as a fully comprehensive specification; but should be used to provide a framework for consultation. Each BESS site should be assessed individually and addressed on a case-by-case basis.

The contents of this guidance utilise academic study, international standards, case studies and industry guidance to support professional judgement.

I would like to thank you again for your early engagement and in advance for your engagement throughout the planning process. KFRS advice is non-statutory but given in good will to protect the lives and safety of the public and emergency responders.

Building Safety, Fire Engineering Team, Canterbury Fire Station, Upper Bridge Street, Canterbury, Kent, CT1 2NH. FET@kent.fire-uk.org 01622 212421



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If you require any further advice, please contact this office using the details above. Please be aware that the Building Safety office hours are 09:00-17:00 Monday to Friday

Yours sincerely,

Jon Tuttlebury

Jon Tuttlebury BSc (Hons) AIFireE
Trainee Fire Engineer

**Building Safety, Fire Engineering Team, Canterbury Fire Station, Upper Bridge Street,
Canterbury, Kent, Ct1 2NH. FET@kent.fire-uk.org 01622 212421**

APPENDIX 4 - Applicant Response to KFRS

BESS Project - Pre-planning Consultation

Date: 18 December 2024
Project: Dartford Energy Hub
Address: Land adjacent Station Road, Southfleet, Kent, DA13 9PA
Developer: Clearstone Energy
Developer Contact: Joe Hassell (Joe Hassell Command)
Kent FRS Contact: Jon Tuttlebury
Stage: Response to initial feedback/queries from Kent FRS

Dear Jon

Thank you for the prompt review of the pre-planning consultation materials submitted in support of the proposed Dartford Energy Hub project. I am responding to your initial feedback and queries. We will also be submitting a full site safety report as the planning application for the project which will go into further detail on some of the points you raised in your response, such as the role of the BESS Subject Matter Expert in incident response. .

Water supplies

- *Will a tank be provided in the upper (most northerly) section of the site?*

Response: We have updated the site plan to include a tank in this section of the site.

- *Ensure that water supplies are in line with current NFCC guidelines*

Response: We can confirm that both the northern and southern sections of the site will each have a minimum of 228,000 litres of emergency water supply stored in tanks on the site. Water supplies will be accessed through a network of fire hydrants. This provides a minimum of 1,900 litres of water per minute for 2 hours, as specified in the current NFCC guidelines.

- *How will water tanks be replenished?*

The draft Emergency Response Plan is based on the provision of adequate onsite emergency water supplies to manage a worst-case scenario of a single battery unit fire. The worst-case scenario assessment will be supported by the results of full-scale burn testing undertaken by the BESS manufacturer ultimately selected for the project. Water tanks would be refilled by tanker once it is safe to do so following a fire incident. Kent FRS would be consulted as part of the creation of the Emergency Response Plan, which would be subject to approval by Dartford Borough Council before construction can start, as part of the wider Battery Safety Management Plan (BSMP) developed for the project.

- *Ensure that there is additional water supply for the container sprinkler system for end-stage container suppression*

Response: We can confirm that an additional water provision will be made for the container sprinkler system. This will be specified at the detailed design stage of the project when a BESS manufacturer is selected for the project and based on manufacturer testing/guidance.

Gaseous Fire Suppression

We can confirm that the BESS technology selected for the project would include as standard the means of extinguishing an electrical fire to prevent propagation to the battery cells. As you suggest, today, this is usually achieved with a gas-based suppression system. Many manufacturers are now taking a proactive approach by physically separating electrical power conversion systems from battery cells within battery energy storage system (BESS) cabinets. Kent FRS would be consulted on BESS technology selection and integrated suppression systems as part of the development of the BSMP.

Battery testing criteria

Thank you for the opportunity to discuss and review battery test data at the procurement stage of the project. Clearstone Energy mandates that our BESS suppliers have conducted full scale burns testing of BESS cabinets to demonstrate the efficacy of safety systems and to support manufacturers guidance on safe spacing between battery cabinets. In our view, modelling from cell, module or rack level testing is not adequate to provide assurance.

Until very recently, few suppliers had conducted comprehensive testing. Wartsila has completed such testing, which is why we use the Wartsila Quantum BESS for our indicative site layout plans and preliminary emergency response planning. We will include test results for the Wartsila Quantum BESS as part of our planning application to demonstrate the level of testing evidence we intend to provide as part of the BSMP.

We are pleased to see that more BESS manufacturers are now conducting full scale testing in addition to UL9540a lab tests.

Fire Management Plan (FMP) and Emergency response Plan (ERP)

To clarify, we will only share the outline of the FMP and ERP plans at the planning application stage, as final decisions regarding the selection of a competent BESS technology have not yet been made. . We are committed to working collaboratively with Kent FRS in the selection of a BESS technology for the project and the consequent development of final fire safety plans.

Annunciation Panels

As you say, the BESS Subject Matter Expert assigned to an incident would take the lead on interpreting fire alarm data and advising attending FRS teams. However, we would also provide training to Kent FRS personnel as part of the Emergency Response Plan.

Kind regards

Simon Rothwell, Clearstone Energy

APPENDIX 5 - GridSolv Quantum Gas Ventilation System Performance Assessment



July 12, 2023

Wärtsilä
Attn: Christopher Groves
Project Manager- Product Development
Hardware Engineering

RE: GridSolv Quantum Gas Ventilation System Performance

Fire & Risk Alliance, LLC. (FRA) was requested to offer our assessment of the GridSolv Quantum gas ventilation system in meeting the performance requirements of NFPA 69-2019: Standard on Explosion Prevention Systems.

