Gate Burton Energy Park
EN010131

Frequently Asked Questions regarding the Battery Energy Storage System ("BESS")
Document Reference: 8.22 (Version 2)
November 2023

Rule 17(1)
Infrastructure Planning (Examination Procedure Rules) 2010

Gate Burton Energy Park Limited

Prepared for:

Gate Burton Energy Park Limited

Prepared by:

AECOM Limited

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1. Introduction

1.1 Purpose

1.1.1 This Technical Note has been produced to further explain the Battery Energy Storage System (BESS) proposed as part of the Gate Burton Energy Park. The Technical Note addresses key questions that have arisen during Examination of the Development Consent Order (DCO) application for the Scheme.

1.1.2 The Gate Burton Energy Park is a proposed development comprising a large-scale photovoltaic array and BESS development, connecting to the National Electricity Transmission System (NETS) at National Grid's Cottam 400 kV Substation (hereafter the "Scheme"). The Scheme constitutes a Nationally Significant Infrastructure Project (NSIP) and therefore requires an application for a DCO to be submitted to the Planning Inspectorate for determination by the Secretary of State.

1.1.3 The DCO application was submitted in January 2023, with the Examination into the Application commencing on 4 July 2023. On 23 and 24 August 2023, Issue Specific Hearing 3 (ISH3) was held on the Scheme, with Session 2 focussing on carbon saving including generating capacity/electricity and the BESS. At this hearing, the Examining Authority (ExA) asked for various details to be clarified in relation to the BESS, such as further details on operation, charging and exportation and questions regarding safety issues (see the Written Summary of the Applicant's Oral Submissions at ISH3 which was submitted at Deadline 3 **[REP3-027/8.13d]**). Prior to ISH3, the ExA also included questions regarding the BESS in its First Written Questions (such as design and location of the BESS and battery safety), which the Applicant addressed in its Response to the ExA's First Written Questions submitted at Deadline 3 **[REP2-041/8.6]**.

1.1.4 In addition, queries and concerns regarding the BESS have been raised by Interested Parties in Written Representations, particularly regarding the siting of the BESS, battery safety and measures that will be put in place by the local fire service to control battery fires (see the Applicant's Responses to Interested Party Submissions at Deadline 2 **[REP3-029/8.15]**). A further comment was received from the ExA in ExA's Third Written Questions and the ExA requested that this document be updated at Deadline 5 (20 November 2023) to incorporate the Applicant's answer.

1.1.5 This Technical Note provides further clarification on the key questions and concerns that have been raised in relation to the BESS in a user friendly format.

1.1.6 The answers in this Note are based on the Applicant's outline proposals for the BESS. The final type and design of the BESS will be decided at detailed design stage and the final design will influence the operating and safety procedures that are put in place. Prior to commencing construction of the

BESS, the Applicant will be required to prepare a Battery Safety Management Plan (BSMP). The BSMP is required to be substantially in accordance with the Outline Battery Safety Management Plan (OBSMP) **[APP-222/7.1]** but will take into account latest good practices for battery fire detection and prevention including consideration of any new or updated guidance that has been published since the OBSMP was written. This ensures that the latest guidance is considered in the development of the final BSMP. The Applicant will also develop an Emergency Response Plan in collaboration with Lincolnshire Fire and Rescue Service.

1.1.7 Requirement 6 on the draft DCO **[REP2-027 and as amended]** states that work cannot commence to construct the BESS until the BSMP is approved. Requirement 6 on the draft DCO states that the final BSMP must be approved by the relevant planning authority, and that the relevant planning authority must consult West Lindsey District Council, Lincolnshire Fire and Rescue, Nottinghamshire Fire and Rescue Service and the Environment Agency before determining an application for approval of the BSMP. This ensures that the relevant parties have the opportunity to influence the final BSMP before construction commences on the BESS.

2. The Role of and Need for the BESS

2.1 What is a BESS?

2.1.1 A Battery Energy Storage System (BESS) is made up of re-chargeable batteries (commonly lithium-ion, but there are alternatives) which can import and store energy and then discharge (export) it when the energy is required.

2.2 Why is battery storage needed nationally for energy production/supply?

2.2.1 The need for battery storage is supported by government policy. The government's National Policy Statements set out the government's policy for the delivery of energy infrastructure and provide the legal framework for planning decisions. National Policy Statement Draft EN-1 (March 2023) para 3.3.25 provides that *"storage has a key role to play in achieving net zero and providing flexibility to the energy system, so that high volumes of low carbon power, heat and transport can be integrated".*

2.2.2 Battery storage plays an important role in the UK's energy mix alongside other electricity generators. The main benefit of battery storage is that it can "balance the grid" by storing energy when demand is low and releasing it when demand is high. This role was traditionally filled by fossil fuel burning energy sources such as coal and gas fired power stations, but as these are ageing and some are being decommissioned, the energy industry is looking to battery storage to fulfil this need. A more detailed explanation of how grid balancing works is set out below at question 2.4.

2.2.3 Further information regarding the national need for battery storage is set out in paragraph 11.5 of the Applicant's Statement of Need **[APP-004/2.1].**

2.3 How does the BESS relate to the Scheme?

2.3.1 Whilst the BESS is not a Nationally Significant Infrastructure Project (NSIP) in itself, it is Associated Development to the Scheme and adds important utility to the operation of the Scheme as a solar generation station by storing energy generated by the Scheme's solar panels and releasing it at times of higher need.

2.3.2 The Scheme's grid connection agreement allows the Applicant to both export electricity to the grid and import it from the grid. By including the BESS, as Associated Development, it supports the operation of the Scheme's solar site **<u>and</u>** provides the ability to balance the electricity produced by other generating schemes by storing it in times of low need and releasing it in times of high need.

2.3.3 Whilst the "grid balancing" function of BESS is important to support the UK's energy mix more generally, the BESS still meets the key principles for

Associated Development established in the Associated Development Guidance (DCLG, April 2013). This status as Associated Development is not affected by the "import" function of the BESS, which provides secondary, ancillary public benefit. This position is also supported by national policy: National Policy Statement Draft EN-3 (March 2023) paragraph 3.10.2 states *"solar also has an important role in delivering the government's goals for greater energy independence and the British Energy Security Strategy states that government expects a five-fold increase in solar deployment by 2035 (up to 70GW). It sets out that government is supportive of solar that is co-located with other functions (for example agriculture, onshore wind generation or storage) to maximise the efficiency of land use".*

2.3.4 There is precedent for a storage system with an import and export function being consented as Associated Development in the recent Hornsea Four Offshore Wind Farm Order 2023 and the Longfield Solar Farm Order 2023. The battery storage proposed as part of the Cleve Hill Solar Farm Order 2020 also had an import/export function.

2.3.5 For further details, please see question 1.1.14 (page 36) in the Applicant's Response to the Examiner's First Written Questions **[REP2-041/8.6].**

2.4 How does the BESS help to manage/balance the national grid?

2.4.1 The main way in which the BESS helps to balance the grid is by storing energy when it is produced and releasing it at points in the day when the grid most needs it. This "grid balancing" role was traditionally filled by fossil fuel burning plants such as coal fired power stations. As those are decommissioned and the country moves towards renewable energy sources, the energy industry is looking to battery storage to fill some of the gap.

2.4.2 Batteries can help balance the national grid by:

a) storing electricity generated by the Scheme's solar panels on sunny days when supply outstrips demand;

b) exporting electricity to the national grid when local solar generation is low (so the Scheme's solar park cannot meet the demand immediately), but national demand is high; and

c) importing electricity from the national grid when national energy demand is low, but national generation is high. For example, on a windy day, the BESS could store electricity generated by wind farms to be exported back to the grid when the demand for electricity increases.

2.4.3 Table 11-1 in the Statement of Need **[APP-004/2.1]** provides further details of the potential contributions that the BESS could make to the national electricity market. For example, the "rebalancing" of the grid can not only help to meet fluctuations in energy demand but can also help on a minute-by-minute basis to deal with rebalancing after a fault in the national electricity system.

2.4.4 Not all grid connections have the capacity to both export electricity to the grid and import electricity from it (to store it for when it is most needed). National Grid has highlighted that *"storage and interconnection (flexibility) capacity will need to increase (from 10GW in 2021) to 19-33GW in 2030 and 48-79GW by 2050 to balance supply and demand both within the GB system and across borders"*[1]. Therefore where both import and export connection capacity is available at a particular grid connection point, it is important to install BESS to use those connections to help balance the grid. If those available connections are not used, it is possible that storage will not be able to come forward to the capacity and timings required to support the full integration of low carbon power into the UK electricity system because many new connection points will be needed to connect the scale of storage foreseen as necessary by the National Grid.

2.4.5 Appendix A of this Technical Note provides a technical explanation of how a co-located battery might operate in the UK energy market, with illustrations to show how it might import and export energy at certain times of the day to balance the grid.

2.5 Why do batteries provide a carbon benefit?

2.5.1 The BESS is capable of providing a carbon benefit by storing renewable energy when supply is high but demand is low, and releasing it when demand increases. This produces a carbon benefit because it means the national grid is less reliant on non-renewable energy sources (such as coal and gas) at times of high demand.

2.5.2 The Applicant acknowledges that the above carbon benefit is not realised if the BESS is storing energy from a non-renewable source. For example, the BESS might store energy generated by a mix of low-carbon and carbon emitting assets ready to be exported to the grid at a later time when demand is expected to be higher. However, whilst this particular example may not produce a quantifiable carbon benefit, by operating in this way the BESS would still play an important role in balancing the grid nationally.

