STATERA

BALANCING THE GRID

CULHAM STORAGE LIMITED

SITE SELECTION PROCESS

May 2024

Contents

1 INTRODCUTION

Purpose of the report

1.1 This report has been prepared by Statera Energy Limited for a proposed Battery Energy Storage System ("BESS") facility at Culham Science Centre, Thame Lane, South Oxfordshire, OX14 3ES. This report provides a summary of the site selection process for the Proposed Development and explains why the Culham Site has been selected in preference to other potential locations.

Primary objective of the scheme

1.2 As the UK transitions to a low carbon future, renewables, particularly offshore wind and solar, will become the dominant forms of electricity generation providing a cheaper, cleaner and greener outlook for future generations.

1.3 The weather dependent nature of renewables means they are inherently intermittent and balancing this intermittent generation on the grid is becoming ever more challenging.

1.4 In order for the UK to achieve its Net Zero targets, far more energy storage, using a variety of technologies, that address different storage duration challenges is required in the UK. These different energy storage solutions are essential to the continued rollout of renewable energy and key to realising the ambitious targets set by the UK Government of achieving a Net Zero economy by 2050 as well as decarbonising the electricity system by 2035.

1.5 BESS facilities provide a means of allowing electricity from the grid to be imported and stored at times of low demand/high generation, which can then be exported back into the grid at times of higher demand / system stress.

1.6 System frequency is also a continuously changing variable that is determined and controlled by the second (real time) balance between system demand and total generation. If demand is greater than generation, the frequency falls while if generation is greater than demand, the frequency rises. If the transmission system is not maintained within the required frequency tolerance system stress can result in widespread power supply issues and damage to network infrastructure.

1.7 BESS are a key part of this energy strategy and provides National Grid (NG) with balancing services to help accommodate the increasing level of renewable energy generation.

1.8 By importing excess renewable energy from the grid and storing it, batteries can capture energy that would otherwise be lost / unutilised.

1.9 During situations when primary power sources (e.g. traditional power stations) are interrupted, BESSs can bridge the gap in production, thus avoiding potential blackouts. It should be noted that the UK electricity network is wholly interconnected and issues in one geographic location can have far reaching implications on the network. Accordingly, BESSs offer additional capacity to deal with system stress and any variations in grid frequency at both a local and national level.

1.10 As has been recognised by NG's System Operability Framework (SOF)[1]: "Faster response is more effective and so less response is needed if speed can be increased." BESSs are able to respond more rapidly than other types of balancing services, as they have no start-up delays. As such BESSs can balance the real-time requirements of the national grid more efficiently.

1.11 The Proposed Development has come forward following the Government's reform of the Nationally Significant Infrastructure Project ("NSIP") process through the Infrastructure Planning (Electricity Storage Facilities) Order 2020 (the "Storage Order") aimed at reducing barriers to investment and delivery of large BESS over a 50 MW capacity.

1.12 The Government considers that larger capacity BESS developments are crucial to meeting the countries overall Net Zero 2050 target. As well as its target to decarbonise the power system by 2035, this will require a substantial growth in renewable energy generation, along with electricity storage to balance the intermittent generation from renewables, and stability services to keep the national grid stable.

1.13 To be most effective in contributing to the country's targets, the proposals need to be of a large capacity (i.e. over 50MW) and located in an area where there is a significant need for new capacity to support renewable energy generation.

1.14 These factors have driven the site selection process and the scale and types of technology proposed.

[1] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.nationalgrideso.com/document/273801/download

2 SITE SELECTION

Transmission versus Distribution grid connection

2.1 To understand the locational requirements of the Proposed Development, it is important to explain the difference between the various parts of the electricity network in the UK. This principally comprises two aspects: the transmission network and the distribution network. The Proposed Development seeks to provide support to the transmission network, as the transmission network needs large volumes of system services to meet its System Security & Quality of Supply Standards legal requirements.

2.2 Within England, transmission is classed as 275kV and 400kV, whereas distribution is classed as 132kV and below e.g., 11kV, 33kV, 66kV and 132kV.