An explosion prevention system for battery energy storage systems is required by NFPA 855-2023: Standard for the Installation of Stational Energy Storage Systems. One such approved method for explosion prevention involves utilizing a gas ventilation system that has been designed and tested in accordance with NFPA 69. The GridSolv Quantum gas ventilation system consists of a single fan positioned at the air inlet on the bottom right side of the door, along with an exhaust filter and grille assembly situated on the top right side of the back door. The required performance criteria of the gas ventilation system are as follows:

***NFPA 69 §8.3.1** The combustible concentration shall be maintained at or below 25% of the lower flammability limit [LFL] for all foreseeable variations in operation conditions and material loadings.*

(1) Where continuously monitored and controlled with safety interlocks, the combustible concentration shall be permitted to be maintained at or below 60 percent of the LFL.

The NFPA 69 gas ventilation system performance criteria are based on the total volume of the protected enclosure and assume a uniform concentration throughout.

The ventilation system is permitted to be controlled by non-safety-integrated level (SIL) instrumentation when the combustible gas concentration is maintained at or below 25% LFL. SIL-rated instrumentation is required if the gas concentration is maintained greater than 25% LFL and at or below 60% LFL, as follows:

***NFPA 69 §15.5.5.1.3** Non-SIL-rated instrumentation shall be permitted to be used for implementation of Chapter 7 and Chapter 8, except when applying §8.3.1(1)*

The Quantum gas ventilation system is designed and tested to maintain the combustible gas concentration below 25%. Therefore, non-SIL-rated instrumentation is permitted for this application, as per NFPA 69.

FRA has conducted empirical computational fluid dynamics modeling using Fire Dynamics Simulator (FDS). The FDS model was built using fully loaded GridSolv Quantum dimensional data provided by Wäertsilä to simulate worst case loading condition. Based on the UL 9540A module level peak gas release test data, the worst-case battery vent gas release scenario was simulated by modeling a constant indefinite release rate of a 6.47% LFL gas mixture at a flow rate of 218 LPM. The empirical FDS model demonstrated that that a single fan 320 SCFM on the inlet side effectively maintains a volume-weighted average combustible gas concentration below the 25% LFL battery gas, at a level of 1.62%.

FRA has conducted full-scale tests to evaluate the performance of the gas ventilation system, utilizing various fan models and manufacturers. The test employed a fully loaded GridSolv Quantum. A custom gas mixture consisting of CO₂, CO, H₂, CH₄ and C₂H₄, simulating the UL 9540A test gas mixture data, was introduced into the Quantum at the worst-case release location at a flow rate of 218 LPM. The worst-case release location was determined by considering the distance from the gas sensors and proximity to anticipated stagnation zones. The full-scale test demonstrated that the following fan and exhaust grille models were able to effectively maintain a steady state gas concentration below 25%.

Manufacturer	Fan Model	Exhaust Grille Model	Measured Flowrate		Steady State H ₂ [% LFL]	Steady State Cell Gas [% LFL]
			Inlet [CFM]	Outlet [CFM]		
Stego	01874.0-31	11874.0-00	338	270	12.4%	17.1%
Delta G3	HEF500AA A	HEF500AE A	370	250	14.0%	19.3%
Stego	01874.9-31	11874.0-00	345	285	14.5%	20.0%
Delta G3	HEF500BA A	HEF500AE A	380	265	17.4%	24.0%
Seifert	4883A4000	400040000	350	210	17.5%	24.0%

In conclusion, the GridSolv Quantum gas ventilation system meets the performance requirement of NFPA 69-2019 in maintaining a combustible gas concentration at or below 25% of the LFL for all foreseeable variations in operation conditions and material loadings. The gas ventilation system performance has been demonstrated through FDS CFD modeling and full-scale testing.

Regards,



Hyeon(Matt) Kim, PE
Senior Fire Protection Engineer
mkim@fireriskalliance.com

APPENDIX 6 - GridSolv Quantum Safety Sheet

WÄRTSILÄ'S GRIDSOLV QUANTUM

WÄRTSILÄ'S GRIDSOLV ACC_DCC CABINET

Deflagration panels

Gas detection: Hydrogen (H₂) detector (Option: Carbon monoxide (CO) detector)

Fire detection: Photoelectric smoke detector

Sensor: Temperature and humidity

Fire suppression: Dry pipe thermally activated sprinkler. (Option: Thermally activated fire suppression system aerosol)

Short circuit protection: aR class fuse

Isolation device: Rack DC switch

Surface treatment: C4 (Option: C5) paint*

Isolation devices:

Main DC switch

Short circuit protection:

aR class fuse

Over voltage protection:

Type I+II

Sensor: Temperature and humidity

Local fire detection panel:

One per row in the ACCDCC

Surface treatment: C4 (Option: C5)

Fire detection:

Photoelectric smoke detector

Audiovisual fire alarm (One per row)

Process stop button and reset button

GRIDSOLV QUANTUM

SAFETY SHEET

Safety is one of Wärtsilä's main values.

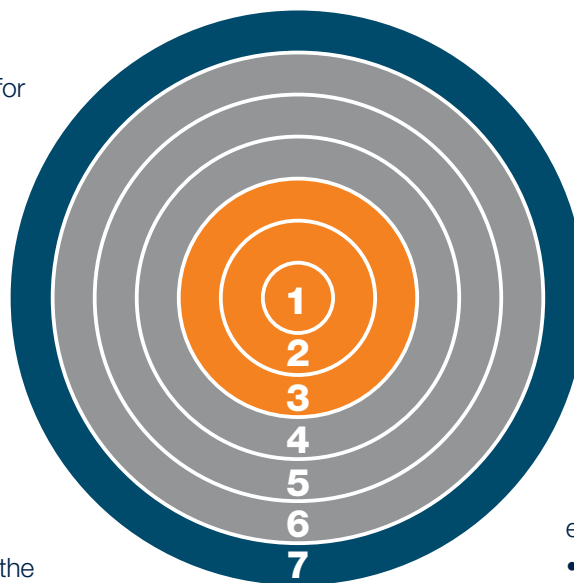
Our culture and policies require us to have hazard-free workplaces for our employees, customers, and suppliers. We do this by applying high standards of occupational health and safety and following any local additional rules and regulations during the product design and lifecycle support. We actively eliminate defects and hazards, and reduce Health and Safety associated risks.