2.5.3 Given that stopping generation at gas fired power stations reduces consumption of natural gas, but stopping generation at a wind farm does not, there is an incentive to turn off natural gas plants rather than wind farms when supply outstrips demand. This can mean excess electricity is more likely to be renewably generated.

2.6 Why is it important to have the BESS co-located with the solar energy park?

2.6.1 Co-location of the BESS with the solar park provides efficiencies in terms of land use and maximises the use of the available grid connection, because on-site infrastructure can be shared between the two technologies.

[1] See Table ES.E.01 of National Grid ESO's 2022 Future Energy Scenarios Report. Also referred to in the Applicant's Statement of Need paragraph 7.2.18 **[EN010131/APP/2.1]**

2.6.2 The Scheme's grid connection agreement allows for both the export of electricity to the grid, and the import of electricity from it. Therefore, the Scheme can contribute to meeting the national need for electricity storage by including the BESS (as Associated Development), which supports the operation of the Scheme's solar site and also provides the ability to balance the electricity produced by the solar site by storing it in times of low need and releasing it in times of high need.

2.6.3 Co-locating the BESS with the Solar Park where there is an "import" connection also provides additional benefits because it allows the co-located scheme to provide certain "Ancillary (Balancing) Services". Schemes which cannot import electricity from the grid would be unable to provide this.

2.6.4 Ancillary (Balancing) Services are procured by National Grid under certain contracts with operators of energy generation schemes. Under these contracts, the scheme must respond to National Grid's requests to import or export power. These services are important because supply of, and demand for, electricity must be matched at all times, and the electricity system needs to be kept in balance and within statutory control parameters. Ancillary (Balancing) Services are used to do this.

2.6.5 The BESS will be able to provide both "upward" regulation (i.e. exporting to the grid) and "downward" regulation (i.e. importing from the grid) by ensuring that the batteries are at approximately 50% charge when they enter into the contracted period for the Ancillary (Balancing) Services (i.e. the period when National Grid calls on the Scheme's BESS for assistance). This allows the BESS to import energy under National Grid's instruction and store it until it's full (100% charged) or export energy until it's empty (0% charge).

2.6.6 Table 11-1 in the Statement of Need **[APP-004/2.1]** describes the potential contributions of the BESS within the Scheme to the Great Britain electricity market, including Ancillary Service provision and more information on those services is included in Section 11.5 of the same document.

2.6.7 For further information, see the Applicant's Response to the Examiner's First Written Questions **[REP2-041/8.6]**, question 1.1.14 (page 33) which includes a table showing how the provision of services requires an import and export connection, which allows for upward and downward regulation as discussed above.

2.6.8 Finally, co-location of the BESS with the Scheme is supported by government policy. Paragraph 3.10.2 of Draft NPS EN-3 (March 2023) states *"Solar has an important role in delivering the government's goals for greater energy independence and the British Energy Security Strategy states that government expects a five-fold increase in solar deployment by 2035 (up to 70GW). It sets out that government is supportive of solar that is co-located with other functions (for example, agriculture, onshore wind generation, or storage) to maximise the efficiency of land use".*

2.7 How big will the BESS be in terms of MW and MWh?

2.7.1 The total battery storage of the Scheme has been assumed (for the purposes of the Applicant's application) to be 500MWh[2], although this may vary with the final design. The figure of 500 MWh describes the amount of electricity that could be stored at one time.

2.7.2 The size of the import connection secured by connection agreement with National Grid for the Scheme is 250MW. This is an important input into the maximum power capacity of the BESS proposed at the facility. Question 2.8 below provides further information on why this figure differs from the MWh figure above.

2.7.3 The Outline Design Principles **[REP2-008/2.3]** describe physical parameters which limit specific elements of the Scheme, including parameters which will have the effect of capping the energy capacity of the proposed BESS. Paragraphs 1.1.2 and 1.1.3 of the Outline Design Principles describes the need for flexibility in design (by way of a 'Rochdale envelope' approach) in order to *"allow provision in the DCO for the technological innovation and improvements that may be realised at the time of procurement and construction, in order to ensure that it can construct the Scheme taking advantage of innovation, safety improvements and cost-efficiencies*." In other words, the final design for the Scheme will be dealt with in the detailed design stage and will take into account any new BESS technology available at that time. The final design of the Scheme will have an effect on the energy capacity of the BESS.

2.7.4 The Applicant therefore is not proposing a limit to the energy capacity of the BESS element of the proposal for Gate Burton Energy Park. The BESS will utilise a lithium-ion energy storage system. In the UK, lithium-ion batteries have been deployed with 1 hour energy capacity, but are moving towards 2 hours and further. To be clear, 1 hour of energy capacity does not mean that the batteries can only store energy for 1 hour. The next question 2.8 explains what is meant by "energy capacity" and question 2.10 explains how long a battery can store energy for.

2.8 What is the difference between the "power capacity (MW)" and the "energy capacity (MWh)" of the BESS and how do they relate to each other?

2.8.1 Two important operational parameters which describe the size of the BESS are its "power capacity" and its "energy capacity".

2.8.2 Power capacity is measured in megawatts (MW) and describes the maximum instantaneous level of power export or import achievable by the BESS. This is analogous to the power capacity of a conventional generator.

[2] See for instance, Chapter 6 of the Environmental Statement: Climate Change **[APP-015/3.1]**

2.8.3 Energy capacity describes how much energy the BESS can hold. Energy equals power multiplied by time. Energy capacity is measured in megawatt hours (MWh) and can be described as MWh, simply hours, or by a C-rate.

2.8.4 The following examples describe how the operational parameters for the size of the BESS are related to each other.

2.8.5 A BESS with 250MW power capacity would, at any specific moment, be able to import, or export (not both) up to 250MW of electrical power.

2.8.6 If that BESS was able to store enough energy to export at full capacity for one hour, it would have an energy capacity of 250MWh (250MW x 1h).

2.8.7 A BESS with 2 hours of energy capacity would be able to store 500MWh (250MW x 2h). This energy could be exported to grid at its maximum power rate (250MW) for 2 hours.

2.8.8 Once fully depleted (i.e. all stored energy has been exported from the BESS), the BESS would take 2 hours at full import power rate (also 250MW) to reach a full state of charge. The state of charge (SoC) can be measured as an absolute number (e.g. when full, the SoC in this example would be 500MWh) or as a percentage of the energy capacity of the BESS (e.g. when full, the SoC would be 100%).

2.8.9 The battery C-rate describes the ratio of the power capacity and energy capacity and the C-rate is the inverse of the number of hours required fully to charge the BESS from empty to full. The above example describes a 0.5C BESS which takes at least two hours to discharge all of its energy from full (100% SoC) to empty (0% SoC).

2.8.10 In reality, BESS are not normally operated across the full 0% to 100% range of SoC, instead cycling across e.g. ~90% of that range (i.e. from 5% SoC, to 95% SoC). Neither are BESS 100% efficient, and a round trip efficiency measure describes what percentage of energy which has been imported to the BESS is then available for export. A typical value would be 88%.

2.8.11 In the examples included in Appendix A, to simplify the explanation given on how BESS may operate, both round trip efficiency and operational range of state of charge have been ignored.

2.9 What is the BESS cycle in terms of importing and exporting energy?

2.9.1 The cycle of importing and exporting energy will vary according to the national need for electricity and the availability of supply both from the Scheme's solar panels, and from other sources of energy.

2.9.2 Typically, BESS (as opposed to other forms of storage, e.g. pumped hydro, or in the future hydrogen) are used to balance supply and demand over short time periods (e.g. milliseconds to days) and may import energy at times of low demand (e.g. overnight) or high supply (e.g. the middle of a sunny day, or when wind generation is high) and release that energy when demand is high, which in the UK tends to be daily at breakfast and dinner time.

2.9.3 Appendix A of this Technical Note provides a technical explanation of how a co-located battery and solar scheme might operate in the UK energy market, with illustrations to show how it might import and export energy at certain times of the day to balance the grid.

2.10 How long can the BESS store energy for?

2.10.1 Question 2.8 explains that a BESS can be characterised by its energy capacity (MWh). This is a measure of *how much* energy the BESS can store but should not be confused with *how long* that quantity of energy can be stored for before being released. The BESS can maintain its charge for many hours or even days.

2.10.2 Typically, BESS (as opposed to other forms of storage, e.g. pumped hydro, or in the future hydrogen) are used to balance supply and demand over short time periods (e.g. milliseconds to days). Assets with the ability to "flip" between import and export in an efficient way are very useful to National Grid for balancing short term differences in supply and demand. A BESS would not be an efficient or effective technology to use to balance energy from week to week or longer and other technologies will be used to fulfil that role.

2.10.3 In the same way that a disposable battery loses charge even when it is not used, a BESS may lose charge if it is left charged but not operated for a period of time. It is not likely however in the BESS' anticipated operational routine that it would be required to store energy for longer than it is technically capable of doing.

2.11 Why does the BESS require charging from external sources to support the generating station?

2.11.1 The BESS helps to balance the grid by storing energy when it is produced and releasing it at points in the day when the national grid most needs it.

2.11.2 As part of this "grid balancing" function, the BESS will at times store power from the Scheme's solar panels, but it may also need to be able to import electricity from the national grid to be stored, for example, at times when local solar generation is low, national demand is low, but national wind generation is high. That electricity will be generated via other sources feeding into the national grid, such as wind, and will be exported to grid when it is needed.

2.11.3 This function of the BESS is necessary because the "grid balancing" role was traditionally filled by fossil fuel burning plants such as coal fired power stations. As those are decommissioned and the country moves towards renewable energy sources, the energy industry is looking to battery storage to fill some of the gap.