2.3 The transmission networks move large volumes of electricity at a national level from where it is generated to the main regional substations. For efficiency purposes and due to the long distances involved, this is done at high transmission voltages (275kV and 400kV). By contrast, distribution networks take electricity from the transmission system and deliver it to the regional factories, schools, houses etc. This is done at lower voltages ranging from 11kV, 33kV, 66kV and 132kV, as distances are shorter, and the volume of electricity required is lower.

2.4 Figure 1 shows that the national transmission system covers all of England, Scotland and Wales.

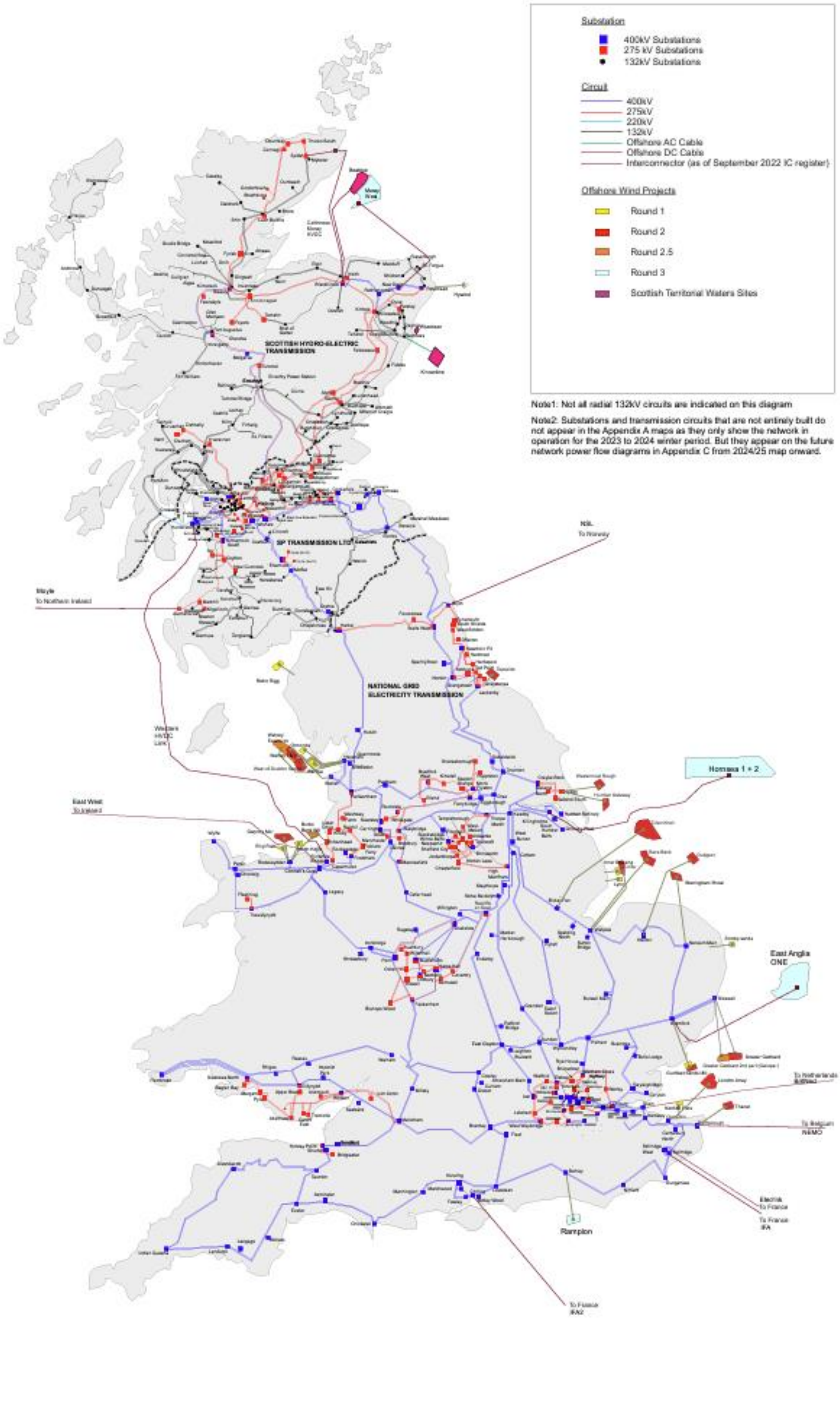

Figure 1: Map of the GB existing transmission system[2]

[2] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.nationalgrideso.com/document/294511/download

2.5 Connecting directly to the NG transmission system (275kV / 400kV) means large volumes of MW (active power) and MVAr (reactive power) can be imported and exported, along with providing large volumes of MWs (Inertia), Hz (frequency) and kA (fault current) to support the transmission network, making transmission connection the only connection method for large scale BESS.