GridSolv Quantum – Layered safety design

The Quantum enclosure comes with a dry-pipe for connection to a site-based water supply or first responder's hose. The sprinkler nozzle will only release if sufficient heat is generated by an actual fire. Safeguarding against an accidental flooding of the cabinet. The cabinet can be optionally fitted with an aerosol-based fire suppression canister with an independent heat-activated release.

- **Location:** The Quantum has been designed as a cabinet used in outdoor Installation for remote locations. The enclosure is rated for IP55 (NEMA 3R), which protects against different weather conditions.
- **No-entry design:** The Quantum enclosure is pre-assembled design for minimal field wiring, civil work, and trenching on site. The enclosure is packed completely with equipment—designed for restricting operator from entering the container—accessibility from the door only.
- **Battery Management System (BMS):** The BMS constantly monitors the battery cell, module, and rack level.
- **Module design:** Battery module has been tested according to UL 9540A, during testing, no fire or explosion occurred, no propagation between the adjacent cells of the module was observed.
- **Deflagration panel:** The Quantum Enclosure wall has a 60-minute fire rating. The enclosure is further

Fire safety layers of protection



- 1 LFP prismatic cell with CID
- 2 UL 9540 A compliant module
- 3 BMS and high-speed fusing short circuit protection
- 4 Modular design
- 5 Fire resistant walls and pressure relief panels and segregation
- 6 Fire detection and suppression water/aerosol-based fire suppression and smoke detection/H₂/CO sensors
- 7 Cabinet environment monitoring

equipped with a roof-mounted deflagration panel that redirects all gases, smoke, and flame in the event of extremely hazardous conditions.

- **Fire suppression:** The Quantum enclosure comes with a dry-pipe for connection to a site-based water supply or first responder's hose. The sprinkler nozzle will only release if sufficient heat is generated by an actual fire, safeguarding against an accidental flooding of the cabinet. The cabinet can be optionally fitted with an aerosol-based fire suppression canister with an independent heat-activated release.
- **Monitoring:** The Quantum enclosure is continuously monitored, and the operator is alerted through the EMS if abnormal temperatures, gasses, and/or humidity is detected.
- **Surge protection:** Surge protective devices connect between the feeder and the ground protects the equipment in the event of voltage spike.
- **Isolation device:** Quantum and ACC/DCC Cabinet has an isolation device that allows an operator to manually isolate the battery system at either rack-level or row-level.
- **Short circuit device:** aR class fuses are in the battery rack switchgear and in the ACC/DCC panel. These are very fast against and effectively limit short circuit current peak and energy.
- **Process Stop button:** A hard wired Process Stop (done by emergency stop relays) will send fast shutdown command to the inverter.

See GEMS product specification sheets for additional details.

wartsila.com

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APPENDIX 7 - GridSolv Quantum Fire Water Suppression Application Assessment



April 21, 2023

Wärtsilä Energy Storage, Inc.
Attn: Christopher Groves
Project Manager- Product Development
Hardware Engineering

RE: GridSolv Quantum Fire Water Suppression Application

Fire & Risk Alliance, LLC. (FRA) was requested to offer our assessment on fire water suppression applications for the GridSolv Quantum unit.

The GridSolv Quantum sprinkler system is provided with a thermally activated sprinkler and piping as a standard option. The header piping connection is located at the base of the Quantum in the lower corner. The Quantum sprinkler system is intended for manual dry-type application, where the piping is normally empty, and water is introduced manually through a water supply control valve.

Heat flux analyses were conducted using Fire Dynamics Simulator (FDS) computational fluid dynamics (CFD) modeling of the ignition of flammable gases resulting from a thermal runaway event within the initiating unit under various internal and exterior configurations to demonstrate the thermal runaway risk in the adjacent non-initiating units. In addition, a heat flux analysis of row-to-row fire propagation was conducted. The heat flux analyses conducted indicate that the risk of thermal runaway propagation between adjacent units and/or Quantum rows is unlikely.

Large-scale fire testing was performed on the GridSolv Quantum, with a focus on assessing the potential fire and heat propagation to adjacent units. The test setup involved placing the initiating unit located between two exposure units, simulating real-life application. The test duration was approximately nine hours, during which the fire spread through the initiating unit without affecting the adjacent units. After approximately 8.5 hours, the decision was made to suppress the fire after numerous citizen calls to the local emergency department. Post-fire inspection of the units demonstrated that the fire did not propagate into the adjacent units and there was no observable damage to the battery modules within the non-initiating unit, indicating that the risk of propagation is low.

Fire water discharge contaminate assessment was conducted based on firewater runoff samples collected at various points during the large-scale fire test (baseline control, exposure cooling, and suppression). The analysis of water quality data from the collected samples showed contaminate

concentration that surpassed the threshold, triggering US regulatory protocols outlined in the Clean Water Act (CWA) and Safe Drinking Water Act (SDWA).

In the remote event that a Quantum becomes fully involved in fire, the recommended response approach is non-intervention from a fire suppression aspect. Consideration may be given to the intermittent exposure protection of adjacent units. A total flooding approach may be used if desired, however it's important to be aware of the potential risk of water streaming coming into contact with energized electrical components. Usage of water can pose additional risks such as short-circuiting and reignition, which may persist for several days. Proper training is required for effective fire response.