3. BESS Design and Operational Safety

3.1 Will the BESS create noise?

3.1.1 The overall plant noise emissions from the BESS will likely be experienced as a continuous and steady hum.

3.1.2 The BESS will operate continuously so there will not be any noticeable impulsive or intermittent characteristics from plant noise emissions.

3.1.3 Plant within the BESS compound can have tonal features (i.e. patterns or characteristics within the noise that give it a distinct and noticeable tone or pitch which makes it stand out from background noise). However, the main noise from the BESS will likely be the cooling fans and as a result any tonal features from the other plant will not be noticeable.

3.1.4 Noise predictions for the Scheme were based on an assumption that there was a wind speed of up to 5m/s in the direction of the place where the measurement was taken (e.g. local residential areas). Also, the predictions assume that all plant is operating externally under full load. Therefore, the actual noise levels experienced from the BESS are likely to be lower than those predicted.

3.1.5 Further details of the noise assessment can be found in the Applicant's Environmental Statement Chapter 11: Noise and Vibration **[APP-020/3.1].** The Applicant's noise assessment is based on a reasonable worst-case scenario and concluded that there would be no significant effects in relation to noise. This is because the BESS has been sited away from sensitive receptors such as residential properties.

3.2 How does the BESS show good design principles?

3.2.1 From a visual point of view, the colour of the various components of the BESS will be muted in keeping with the surrounding environment. This will reduce its prominence.

3.2.2 The proposed locations for the on-site Substation and BESS were carefully selected in areas screened by existing vegetation, woodland and topography. On the western side of the railway the BESS and Substation would be located close to the railway to increase the separation distance between this area of the site and the sensitive receptors to the west, including residents and heritage assets at Gate Burton. The area near the railway is also considered to be a less sensitive area of the Area of Great Landscape Value than areas further west. Locating the BESS and Substation between the two large blocks of woodland on-site screens the area from views to the north and south and the topography in this area means it would be less visible than in other areas of the Site.

3.2.3 Locating the BESS and the substation together also makes sense from a design perspective, as it means all the more industrial, taller elements of the Scheme are in one area, reducing the number of receptors and views affected and increasing the effectiveness of screening planting.

3.2.4 For further information, see section 4 of the Applicant's Planning Design and Access Statement Part 1 **[REP2-004/2.2].**

3.3 How will the BESS by monitored during operation?

3.3.1 The BESS facilities will be monitored by the onsite control systems as well as 24/7 monitoring by a remote control room. The monitoring system will automatically alert Lincolnshire Fire and Rescue Service (LFRS) in the event of an incident.

3.3.2 The control room will alert LFRS and be the first point of contact to link the LFRS with a Subject Matter Expert, who will be available 24/7.

3.3.3 The 24/7 control facility will be responsible for the security of the site with contemporary detection and monitoring systems. It will have the capability to immediately shut the system down should the need arise. It can also be responsible for the implementation of the emergency plan acting as a point of contact to the emergency services.

3.3.4 In line with NFPA 855, Standard for the Installation of Stationary Energy Storage Systems (2023) recommendations, site operatives and first responders will have access to the real time BESS monitoring systems. Analysis of the data allows them to decide if the battery system can be restarted safely for operational use or decommissioning.

3.3.5 In some circumstances, it may be necessary to discharge the batteries to enable first or second responders to deal with the incident. This capability could be potentially achieved through the onsite control room, or from a remote 24/7 facility. The precise methodology would be agreed in the Scheme's Emergency Response Plan once the detailed design of the BESS is known.

3.4 How will members of the public be warned about the BESS site hazards?

3.4.1 The BESS compound will have signage in accordance with the relevant Electrical Regulations but will also have the control room emergency telephone number should a member of the public of emergency services need to make contact (although, due to the position of the BESS away from residential areas and members of the public, this is more for use by emergency services/first responders).

3.4.2 For the benefit of the emergency services, signage would be installed in a suitable and visible location on the outside of the BESS units identifying the presence of a BESS system. Signage as per the National Fire Chiefs Council Guidance (2023) would also include details of:

- Relevant hazards i.e. the presence of high voltage direct current electrical systems
- The type of technology associated with the BESS
- Any fire suppression system fitted
- 24/7 emergency contact information

3.4.3 The exact details of the signage will be determined in consultation with Lincolnshire Fire and Rescue Service.

3.5 How is the safety plan for the BESS fully functional and effective?

3.5.1 The chosen BESS system will need to meet global testing and certification standards. The Applicant's Outline Battery Safety Management Plan **[APP-222/7.1]** details a list of global testing and certification standards that a BESS system must comply with at the detailed design stage. This would also be updated to take into consideration the current standards (and any new ones) that are in place at the detailed design stage.

3.5.2 Also, the detailed design stage will consider the lifecycle of the BESS from installation to decommissioning. The Applicant will work closely with LFRS to provide all relevant information on BESS and site design features to inform all necessary hazard and risk analysis studies and assist in the development of comprehensive Risk Management (RM) and Emergency Response Plans (ERP). Risk assessment tools will be utilised and, if necessary, site specific consequence modelling will be conducted to ensure that a comprehensive safety plan is in place to deal with site operations and any emergencies.

3.5.3 Prior to commencement of construction of the BESS, the Applicant will be required to prepare a Battery Safety Management Plan which will be substantially in accordance with the Outline Battery Safety Management Plan **[APP-222/7.1]** already submitted, but updated to consider the up-to-date safety standards in place at the time it is made.

3.6 Has the Applicant considered the National Fire Chiefs Council Guidance in its initial planning for the layout of the BESS? In particular, why has the Applicant chosen to site the BESS modules 3 metres apart?

3.6.1 In terms of module spacing, The NFCC FRS guidance document states: " A standard minimum spacing between units of 6 metres is suggested 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 can confirm that 6m separation will be observed unless UL 9540A unit or installation level testing and / or 3rd Party Fire & Explosion testing has demonstrated through heat flux data that distances can be reduced. Separation specifications must be in accordance with legislative code requirements available at detailed design stage. This will be provided within the detailed Battery Fire Safety Management Plan. Site specific CFD scenario and consequence modelling will be conducted to see if additional spacing is required. Test data and separation distances will be assessed by an independent Fire Protection Engineer.

4. Battery Fires, Explosions and Emergency Responses

4.1 What is thermal runaway and how does it differ from a fire?

4.1.1 Thermal runaway occurs where a battery cell enters an uncontrollable self-heating state. This can result in very high temperatures and venting or flaming from the cell. Major causes of thermal runaway include a fault in the battery cell (internal defects), a faulty Battery Management System (BMS), insufficient electrical isolation or environmental contamination.

4.1.2 Thermal runaway can lead to either a flaming reaction (i.e. fire) or venting reaction (i.e. release of gases). A venting reaction from battery cells can lead to a build-up of explosive gases which will need to be vented from BESS enclosures to mitigate an explosion risk.

4.1.3 The Applicant's Outline Battery Safety Management Plan **[APP-222/7.1]** provides details of how the Applicant intends to reduce the risk of thermal runaway (and fire) and how it intends to manage these hazards in the unlikely event that they occur. This will be updated to take consideration of current safety standards at the time the Battery Safety Management Plan is made (prior to construction).

4.2 What are the usual risks for battery fires?

4.2.1 The Electric Power Research Institute (EPRI) identified four BESS incident root causes:

a) faulty Battery Management System (BMS): this can be caused by inadequate protection settings, or unreliable software or hardware performance. This can lead to operating thresholds (such as voltage, temperature, or duration at a certain stage of charge) being exceeded and this can result in a fire;

b) insufficient electrical isolation: this occurs where a ground fault or short-circuit that leads to electrical "arcing" (i.e. electricity "jumping" from one connection to another) in a module or rack;

c) environmental contamination: this might be exposure to humidity, dust or an otherwise corrosive atmosphere that breaks down existing electrical isolation measures or insulation within the unit and causes a fire.

d) internal cell manufacturing defect: this is a fault within the manufacturing process which, if not picked up in quality control, can introduce unintended distortions, debris or other contaminants into the battery cell (or its chemical components). These defects can induce (either immediately or over a period of use), an internal short circuit which can lead to a fire.

4.2.2 Comprehensive design and maintenance programmes can address a), b) and c). Internal cell manufacturing (cause d)) can be addressed by only choosing a BESS system from a "Tier 1" battery supplier which employs rigorous quality control processes.

4.2.3 As set out in the Outline Battery Safety Management Plan **[APP-222/7.1]** the Applicant recognises that robust quality processes are essential within the development and procurement stages in terms of safe, continuous operation. The Applicant is experienced in conducting thorough tendering processes for procuring battery storage equipment and services, working with Tier 1 suppliers of battery cell manufacturers, inverters and transformers. In addition, the Applicant only works with leading battery integrators with global presence – whose expertise in system integration of battery cells and modules, inverters and transformers, in combination with intelligent software for management and optimisation of energy services from the battery – is critical for successful operation of any battery project.

4.3 What additional safety measures are being put in place as a result of lots of batteries being sited together?

4.3.1 Siting a number of batteries together will be managed by the design of the BESS and the detailed mitigation measures in place to ensure safety. The key mitigation measures will depend on the type and design of BESS ultimately chosen.

4.3.2 The Applicant's Outline Battery Safety Management Plan will be updated and submitted to the local planning authority as a detailed Battery Safety Management Plan (BSMP) prior to the commencement of construction. The detailed BSMP will include:

• The detailed design, including drawings of the BESS.

• A statement on the battery system specifications, including fire detection and suppression systems.

• A statement on operational procedures and training requirements, including emergency operations.

• A statement on the overall compliance of the system with applicable legislation.