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2.7 By contrast, a distribution connection does not have the capability to support all the key requirements needed by National Grid to meet their legal requirements under the System Security & Quality of Supply Standards.

2.8 Figure 2 compares the grid services that can be provided when connecting to the transmission rather than the distribution grid system.

Capacity market (MW)	✓	✓
Frequency support (Hz)	✓	✓
Reactive power (MVAr) transmission voltage support	X	✓
Inertia (MWs) Grid stability support	X	✓
Fault current (Ka) Grid stability support	X	✓

Figure 2: Ancillary services availability for Distribution v Transmission connections

2.9 Before the Energy White Paper (CD105)[3] was issued in December 2020, the majority of BESS developments were kept under the 50MW limit to avoid having to seek consent via the longer and more costly NSIP process. The Government realised that this cap was holding back much needed large scale BESS development, and so decided to remove the cap to facilitate the delivery of large-scale BESS schemes, which led developers to target transmission, rather than distribution grid connections.

2.10 As a result of cost and complexity, a 50MW grid connection (and up to 100MW) is normally connected at a distribution network level, whereas large >100MW+ BESS are connect to the transmission network, as only the higher rated (275kV and 400kV) grid has the capacity to manage the large volumes of power flows.

[3] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://assets.publishing.service.gov.uk/media/5fdc61e2d3bf7f3a3bdc8cbf/201216_BEIS_EWP_Command_Paper_Accessible.pdf

Key selection criteria

2.11 To meet the primary objectives of the scheme, the following key selection criteria were applied:

- **Located in a region where there is a need for voltage and power flow support –** this is important to replace generation from traditional coal and gas plants and manage voltage issues arising from the increasing generation from renewable energy sources
- **Connection to the National Grid transmission networks 275/400kV** – In order to deliver the greatest benefit, connection to the transmission system is required. The 275/400kV network is generally used to transmit energy from its source to areas of demand. To maximise the benefits of the Proposed Development, it is important to connect large scale BESS to a 275/400kV grid substation. The 275/400kV transmission network often suffers from voltage and stability issues. BESS help to address these issues.
- **Available grid connection by 2030 –** to enable the Government to reach its 2035 net zero carbon electricity target.
- **Located within a heavily constrained transmission area** – to provide the greatest level of support to the national grid, the project should be located within an area of the national grid transmission network which is heavily constrained due to high loaded circuits.

2.12 Along with meeting the primary objectives there are a number of site-specific considerations also taken into account when locating the Proposed Development, these are set out below:

- **Adjacent to an existing National Grid substation** – to reduce the amount of overhead cabling or trenching linking to the substation and minimise electrical losses through the connection.
- **Site size large enough to accommodate 500 MW BESS infrastructure** – to optimise the capacity of the connection and to encourage investment to support the commercial viability of the scheme;
- **Acceptability of environmental and planning constraints (e.g. Green Belt, agricultural land classification, ecological/landscape designations, heritage assets, flood risk, etc.)** – due to the location near substations, the potential sites will be located away from urban areas and will have some planning and/or environmental constraints. These will need to be understood and balanced to ensure the substantial benefits of the scheme can be delivered, whilst minimising and mitigating any potential harm;
- **Physical and visual separation from residential properties and settlements** – to reduce any potential adverse impacts to amenity and local character; and
- **Ease of access to the site for construction –** to reduce impacts to the local highway network and to reduce the construction timescale to help achieve 2026 grid connection.

The location searches.

Step 1 – Identifying future national needs.

2.13 In the next decade the GB Electricity Transmission System will face growing needs in a number of regions.

2.14 Required transfers across Scottish boundaries are expected to almost triple from today to 2030.

2.15 Required transfers across North Wales boundaries are expected to quadruple between 2027 and 2032 to a maximum of 11 GW. Large amount of generation, including new offshore wind generation is expected to connect in this region.