In conclusion, heat flux analyses were conducted for the GridSolv Quantum indicate that the risk of thermal runaway propagation between adjacent unit or rows is unlikely. Large-scale fire testing was performed, that lasted about 9 hours, confirmed the fire did not propagated into the adjacent units and there was no observable damage to the battery modules within the non-initiating unit, indicating that the risk of propagation is low. In the remote event that a Quantum becomes fully involved in a fire, the use of water poses a risk due to potential contact of water streams with energize electrical components. Environmental concerns are also present. Additionally, utilizing water may lead to further hazards, such as short-circuiting and reignition, which may persist for several days. Therefore, the GridSolv fire water suppression guidance has been revised to recommend non-intervention, with exposure protection as the appropriate response tactic. If direct fire response is desired, the first responders must be provided with proper training for safe and effective fire response.

Regards,

A handwritten signature in black ink that reads "Hyeon Kim". The signature is fluid and cursive, with the first name "Hyeon" and last name "Kim" clearly distinguishable.

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APPENDIX 8 - Gridsolv Quantum BESS Fire Safety Assessment

2.3 Row-to-Row Fire Propagation Analysis

2.3.1 Scope and Methodology

2.3.1.1 Model Setup

A fire model in FDS was setup to analyze the potential of row-to-row fire propagation when one full row of Quantum BESS cubes is under a fire condition. For this one (1) scenario was modeled containing three (3) rows of Quantum BESS cubes, 3m (~10ft) apart, with 3 Quantum BESS cubes in each row. A constant 50mph wind condition from the south direction of the model was applied to observe the fire propagation potential at a worst-case weather condition.

For this scenario it was assumed that a prior deflagration event had occurred in a single initiating container in the middle row which resulted in the top deflagration vents of that container blowing off thereby creating a cavity 1.12m² in area and a subsequent ignition of the vent gas resulted in a combustion event in the initiating container.

It was assumed that the deflagration event has already occurred, and the subsequent burning of the vent gas starts to take place from $t = 0$ s. It was also assumed that only the initiating container burns for the first 7 minutes before it ignites the two (2) neighboring containers on either side of the initiating container. Subsequently, the three containers burn for an additional 8 minutes at which point the initiating container fire is assumed to be exhausted and the two (2) neighboring containers continue to burn for an additional 7 minutes before exhausting. The total duration of the simulation was 22 minutes. The fire is assumed to be not ventilation limited and a maximum HRR of the combustion event inside each container is assumed to be 7,600 kW. Figure 30 and Figure 31 below shows the model setup for the analysis.