• An environmental risk assessment to ensure that the potential for indirect risks (e.g., through leakage or other emissions) is understood and mitigated using methods consistent with Best Available Techniques (BAT) in relation to the specific battery chemistry selected.

• An emergency plan covering construction, operation and decommissioning phases developed in consultation with Lincolnshire Fire and Rescue Service, to include the adequate provision of firefighting equipment onsite.

4.3.3 Provision of the above information will demonstrate prior to construction that all of the considerations and requirements regarding battery safety (including siting a number of batteries together) have been addressed and the BESS design and installation is safe. The relevant local authority must approve the BSMP before construction of the BESS can commence.

4.4 What measures will be in place to detect a fire?

4.4.1 The Applicant's Outline Battery Safety Management Plan **[APP-222/7.1]** provides further details the Applicant's plans for fire detection.

4.4.2 The final fire and explosion protection design will be validated by an independent Fire Protection Engineer and will be approved by Lincolnshire Fire and Rescue Service, but the Applicant's initial plans include the following.

4.4.3 The Scheme will employ monitoring systems that will help identify any abnormal operation and safely shut down the system before the abnormality develops. These systems will be independent from the control systems and equipment that can cause the abnormal event.

4.4.4 Data analytics (DA) will be employed to help minimise risks: the battery management system (BMS) routinely records a wide variety of data (including current, voltage and temperature) and can monitor sensors around the BESS (such as smoke detectors, gas detectors and ground fault sensors). DA will automatically detect anomalies in the data which might indicate a risk to safety. DA will also routinely monitor the ageing of the battery cells and can alert the operator to maintenance that may be required.

4.4.5 Fire detection equipment will be installed at the BESS. This will comply with NFPA 855 (2023): Standard for the Installation of Stationary Energy Storage Systems and NFPA 69: Standard on Explosion Prevention Systems.

4.5 What measures will be in place to suppress a fire?

4.5.1 The measures to suppress fire will depend on the type of BESS that is selected for the Scheme. This will be decided at detailed design stage. For instance, a "container and rack" based BESS system will not have exactly the same fire suppression measures as a "cabinet based" system. There is an increasing industry trend towards using "cabinet based" BESS systems in which battery modules are more tightly packed with less space between them. The Applicant's Outline Battery Safety Management Plan **[APP-222/7.1]** provides further details the Applicant's outline plans for fire suppression.

4.5.2 For cabinet-based systems, manufacturers are increasingly electing not to integrate fire suppression systems and to instead demonstrate that a worst-case scenario is the safe burn out of a single BESS cabinet without requiring direct intervention from the fire service and without the fire spreading. The advantage of this is minimal fire brigade intervention (and increased safety) and decommissioning is an easier process because stranded energy risks (i.e.

live battery modules within the affected BESS cabinet, which can be dangerous) are also removed/burned.

4.5.3 If a BESS enclosure is a "container" design (20 ft, 40 ft, 53 ft), a fire suppression system will probably need to be integrated unless a full free burn test has shown that both fire and explosive events can be safely contained without fire suppression. If the BESS enclosure is a walk-in design, a fire suppression system (FSS) must be installed. A BESS fire suppression system (FSS), if integrated, will conform to NFPA 855 (2023) guidelines, and the suppression system will be tested to UL 9540A latest standard or significant scale 3rd Party fire and explosion testing. NFPA 855 (2023) confirms water is the most effective battery fire suppression agent and, therefore if an FSS is integrated, a water-based system would be considered for each BESS enclosure designed to control or fully suppress a fire without the intervention of the Lincolnshire Fire and Rescue Service. The suppression system would be capable to operate effectively in conjunction with a gas exhaust / ventilation system to minimise deflagration risks.

4.5.4 The Applicant will liaise with Lincolnshire Fire and Rescue Service to agree a strategy for fire suppression which will be clearly communicated in the Emergency Response Plan.

4.5.5 Unless there are immediate threats to life safety or similar threats, recent BESS fire test research recommends monitoring BESS equipment with thermal imaging devices and monitor BESS control data, if necessary, consider a defensive fire attack by performing exposure cooling (boundary cooling) on adjacent equipment to limit the spread of the fire.

4.5.6 As set out in the Outline Battery Safety Management Plant **[APP-222/7.1]**, other measures would include:

- Thermal monitoring of the battery enclosures and an automated "cut out" which will shut the system down if it goes beyond safe parameters;
- Using battery modules with liquid cooling systems with automated fail-safe operation, which ensure no cooling system leaks. These systems have a far better safety record for BESS systems compared to air cooled battery modules. An Emergency Stop mechanism, which can be operated both remotely and locally;
- Fire and vapour cloud detection such as:
    - aspirated very early smoke detection apparatus (VESDA)
    - detection of volatile organic compounds (VOC), hydrogen and carbon monoxide which are released during cell venting. If hydrogen is detected, this will trigger the gas venting / exhaust systems in accordance with NFPA 885 (2023) and NFPA 69 guidance to avoid explosion risks (by venting the gas away from the BESS); and
    - a standard heat detection system.

4.6 Is Ventilation required at the BESS and what is its purpose?

4.6.1 The type of gas ventilation/exhaust system for the BESS depends on the type and design of BESS installed. The design of the BESS (and the requirement for ventilation) will ultimately be decided at the detailed design stage.

4.6.2 The purpose of a gas ventilation/exhaust system is to take smoke, flames and gases safely outside the BESS enclosure, without compromising the safety of first responders.

4.6.3 As a minimum, the BESS ventilation system would comply with NFPA 855 (2023) / NFPA 69 guidelines which require the prevention of a dangerous build-up of explosive gases (25% Lower Explosion Limit).

4.6.4 The gas exhaust/ventilation system would be separate to any HVAC or other cooling system which is providing climate control for the BESS.

4.7 Why does water work for battery fires?

4.7.1 NFPA 885 (2023) confirms that water is the most effective way to suppress a lithium-ion battery fire and, therefore if a BESS Fire Suppression System (FSS) is integrated, a water-based system should be considered for each BESS enclosure designed to control or fully suppress a fire without the intervention of the FRS. The suppression system would be capable of operating effectively in conjunction with a gas exhaust / ventilation system to minimise deflagration risks. The Applicant's Outline Battery Safety Management Plan **[APP-222/7.1]** provides further details on the use of water and the Applicant's plans for fire suppression and detection. Water can be effective because of its cooling capacity if able to penetrate the battery systems or to provide cooling for adjacent battery racks or BESS enclosures. Any suppression agent that does not supply this level of cooling capacity will only insulate battery cells leading to increased fire or explosion risks. NFPA 855 (2023) stipulates that any other fire suppression system must be fully tested with the exact BESS system that it will be integrated with.

4.7.2 The Applicant will liaise with Lincolnshire Fire and Rescue Service (LFRS) to develop a defensive firefighting strategy as part of its Emergency Response Plan, allowing a cabinet to burn but ensuring separation between cabinets is more than sufficient to facilitate cooling of the surrounding cabinets and hence prevent fire spread.

4.7.3 The Applicant's fire suppression strategy is set out at question 4.5 above, with further detail in the Outline Battery Safety Management Plan **[APP-222/7.1]**.

4.8 How much water is required for fire suppression and what are the options to provide this?

4.8.1 The final water supply requirement will be decided at detailed design stage, based on the fire test data for the selected BESS system, and would be agreed by Lincolnshire Fire and Rescue Service and validated by an independent Fire Protection Engineer.

4.8.2 As set out in the Applicant's Outline Battery Safety Management Plan **[APP-222/7.1]**, it is not anticipated that firefighting techniques will involve direct jets of water onto equipment. Instead, techniques will be limited to containment and cooling of the adjacent units to prevent the fire from spreading.

4.8.3 The Applicant has been in discussions with the Lincolnshire Fire and Rescue Service (LFRS) who have advised that a water supply with a flow of 1900 litres per minute or 32 litres per second would be required on site for indicative design purposes. This is in line with the NFCC guidance which says that provisional firefighting supplies *"should be capable of delivering no less than 1,900 litres per minute for at least 2 hours".*

4.8.4 The Applicant intends to meet this water requirement by incorporating two water storage tanks within its indicative scheme design for the BESS site. These will hold 228,000 litres of water for use in an emergency.

4.8.5 In order to fill the on-site water storage tanks, the Applicant intends to either connect into Anglian Water's water main located in the A156, or use a water tanker to bring the water to site. The tanks will be filled with water before the Scheme is commissioned and water levels topped up periodically as required.

4.8.6 Sufficient space has been allocated in the BESS area for water tanks. The Applicant's intended locations of the water tanks has been agreed with LFRS and are indicated on Figure 1 attached at Appendix B. In September 2023 it was suggested that the tanks should be located outside the BESS enclosure to ensure they are accessible in the event of a fire, with locations selected to avoid the prevailing wind direction. The Applicant updated the Works Plans **[document 5.2]** at Deadline 4 to enlarge Work Number 2 to allow construction of these water tanks at the locations agreed with the LFRS, outside the BESS enclosure.

4.8.7 Discussions with Anglian Water are also ongoing regarding connection to a water main. An indication of where the water main might join into the BESS site is shown in blue hatching on Figure 1 at Appendix B.

4.9 Does the local fire service have access to enough water to deal with a battery fire?

4.9.1 As set out in question 4.8 above, the Applicant intends to provide water tanks on site to ensure there is sufficient water on site to deal with a battery fire.

4.9.2 The Applicant has engaged with Lincolnshire Fire and Rescue Service (LFRS) to advise on the design of the Scheme and a safety management plan. Engagement will continue throughout the development, construction, and operation of the Scheme. The local fire service has not raised concerns about their ability to respond to a fire emergency on the site and the design of the Scheme has incorporated measures to reduce the risk both of a fire occurring and of the local fire service needing to respond if one occurs. For example, the BESS water tanks are being proposed at a location that was suggested by LFRS.