2.16 In the East Anglia region, growth in low-carbon and renewable generation over the next decade will continue, potentially reaching a total installed capacity of over 13GW by 2030, up from 5.5GW today.

2.17 Interconnector and storage capacity is anticipated to exceed or match transmission connected generation in the South of England by 2020/ This will cause network flows in the region to be heavily dependent on interconnector flow condition and could bring large swings in power transfer which will need to be carefully managed.

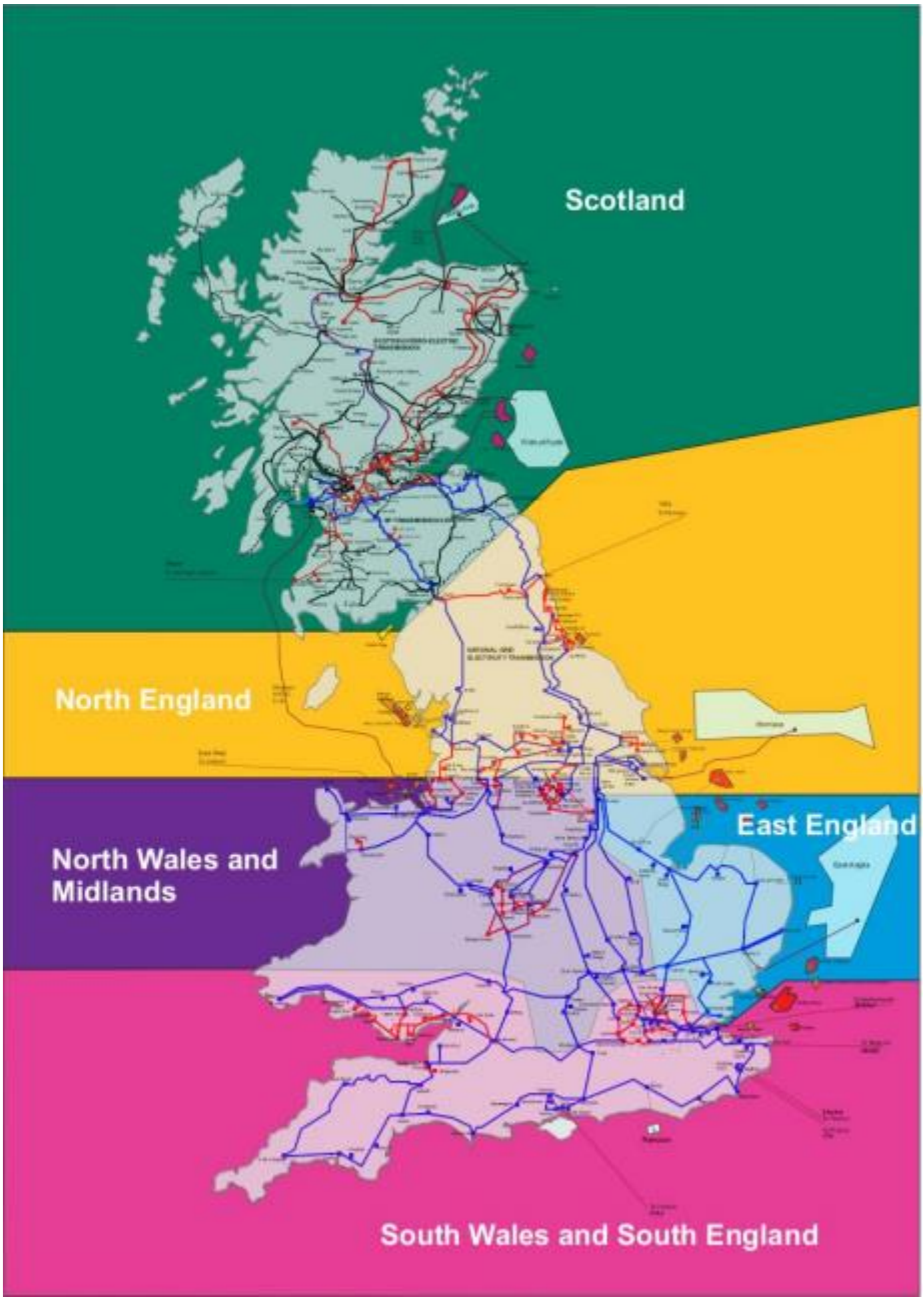

Figure 3: Extract from National Grid Electricity Ten Year Statement (2023) showing the National Electricity Transmission System (NETS) spilt into regions.