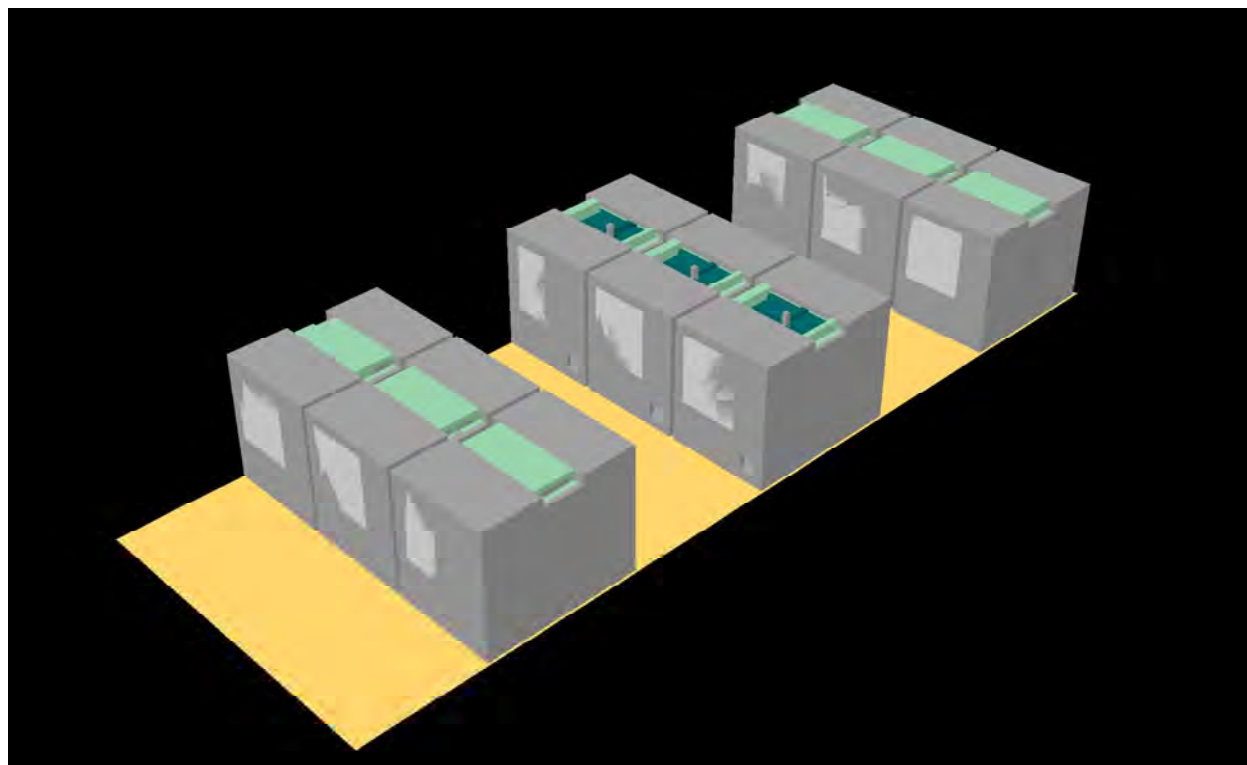


Figure 30. Site plan of FDS model for row-to-row propagation analysis

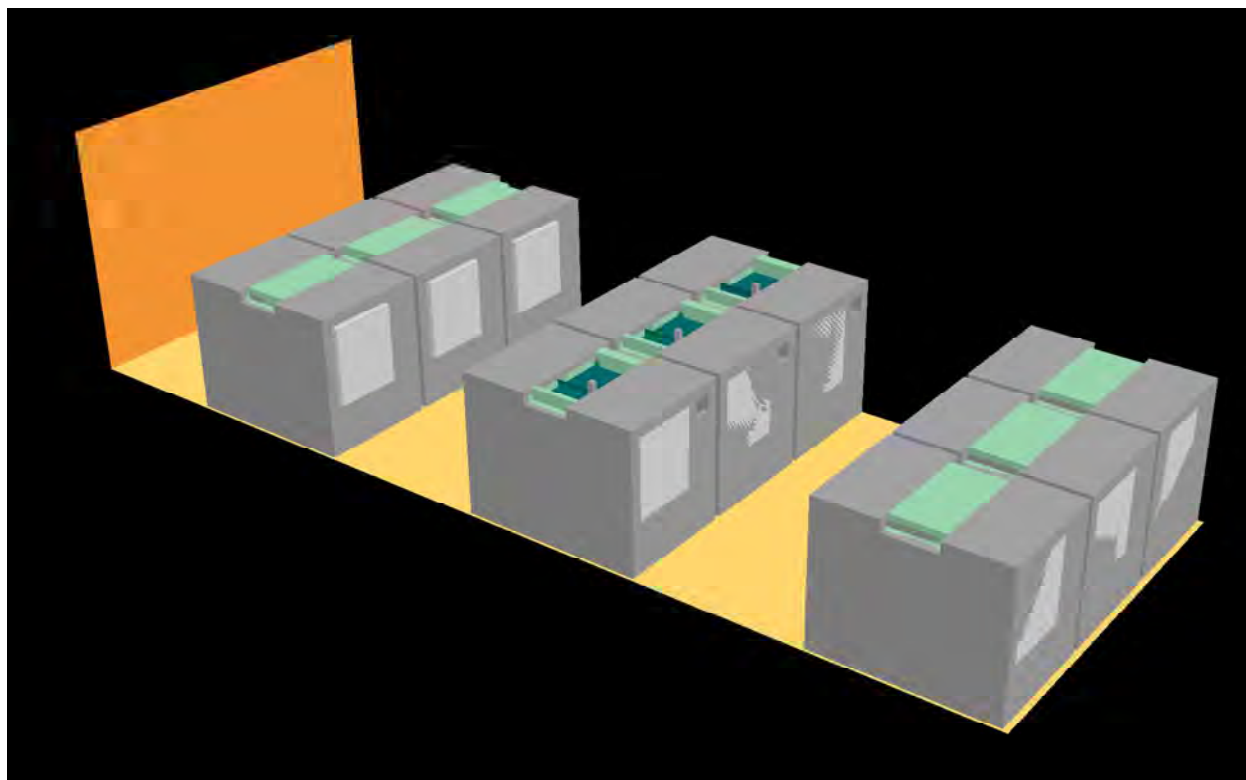


Figure 31. Site plan of FDS model for row-to-row propagation analysis showing equipment and surrounding environment with the wind input from south side of the model (in orange)

2.3.1.2 Design Fire and Model Approach

The data from UL9540A module level test data consisted only of a non-flaming incident and hence the design fires for this analysis were developed based on available data and assumptions mentioned for each of the scenarios detailed below. The gas mixture observed in the UL9540A testing included methane, ethylene, ethane, propane, propylene, carbon monoxide, carbon dioxide and hydrogen.

The density of the gas mixture at ambient conditions was found using a reaction test in the FDS solver which was 1.015 kg/m³. Based on the amount of released gas, density and the release time of 119 seconds, the mass loss rate for the gas mixture was calculated to be 2.45 g/s adjusted for the non-combusting CO₂ in the gas composition. The heat of combustion for the battery gas was calculated to be around 30,032 kJ/kg. The heat of combustion for PP module enclosure was found to be 43,100 kJ/kg¹.

The total energy per module was estimated to be 126,315 kJ with a peak HRR of around 1,900 kW considering the contribution from both the released battery gas and plastic module cover. Since

¹ Babrauskas, V. (2014), Ignition Handbook, Fire Science Publishers, Issaquah, WA, pp. 1067, 2014.

the purpose of this analysis is to analyze the effect of fire on the adjacent environment the fire was considered to start at the peak HRR of 7,600 kW from time $t=0s$ in each Quantum BESS cube.

2.3.2 CFD Modeling Results and Analysis

The following section presents the results for incident thermal heat flux and the wall temperature of the inside surfaces of the non-initiating rows of Quantum BESS cubes.

Figure 32 to Figure 37 present the results for the row-to-row propagation analysis. Figure 32 shows the combustion event in the middle row of Quantum BESS cubes in the presence of wind.

Figure 33 to Figure 35 shows the incident heat fluxes on the non-initiating row of containers. The first row of cubes does not encounter any significant incident heat flux since the wind direction tilts the flame away from the first row and therefore the incident heat flux stays below 9 kW/m^2 which is mostly concentrated on the top part of the container. The third row of cubes encounters an incident heat flux of about $24\text{--}28\text{ kW/m}^2$ which is mostly incident on the top corners of the 2 side cubes, while the center cube experiences about $18\text{--}20\text{ kW/m}^2$ incident heat flux on the top $1/3^{\text{rd}}$ part of the cube. The incident heat flux on the rest of the cubes' outer surface area facing the flame is in the $10\text{--}16\text{ kW/m}^2$ range which is decreasing as we move down the cube height.

Figure 36 and Figure 37 present the results for the wall temperature of the interior surfaces of the Quantum cube walls & ceiling, in the non-initiating rows at the end of the simulation (i.e., 22 minutes). The containers in the first row experience no rise in the inside wall temperature of cube walls and ceiling. The containers in the third row, due to the wind conditions and flame tilt in its direction, experiences a very minor rise in temperature of around 10°C and is at approximately 35°C which is observed on the inside surface of the central vent panels. Other than that the inside surface areas of the cube walls and ceiling do not experience any significant rise in temperatures.