4.10 Is there sufficient room to include the fire safety measures and the BESS within the BESS site?

4.10.1 The Applicant is confident that there is sufficient room within the BESS site to include the necessary BESS fire safety measures.

4.10.2 The exact fire safety measures that will be in place will be decided at the detailed design phase. However, Figure 1 at Appendix B provides an indicative site layout, showing the safety measures that might be included and are envisaged in the Applicant's Outline Battery Safety Management Plan **[APP-222/7.1]** and Surface Water Drainage Strategy (see Appendix 9-C of the Environmental Statement **[APP-139/3.3])**. This has been overlaid on the Applicant's Works Plan for the BESS (Work No.2) (shown in pink) to show that there is sufficient room for the safety measures.

4.10.3 Figure 1 includes the Applicant's proposed water storage tanks as blue circles and shows the volume of water required for firefighting can be accommodated on the BESS site. Figure 1 also indicates the potential location of lagoons and drainage systems beneath the BESS modules which could be in place to deal with fire water in the event of an incident. Further details on drainage for fire water are set out in question 4.11 below.

4.10.4 To clarify further, it is helpful to set out what must be included within this area under the draft Development Consent Order (dDCO). The BESS is defined as Work No.2 in the dDCO and is described as follows:

"a battery energy storage system compound including-

(i) battery energy storage systems (BESS) units each comprising an enclosure for BESS electro-chemical components and associated equipment, with the enclosure being of metal façade, joined or close coupled to each other, mounted on a reinforced concrete foundation slab or concrete piles;

(ii) transformers and associated bunding;

(iii) inverters, switch gear, power conversion systems (PCS) and ancillary equipment;

(iv) containers or enclosures housing all or any of Work No.2(ii) and (iii) ancillary equipment;

(v) monitoring and control systems housed within the containers or enclosures comprised in Work Nos. 2(i) or (iv) or located separately in its own container or enclosure;

(vi) heating, ventilation and air conditioning (HVAC) systems either housed on or within each of the containers or enclosures comprised in Work Nos. 2(i), (iv) and (v), attached to the side or top of each of the containers or enclosures, or located separate to but near to each of the containers or enclosures;

(vii) electrical cables including electrical cables connecting to Work No. 3;

(viii) fire safety infrastructure including water storage tanks and a shut-off valve for containment of fire water and hard standing to accommodate emergency vehicles; and

(ix) containers or similar structures to house spare parts and materials required for the day to day operation of the BESS facility."

4.10.5 Access Roads and Landscaping for the BESS doesn't need to be within the BESS site itself and can instead be accommodated in the areas around it. Landscaping and access tracks are included more generally within "Work No.5" in the draft DCO, which covers a much greater area on the Works Plans.

4.11 How do you manage contaminated water after a battery fire?

4.11.1 The precise system for managing contaminated water would be dealt with at the detailed design stage. As set out in the Surface Water Drainage Strategy for the Solar Site (see Appendix 9-C of the Environmental Statement **[APP-139/3.3])** the Scheme's drainage strategy includes a separate system around the BESS. A combination of positive drainage and swales/infiltration basins around the perimeter of the BESS act as a natural barrier to runoff or collecting runoff into a storage lagoon. An indicative layout for this system is shown on Figure 1.

4.11.2 An automatic system will be installed that allows rainwater to exit the bund under normal operating conditions but closes in the event of a fire or if the fire suppression system is otherwise activated. This would isolate the water to ensure that any firewater runoff is captured for analysis. The final design of the system would be agreed at the detailed design stage.

4.11.3 This trapped firewater may then be reused as firefighting water as required. This approach follows the management plan detailed in the "Protocol for the disposal of contaminated water and associated wastes at incidents 2018" jointly issued by the Environment Agency, Northern Ireland Environment Agency, Water UK and the Chief Fire Officers Association.

4.11.4 A post event action plan will be drawn up that will determine any immediate and follow up actions required to an event including an assessment in general accordance with LCRM (Land Contamination: Risk Management) and BS 10175:2011+A2:2017 (Investigation of Potentially Contaminated Sites – Code of Practice)

4.11.5 Further details can be found in the Applicant's Outline Battery Safety Management Plan **[APP-222/7.1]**

4.12 What is the emergency response plan to deal with a fire?

4.12.1 As set out in the Applicant's Outline Battery Safety Management Plan **[APP-222/7.1],** the BESS will have a robust and validated Emergency Response Plan (ERP), developed in consultation with Lincolnshire Fire and Rescue Service (LFRS). The ERP will be updated at the time it is finalised in line with current safety standards and guidelines such as NFCC and NFPA. As a guide, it will include:

- A full description and site plans identifying all of the relevant features required in an emergency such as layout, rendezvous point and staging area, emergency stop locations and firefighting equipment.
- Design drawings and schematics of the system for reference.
- Procedures for the isolation of enclosures in the case of failure.
- Location of electrical switchgear.
- Battery data including: Material Data Safety Sheets (MSDS); Control of Substances Hazardous to Health Assessment (COSHH); number of cells; and details of the fire detection and suppression system.
- Fire fighting strategy, including: conservative plume and explosion impact assessments; review of local risk points e.g. adjacent trees or infrastructure requiring possible protection from fire propagation; and review of fire water provisions.
- Location of alarm panels, details and location of signage.
- Chain of command and phone numbers of the control room and 24/7 SME.
- Details of any explosion prevention venting system including discharge locations and orientation.
- Evacuation routes.
- Medical emergency procedures.
- Maintenance Records.
- Decommissioning procedure for damaged BESS batteries and equipment.
- Protocols and schedule for conducting safety and emergency response drills.

4.12.2 In the unlikely event of an incident, the Applicant will fully engage with the local community. In addition, an executive stakeholder steering committee comprising key organisations will be set up within 24 hours of the incident. In this way, with multiple parties involved in the emergency response to the fire event actively participating in the steering committee, communication will be effective and accurate. Finally, the Applicant will be open and free with information to industries, first responders and local authorities where possible.

4.12.3 The Emergency Response Plan will be developed in consultation with the Lincolnshire Fire and Rescue Service. Information will also be made available to Lincolnshire Fire and Rescue Service for inclusion in their Site-Specific Risk Information (SSRI) records.

4.13 How will the fire brigade access the fire?

4.13.1 The Applicant's Outline Battery Safety Management Plan **[APP-222/7.1]** provides further details of Fire Service Access. The minimum proposed access-road width to reach the BESS will be 4m. In order to assess a worst-case scenario and to allow for a wider access for vehicles during construction and Abnormal Indivisible Load vehicles the Environmental Impact Assessment has assessed the road to the BESS with a width of up to 8m. This means that the road can be delivered at a greater width if necessary without any additional environmental effects. In addition, the BESS will be surrounded by a ring road with multiple access routes into the BESS without any cul-de-sacs to allow free access. The proposed access was developed through consultation with the Lincolnshire Fire and Rescue Service.

4.14 What is the risk of there being an explosion at the BESS (as opposed to fire)?

4.14.1 The main cause of an explosion at the BESS would be a thermal runaway event. Question 4.3 above sets out the mitigation measures in place to mitigate against this risk, with further details provided in the Outline Battery Safety Management Plan **[APP-222/7.1]**. The level of risk depends on the design of the BESS, how the BESS has failed and the concentration of gas that has been released.

4.14.2 The location of the BESS (i.e. centrally located within the Scheme and away from residential areas) means that the risks to local residents associated with an explosion are very low.

4.15 What is the evacuation plan for local residents?

4.15.1 The location of the BESS (i.e. centrally located, and away from residential areas) means that the risk to local residents in the unlikely event of an incident at the BESS is very low. As a result, the Applicant does not anticipate an evacuation plan will be required. The Applicant will work closely with Lincolnshire Fire and Rescue Service to provide all relevant information at the detailed design stage on BESS and site design features to inform all necessary hazard and risk analysis studies and assist in the development of comprehensive Risk Management and Emergency Response Plans.

4.16 Are there any health effects of inhaling gases from a battery fire?

4.16.1 BESS hazards for first responders and site operatives once a fire has started, depend on the BESS design but are typically defined as: fire, explosion, chemical hazards, carbon monoxide, carbon dioxide, hydrocarbon gases, and hydrogen.

4.16.2 The Applicant has considered unplanned emissions from the BESS in its Environmental Statement (see Appendix 15-C: Unplanned Emissions from Battery Energy Storage System (BESS) **[APP-172/3.3]**).

4.16.3 If the battery cells become damaged by heat or are burnt within a fire affecting a single module, a rack of modules or multiple racks, then the combustible materials consumed in the fire could give rise to a range of air pollutants. A standardised set of emission factors for BESS is not currently available from the Environment Agency and, therefore, equivalent data must be sourced from manufacturers and the research literature.

4.16.4 Appendix 15-C of the ES **[APP-172/3.3]** sets out the literature that the Applicant has considered. Based on that research, the Applicant identified that only emissions of hydrogen fluoride have the potential to occur at concentrations that may pose a hazard to health at off-site locations (i.e. away from the BESS site itself). Emissions of methane and chlorine are unlikely to be emitted at measurable concentrations and therefore could not cause elevated concentrations at any receptor location. Concentrations of carbon monoxide might be elevated on site but would rapidly decrease at locations away from the BESS and would not cause elevated concentrations at any receptor location.

4.16.5 Based on this, the Applicant has conducted modelling of the likely dispersion and dilution of hydrogen fluoride that would happen at the Scheme's BESS. This is based on the concept design of the BESS, the likely meteorology at the BESS (i.e. wind and other weather patterns), and the building and terrain effects around the BESS.