2.18 As we continue the transition towards a low carbon economy, renewable energy is ever more prominent as the lowest cost form of electricity generation for consumers. At the same time renewable energy is helping to ensure security of electricity supply for the United Kingdom while providing a cleaner, greener outlook for future generations.

2.19 With a higher proportion of our energy sourced from renewables, it is becoming increasingly challenging to balance the UK electricity system because of the intermittency of wind and solar output. For example, in summer months on bright, windy days it is not uncommon for too much electricity to be generated, whereas on cloudy wind-less days in winter months there may be a shortfall. In each case, National Grid, acting as the System Operator, will need to take balancing actions to ensure that supply meets demand.

Services that can be provided:

- *Frequency response* – The balance between supply and demand of electricity is reflected in the grid frequency (50Hz in the UK), and it is National Grid's role as system operator to keep the system in balance. If supply exceeds demand, the frequency rises above 50Hz, if demand exceeds supply, frequency falls below 50Hz. Most electrical devices require frequency to be in a certain range – if frequency goes outside of this range for a prolonged period of time the UK can encounter black-outs or electrical devices, such as televisions or computers, will turn off to protect themselves. Our batteries can respond in sub second times to dynamically balance supply and demand on a second-by-second basis, providing a valuable tool to National Grid in helping to "keep the lights on".

- *Renewables integration* – Due to their nature, batteries can both supply energy when demand outstrips supply, but also absorb energy when supply exceeds demand (such as excess wind or solar), meaning this energy is not wasted, but stored to release when required.

- *Capacity Market* – If a major power plant, such as a large nuclear reactor or large gas generator, fails during the depths of winter, this could potentially lead to blackouts across the country unless other generation can be brought online to replace the power lost by the failed plant. Capacity Market participants provide these back-up services.

2.20 BESS's facilities open the door for more solar and wind power to be added to the grid while maintaining grid stability, enabling a green low carbon future. This does not necessarily mean more renewables in the immediate area/region but nationwide.

Step 2 – Identifying the Region with the greatest need for voltage and power flow support

The B9 Boundary - Midlands to South of England

2.21 The B9 boundary separates the northern generation zones and the southern demand zone.

2.22 Developments on the east coast and the East Anglia regions, such as the locations of offshore wind generation connection and the network infrastructure requirements, will affect the transfer requirements and capability of boundary B9.

2.23 In all four scenarios set out by National Grid, the requirements gradually increase to above the boundary capability for B9. The increase is more than last year showing a need for additional boundary capability in the future for three out of the four scenarios.

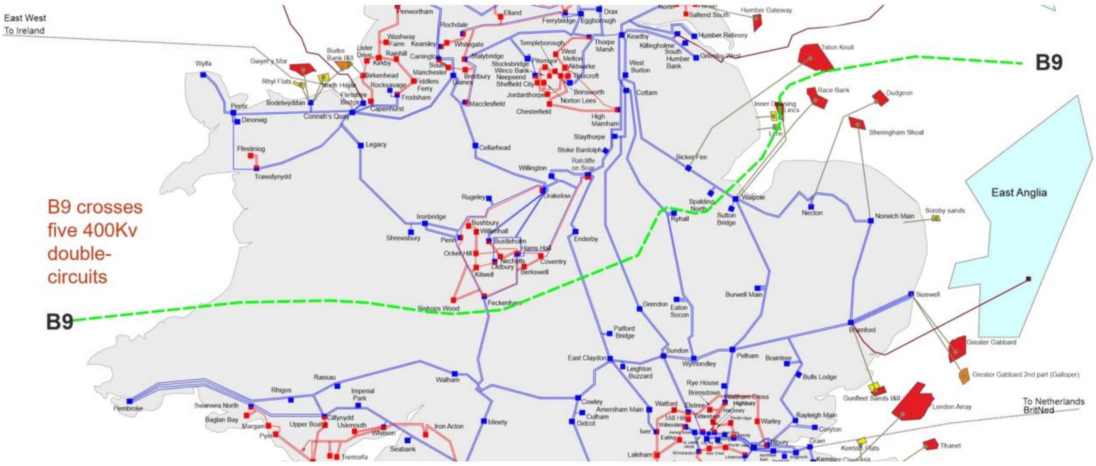

Figure 4. *Extract from National Grid 2023 ETYS B9 Boundary – Midlands to South of England*