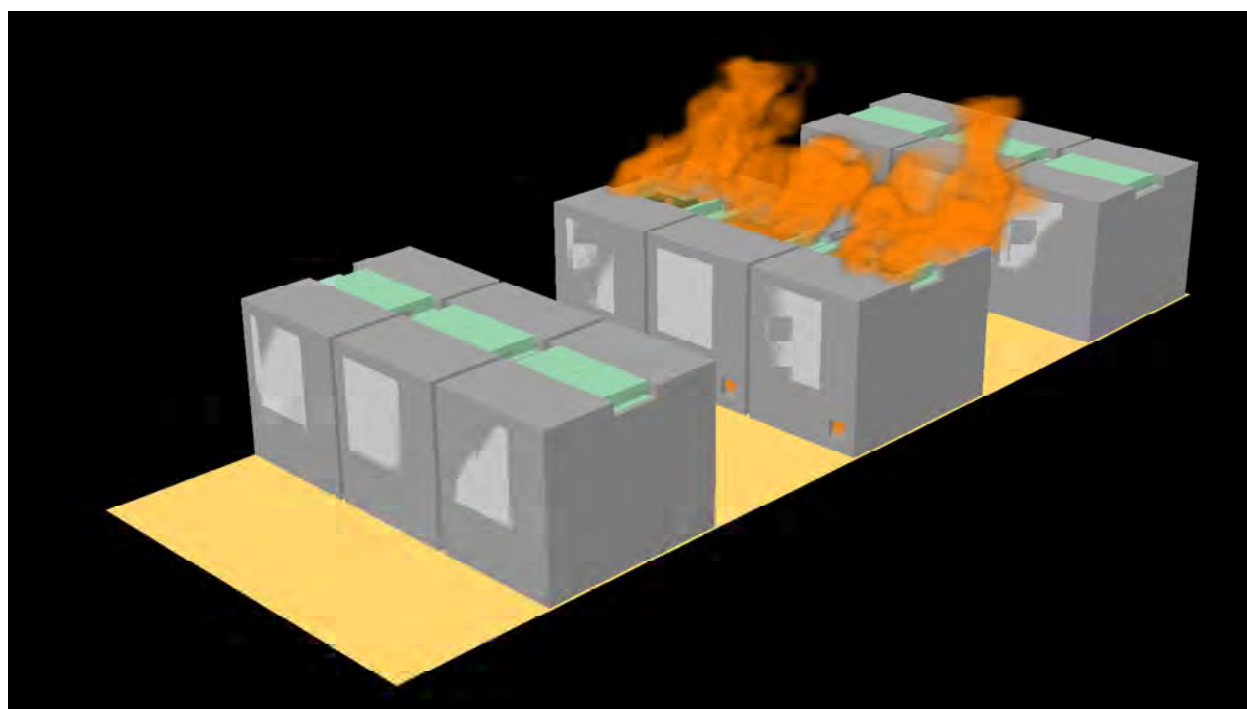


Figure 32. Simultaneous flaming event inside all the containers in the middle row and flame tilt due to the presence of wind

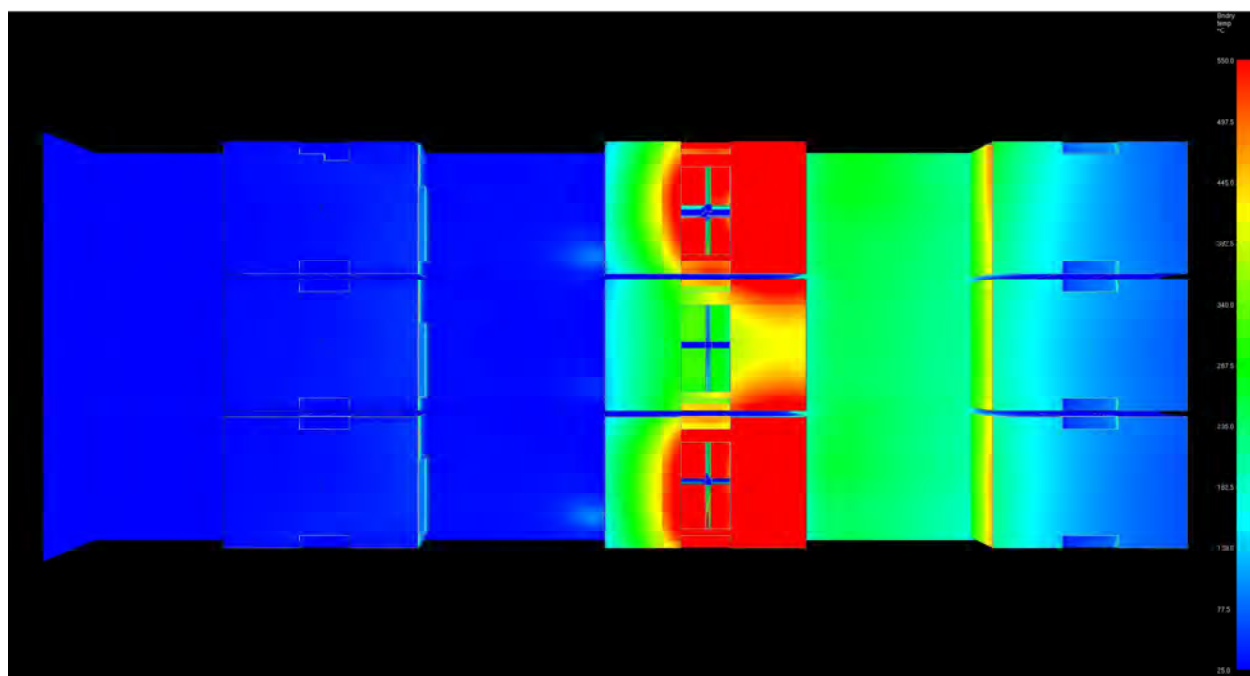


Figure 33. Incident Heat Flux on the non-initiating rows of Quantum BESS cubes (top view)