4.16.6 The distance required to reach a dilution of 1/1000th of the source concentration is different for each direction from the BESS and full details are set out in Table 3 in Appendix 15-C. However, taking 0° North as an example, concentrations of hydrogen fluoride would be diluted to 1/1000th of the source concentration (a dilution factor of 0.001) under 90% of the meteorological conditions likely to occur at the BESS (see Table 3, Appendix 15-C **[APP-172/3.3]**), within 150 m for all wind directions. When the Applicant considered 100% of the likely meteorological conditions, the dilution distance rose to 950m. However, this represents such an extreme combination of meteorological conditions that it is very unlikely to occur.

4.16.7 The Applicant has also considered the potential time for which hydrogen fluoride concentrations could be elevated, based on the concept design for the BESS. Assuming a BESS facility that takes the form of a 5-rack fire before fire control measures bring the fire under control, emissions of hydrogen fluoride could cause concentrations over time periods of 10 minutes, 1 hour or up to 6 hours that are below the AEGL-1 value[3] (i.e. the level of notable discomfort) at locations further than 150 m of the fire, which is closer than the nearest sensitive receptors.

4.16.8 Given the specification reached in detailed design will be required (by a requirement to the DCO) to be consistent with the parameters assumed in the

[3] Acute exposure guideline level (AEGL) values start at AEGL-1 and increase in severity of health outcome to AEGL-3. AEGL-1 is the "level of the chemical in air or above which the general population could experience notable discomfort"

Outline Battery Safety Management Plan, the assumptions made in Appendix 15-C are a worst case, as there will be mitigation measures to suppress fire which have not been accounted for in the Applicant's assessment. As such the potential consequence exposure to hydrogen fluoride at actual receptor locations surrounding the BESS would be below the AEGL-1 value.

4.16.9 The concept design of BESS includes a number of design elements to prevent, detect and control a fire should one occur. These include internal cooling, fire suppression and fire protection. The batteries will be controlled by charging management systems that will detect if a cell or battery is not operating correctly. The BESS will be fitted with a fire monitoring system with smoke, hydrogen and carbon dioxide gas detectors, temperature monitoring and alarms so if one cell or module were to catch fire the fire suppression system will automatically be triggered to reduce the temperature and ensure that the burning cell/module does not affect the other cells/modules in the BESS. Therefore, in the unlikely event that a fire was to break out in a single cell or module it is very unlikely, given the control measures, that the fire would spread to the rest of the BESS. Even should all the systems fail, and a large-scale fire break out within enclosures, then the resultant hydrogen fluoride concentration at the closest receptors would be below the level that UK Health Security Agency has identified as resulting in notable discomfort to members of the general population.

4.16.10 The expected hydrogen fluoride emissions will be checked again at detailed design stage once the make, model and layout of the BESS is known, and, if necessary, consequence modelling will be undertaken to demonstrate that the impacts associated with an unplanned fire would not exceed the effects outlined in Appendix 15-C or cause any significance adverse health effects to the local community.

4.17 What are the implications of a battery fire, in terms of contamination etc, on the local area?

4.17.1 NFPA 855 (2023) defines five BESS hazard categories, hazards are assessed under both normal operating conditions and emergency / abnormal conditions, generally these threats are only relevant to first responders and site operatives:

- Fire & explosion hazards
- Chemical hazards
- Electrical hazards
- Stored / stranded energy hazards
- Physical hazards

4.17.2 Detailed consequence modelling at the BESS detailed design stage will assess fire, explosion, and toxic gas emission impacts on local respondents, the Applicant is confident that BESS and site design will be appropriate to minimise any short-term impacts to air quality and prevent any land or water contamination.

4.17.3 BESS design and site layout would minimise the requirement for direct fire rescue service intervention in a thermal runaway incident i.e. direct hose streams or spray directly on BESS battery systems. The intervention of Lincolnshire Fire and Rescue Service in worst case scenarios would ideally be limited to boundary cooling of adjacent BESS units to prevent the fire from spreading, this minimises the potential for any contaminants to be contained in firefighting water run-off. This strategy would be finalised with the local FRS and be clearly communicated in the ERP.

4.18 Are the fire suppression techniques used for a thermal runaway event the same as for a conventional fuel air fire? If not, how would the fire suppression system be employed with other controls or what alternative strategies are proposed for thermal runaway?

4.18.1 As explained in section 4.1.1 above, thermal runaway refers to a self-perpetuating and uncontrollable increase in temperature within a battery. Due to the nature of such an event, **prevention** is the main focus. The safety measures designed to minimise the effects of overheating can vary depending on the selected supplier (as explained in section 4.5.1). Prevention/mitigation measures may include (non-exhaustive list):

- Robust battery management systems (BMS) capable of adequately monitoring and controlling cell temperature and voltage. They would then send alarms signals if any of the thresholds are exceeded.
- Thermal management: this can include liquid cooling at container, rack or cell level. For cabinet sized battery enclosures liquid cooling is a common solution, for larger sizes such as 20ft or 40ft containers HVAC may be more effective (see illustration of HVAC system below).
- Separator design: separators are used to prevent short circuits.
- Cell design: optimum cell arrangement for better heat distribution and improved fire safety.
- Cell venting: pressure release vents that release gas in the event of an accumulation of explosive gases, reducing the risk of explosions.
- Over-current protection at cell level.
- Charging practice: limiting the maximum charge and discharge rate.
- Monitoring and regular maintenance: preventative maintenance has become industry standard.

Illustration of HVAC airflow (SYL)

Figure 5-3: Airflow in Battery Racks

4.18.2 In the event that a thermal runaway occurs, the "direct response" to it would be to let the affected unit burn (due to the nature of thermal runaway). Regarding the likelihood of fire spreading or two or more enclosures going into thermal runaway, the Applicant will liaise with Lincolnshire Fire and Rescue Service (LFRS) to develop a defensive firefighting strategy as part of its Emergency Response Plan (ERP), allowing a cabinet to burn but ensuring separation between cabinets is more than sufficient to facilitate cooling of the surrounding cabinets and hence prevent fire spread.

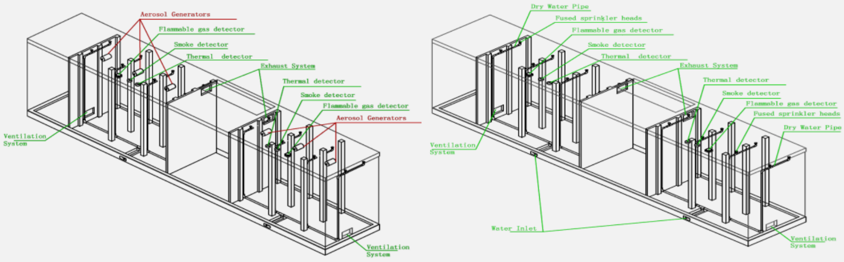
4.18.3 However, the above does not mean that the fire detection and suppression systems are of no use in a thermal runaway event. The fire detection system plays a crucial part in the response to the thermal runaway by setting off the alarm (acoustic signals, SCADA signals, strobe etc). The fire detection system can also communicate with the EMS so that the concerned battery rack can be electrically isolated. Further details on typical fire suppression systems appears below.

Fire detection and suppression system:

Suppliers have different approaches, but Tier 1 manufacturers usually include heat, smoke and gas sensors. If smoke, heat or gas is detected and alarms are triggers, some solutions comprise the release of aerosols into the enclosure (usually when water is not available).

Example of a suppression design in a containerised solution (Sungrow)

AEROSOL & WATER FIRE SUPPRESSION SYSTEM



Aerosol FSS can be used alone in some areas where water resources are relatively scarce. Aerosol FSS and water based FSS can exist in the system at the same time. Above figures are for reference, the actual product may be different (location and quantity)
Water Based FSS is the standard configuration of Sungrow Liquid Cooled ESS.The battery cabinet has 2 separate battery chambers, and each battery chamber has a water based FSS.
The water inlet is reserved for a quick-connect water inlet that meets local standards. The pipe network specification is designed according to hydraulic calculations, drawings and flow requirements. Sungrow will provide hydraulic calculations reports.

Appendix A: How a co-located battery may operate in the UK Energy Market

The purpose of this technical appendix is to supplement the Applicant's Written Summary of its Oral Representation given in Session 2 (Carbon Savings) of Issue Specific Hearing 3 (Environmental Matters) (ISH3) in the examination for the Gate Burton Energy Park (GBEP).

In this note, the Applicant explains with illustrations how a battery may operate in the UK energy market.

At ISH 3, the Applicant summarised that the BESS at Gate Burton Energy Park (GBEP) is foreseen to undertake the following five types of operation during its operational life:

- Importing from the GBEP solar facility when local solar generation is high but national generation is higher than national demand
- Exporting to the grid when GBEP solar generation is low but national demand is higher than national generation
- Importing from the grid when national demand is low but national generation is high
- Exporting to the grid when national generation is low but national demand is high
- Importing or exporting from the grid under an Ancillary (Balancing) Service contract instruction from National Grid Electricity System Operator (NGESO)

BESS will operate in the electricity market in response to a market need. Market need manifests as a differential in market price at different times, driving the BESS to import or export accordingly. A greater market need will drive a greater price differential. Electricity is bought and sold ahead of time (based on operational forecasts of supply and demand, see following) and also by National Grid Electricity System Operator (NGESO) at delivery. We describe buying or selling ahead of time as **trading** and commitments are then delivered through BESS operations, as is illustrated in the following. Any other operation at delivery will be under an Ancillary (Balancing) Services contract arrangement.