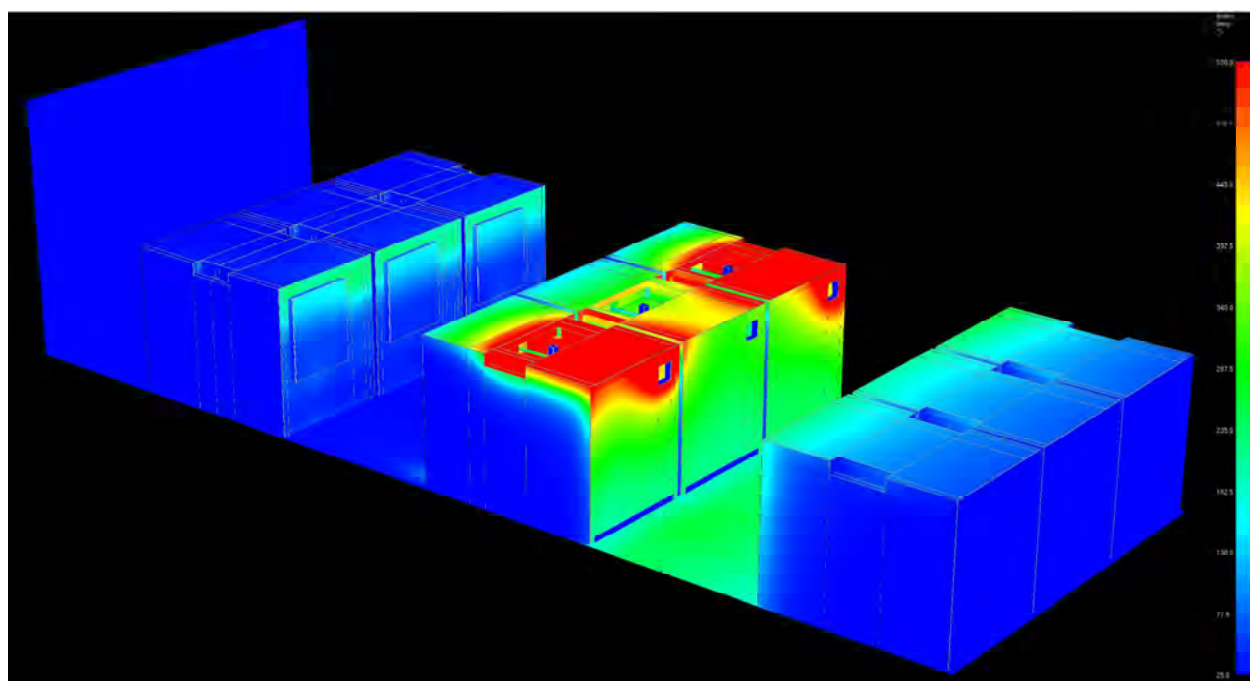


Figure 34. Incident Heat Flux on the first row of cubes (non-initiating row) of Quantum BESS cubes

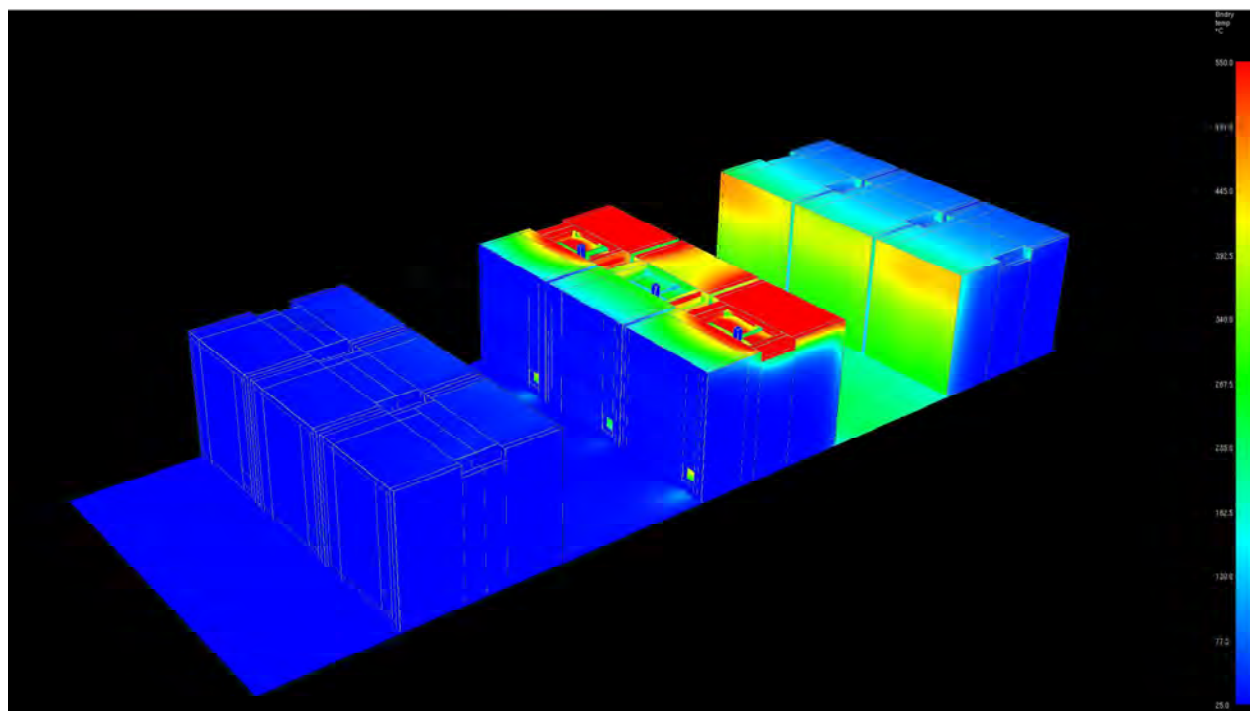


Figure 35. Incident Heat Flux on the third row of cubes (non-initiating row) of Quantum BESS cubes

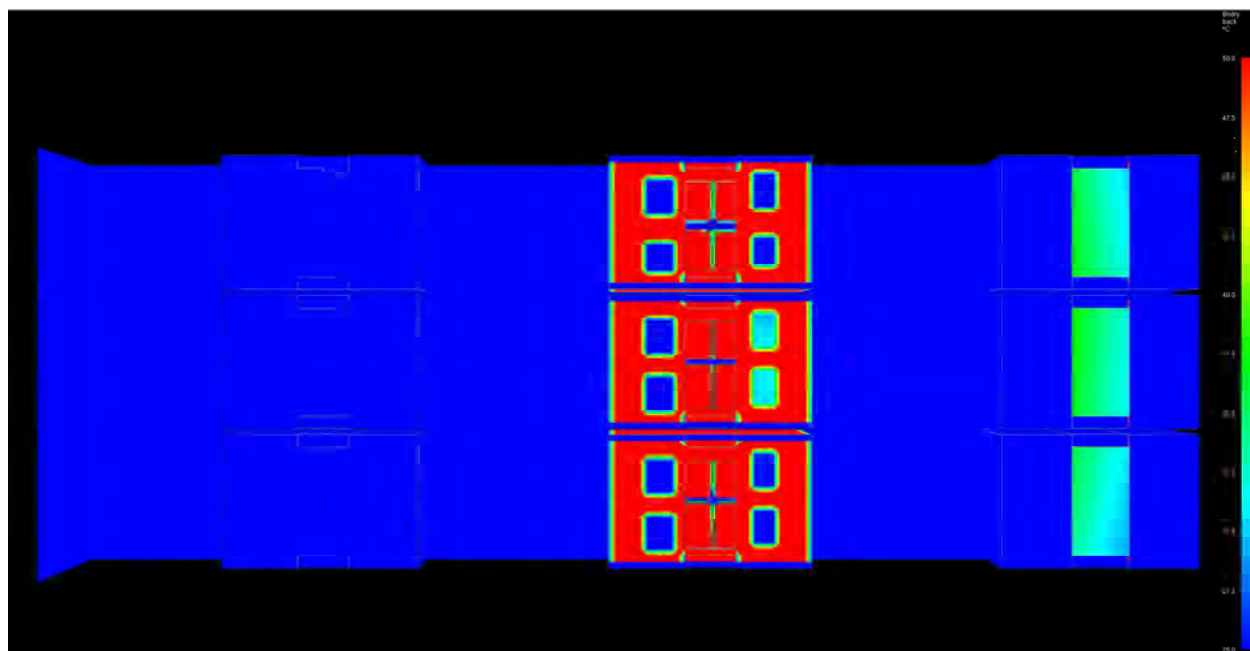


Figure 36. Wall Temperatures of the inside surfaces of the cubes' walls and ceiling in the non-initiating rows of Quantum BESS cubes (top view)

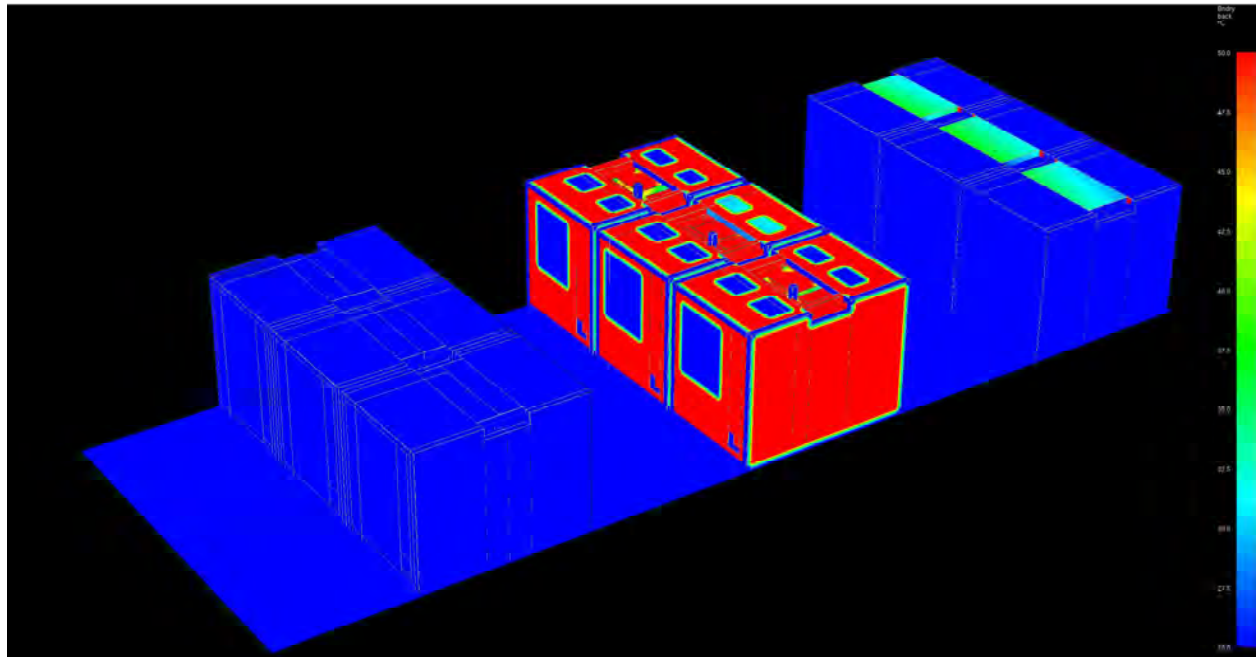


Figure 37. Wall Temperatures of the inside surfaces of the cubes' walls and ceiling in the third, non-initiating row of Quantum BESS cubes