Section 10.2 of the **Statement of Need [APP-004/2.1]** describes the commercial operation of the UK's electricity market and how changing levels of forecast supply and demand may affect electricity price. In summary, if over some future period of time, the national supply of electricity is expected to be higher than the national demand for electricity, then market price will be low. If national demand is forecast to be higher than supply over a different period of time, then market price will be higher.

A BESS which imports during lower price periods and exports that power during higher price periods will therefore help balance supply and demand in both periods.

Once charged, a lithium-ion BESS is able to hold its charge without significant depletion (charge leakage) for a period of at least days, meaning that BESS are able to import energy one day and export it the next.

In practice however, lithium-ion BESS are anticipated to provide short term balancing and electricity market operations and the long-term storage of imported energy in the BESS is not currently foreseen as a normal mode of operation for the BESS proposed at GBEP.

The following figures illustrate how solar and BESS may work together under a number of different well-defined and distinct market scenarios. The reality of electricity market operation is that BESS and solar operations are unlikely to be so clearly defined and actual operations may vary significantly on a day to day basis.

For example, in Figures 1 – 4 following, the BESS is shown moving from 0% to 100% State of Charge and back again on each operation. In reality, this may not be the case, and the BESS may instead undertake many more partial, rather than full, import / export operations.

Charging from the GBEP solar facility when local solar generation is high but national generation is higher than national demand and exporting to the grid when GBEP solar generation is low but national demand is higher than national generation

Local solar generation is usually highest in the middle of the day, and national demand is usually highest in the evening (around approximately 17:00 in winters, 19:00 in summers).

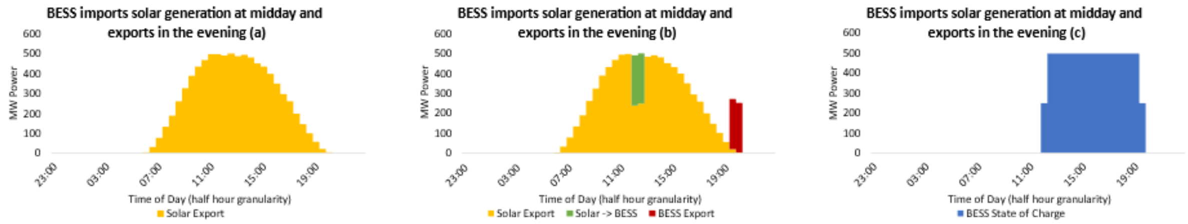


Figure 1(a, b, c) – BESS imports solar generation at midday and exports in the evening

Figure 1(a) represents solar generation at the facility over the course of one sunny day. If the operator’s forward view was that energy may be in surplus in the middle of the day but would be needed in the evening, the operator could schedule the BESS to import from the solar generation during the middle of the day (Figure 1(b), green bars) and to export that energy later when it was needed more (Figure 1(b), red bars). Figure 1(c) shows the State of Charge of the BESS on that day.

The BESS may be configured to import and export at a lower rate than its maximum power output, this will allow it to import over a longer period and export as shown in Figure 2. Critically, the amount of energy the BESS can store is the same as in Figure 1. Operators would determine their rate of import and export according to market needs.

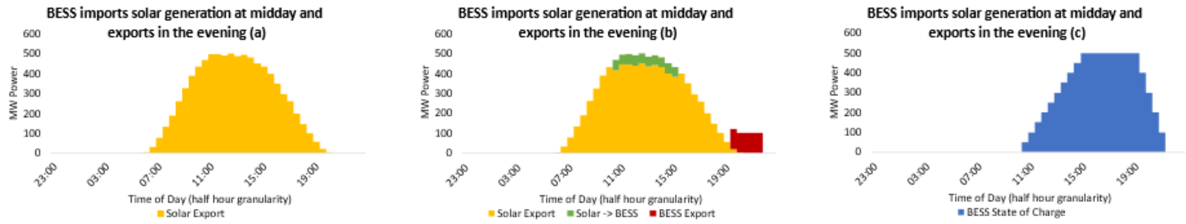


Figure 2 (a, b, c) – BESS imports solar generation at midday and exports in the evening – lower import / export rates

Importing from the grid when national demand is low but national generation is high and exporting to the grid when national generation is low but national demand is high

National UK electricity demand varies through the day and can also be different from day to day for example weekdays versus weekends, or summer versus winter days. Additionally, solar is not the only variable renewable generation on the UK electricity system. This means that it may be useful for the BESS to support the national supply and demand balance by importing directly from the grid rather than from the co-located solar, as was shown in Figures 1 and 2 previously. A good example of when the BESS might import from the grid in response to national supply / demand balance, might be when wind generation is high.

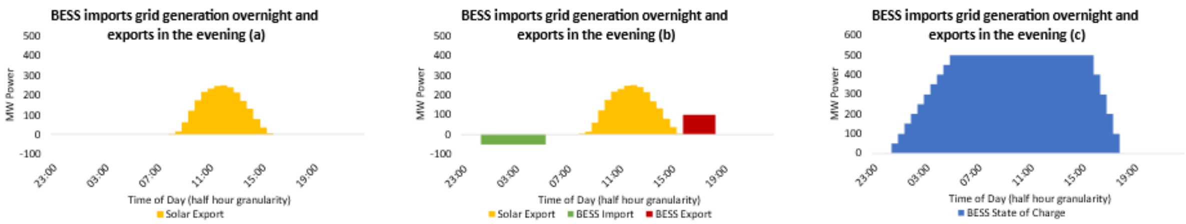


Figure 3 (a, b, c) – BESS imports grid generation overnight and exports in the evening

Figure 3 above shows how the BESS may import overnight, store its charge through the day, and export in the evening peak. Figure 3 uses a solar output profile which may be more typical of a winter's day, but the type of operation shown is not foreseen to be restricted only to the winter.

On some days, operators may foresee the need for the BESS to operate more than one import/export cycle over a 24 hour period, and Figure 4 shows how this might work. In practice, the BESS operational parameters will limit how the BESS is able to respond to market need.

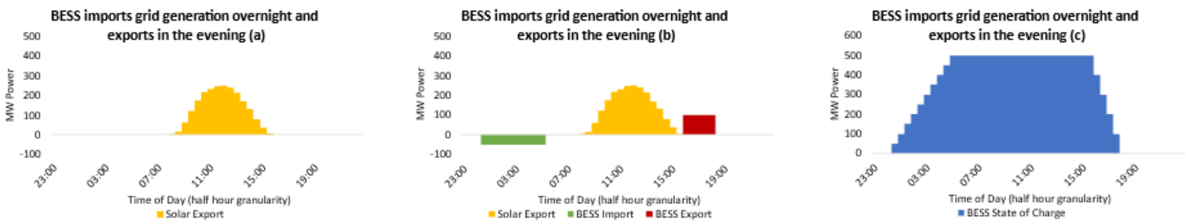


Figure 4 (a, b, c) – BESS imports grid and solar generation and exports twice in the day

Importing or exporting from the grid under an Ancillary (Balancing) Service contract instruction from NGESO

Ancillary (Balancing) Services are contracted at relatively short notice (e.g. contracted today for delivery tomorrow) and service time windows tend to be contracted in multiples of 4 hours, commencing 23:00, 03:00, 07:00, 11:00, 15:00 and 19:00 daily.

It has been described previously in this technical note, that many Ancillary (Balancing) Service contracts require BESS to provide both upward (export) and downward (import) regulation to the national grid, and that to do this BESS would be likely to seek to commence their period of contracted operation with a State of Charge at or close to 50%. This may mean therefore that immediately prior to a contracted period for Ancillary (Balancing) Service provision, a BESS may elect to import or export to achieve a State of Charge of 50% at the start of its contracted window.

As is described in the Statement of Need **[APP-004/2.1]** and the Applicant's response to the **ExA's FWQ1.1.14 [REP2-041/8.6]**, Ancillary (Balancing) Services help to keep the UK electricity system operating safely and securely.

The UK's electricity system operates at a nominal frequency of 50Hz and National Grid procure services over very short timescales (sub-second **response** services) out to minutes or hours for **reserve** services to keep frequency at or close to 50Hz at all times.

BESS operation under reserve service contracts will be similar to the BESS operation shown in figures 1 – 4 above, i.e. consistent importing or exporting over periods of minutes or hours at pre-agreed levels. BESS operation under response service contracts will however be different.

Response contracts require the immediate import or export of energy to the grid based on whether the instantaneous frequency of the national grid is higher or lower than the statutory 50Hz. Importing energy into the BESS has the effect of reducing grid frequency (so import actions are instructed when frequency is high). Exporting energy from the BESS has the effect of increasing grid frequency (so export actions are instructed when frequency is low).

Under normal operating conditions, the frequency of the national grid varies by small amounts from the statutory 50Hz level. Short duration injections (or exports) of energy to the grid nudge frequency back to the statutory level. Figure 5 following shows how grid frequency changed second-by-second over a 30 minute period of operation in July 2023, and how a BESS operating under a Frequency Response contract may respond to those normal changes in grid frequency.

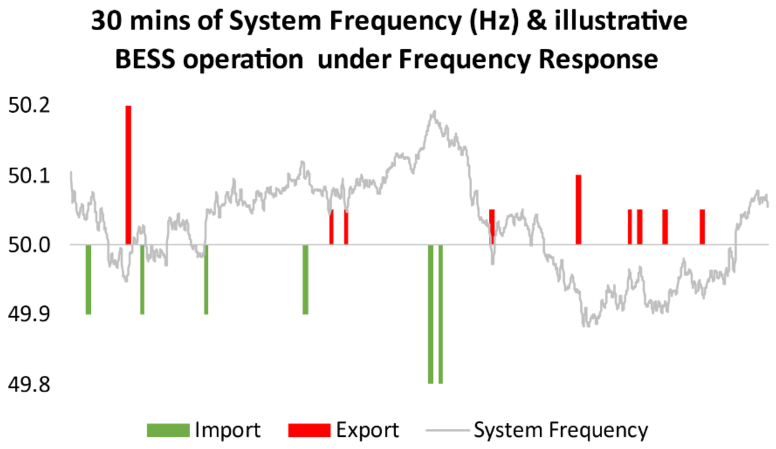
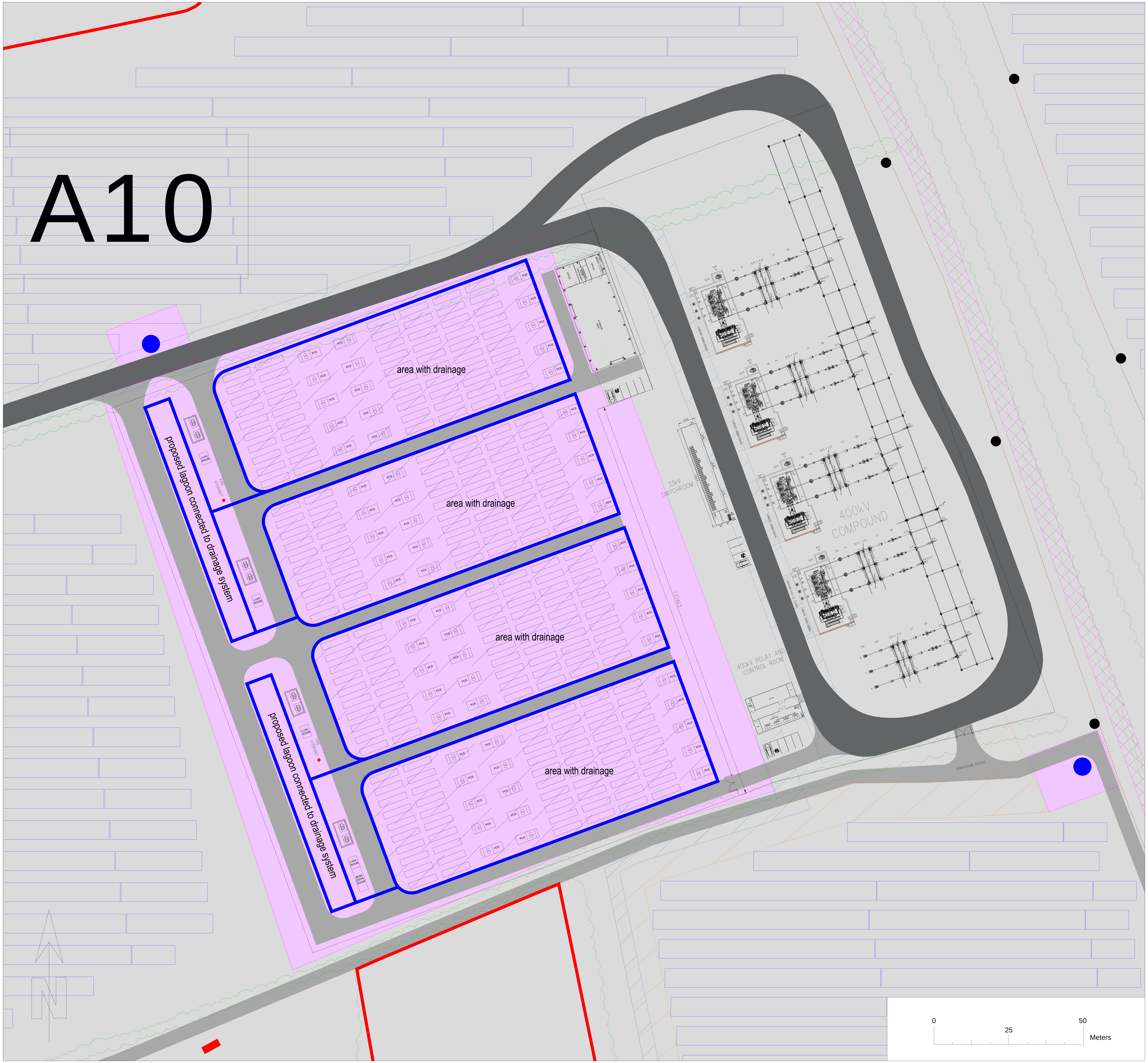


Figure 5 Illustrative BESS operation under Frequency Response

Figure 5 seeks to illustrate that if frequency is moving away from the nominal 50Hz line, BESS will respond to bring frequency back towards 50Hz. The height of the green (import) and red (export) columns is intended to signify the magnitude of the BESS response, and is driven by a combination of the rate of change of frequency (quicker changes require a larger response) and how far away grid frequency is from its nominal 50Hz.

In reality BESS imports/exports may be much more frequent than those illustrated in Figure 5. In normal operational conditions, under Frequency Response, a BESS could be expected to import roughly the same amount of energy as it exports, leaving its State of Charge broadly unchanged over the contracted period. However it is important that the contracted State of Charge is known before the contracted period starts such that in fault conditions, the BESS can be relied upon to deliver the extent of the services it has contracted with NGESO.

Appendix B: Figure 1 - Indicative layout of BESS



Gate Burton ENERGY PARK

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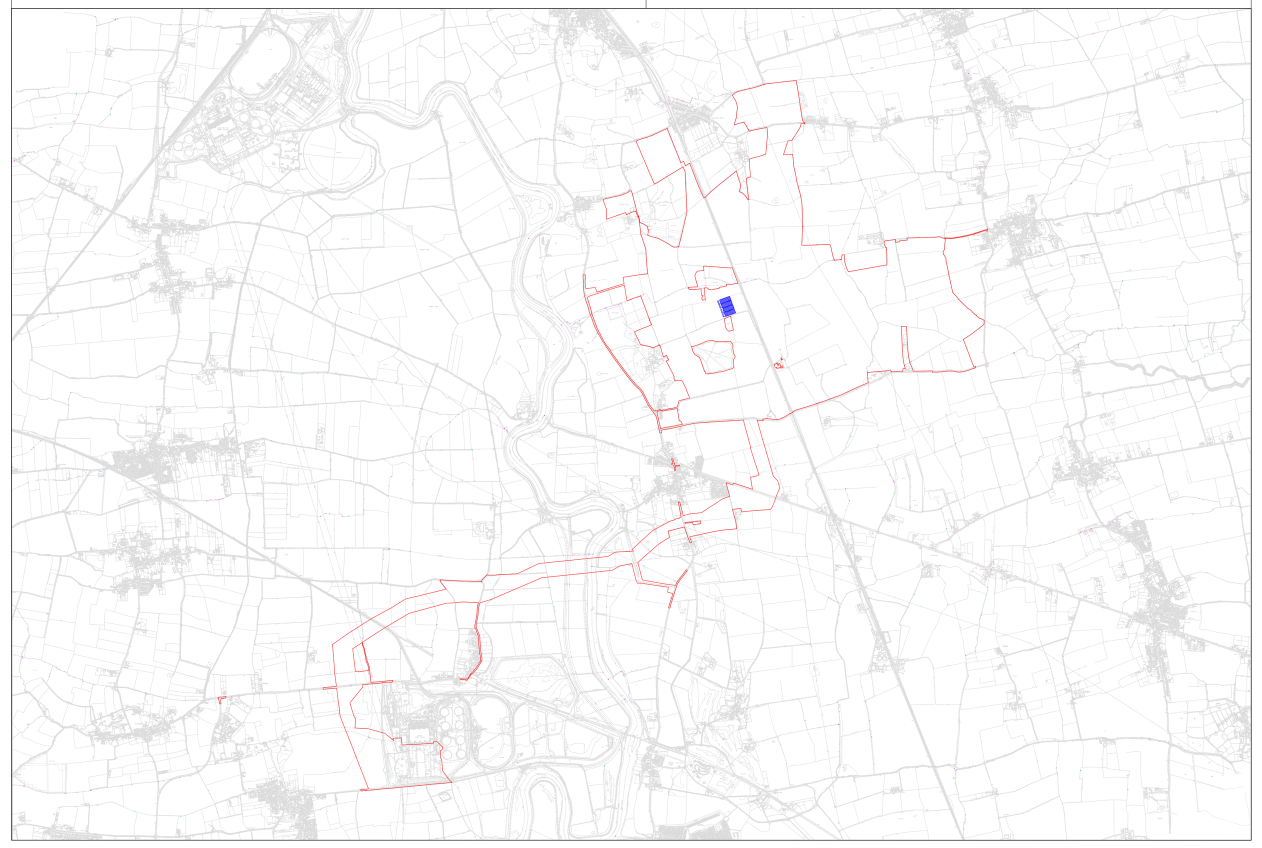
Illustrative layout of the BESS

Dimensions	Format : A1
	Scale: 1:600



LEGEND

Order limits

Access roads

Access road for Abnormal Indivisible Loads

Perimeter fenceline

Solar site infrastructure

Power Conversion Unit (PCU)

Solar arrays

Gate

Water tank 114,000L

Work No. 2: BESS

Hedgerows

CCTV camera

Buffers

Water supply easement

400 kV cable route easement

Buffer existing utilities & avoidance areas

Date	Writer	Version	Status	Checker
10/01	CDU	B	Storage Energy Park Update	GDA
25/08	ABO	C	Water tanks moving	GDA
29/09	ABO	D	Update for Deadline4	GDA

skyray

47 Rue Maurice Flandin,
69 003 Lyon, France
contact@skyrayengineering.com

https://www.skyrayengineering.com/