2.24 BESS provide a combination of fast responding electricity storage and generation to help balance the intermittent nature of renewables and the growing demand of the UK population. They work best located to the centres of demand, providing stability, resilience, and energy security to the UK's electricity system.

2.25 Considering the key messages in Step 1 and the significant amount of existing and new generation highlighted in Step 2, the B9 boundary area was identified as being the part of the National Grid with the great need in the coming decade.

Boundary LE1 – Southeast

2.26 Boundary LE1 encompasses the south-east of the UK, incorporating London and the areas to the southeast of it.

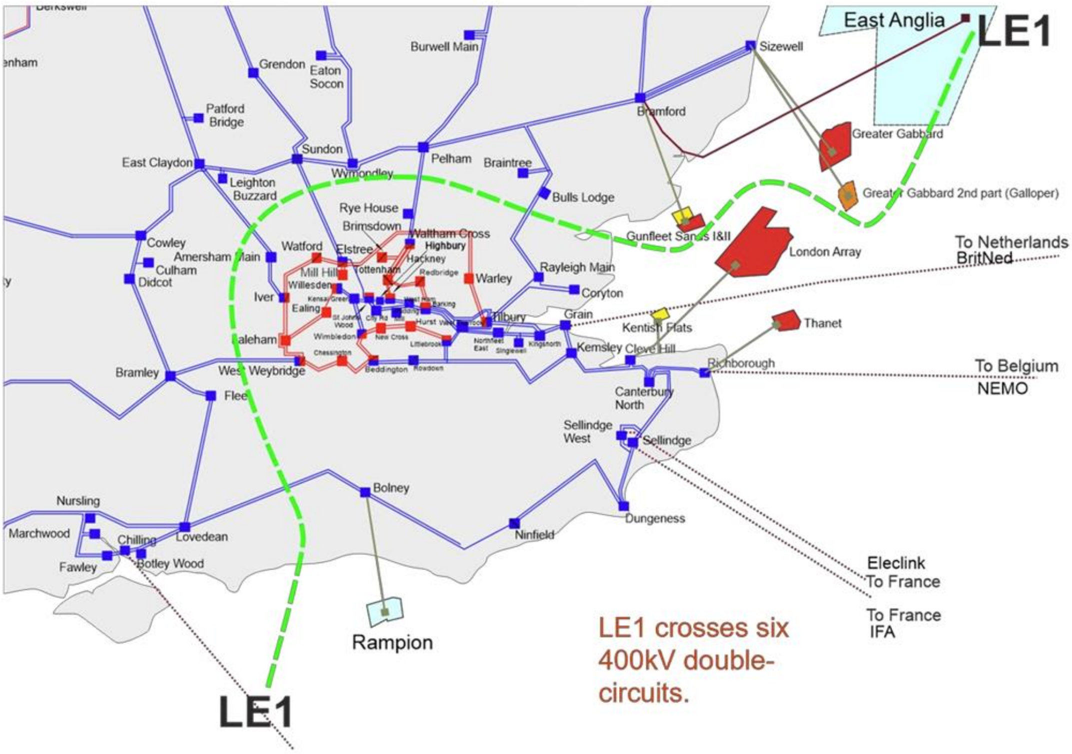

Figure 5. *Extract from National Grid 2023 ETYS* Boundary LE1 – *Southeast*

2.27 LE1 is characterised by two distinct areas. Within London, there is high local demand and little generation. The remainder of the area contains both high demand and high levels of generation.

2.28 LE1 almost exclusively imports power from the north and west into the south-east, and the purpose of the boundary is to monitor flows in this direction. With the existing and proposed interconnectors importing power from the continent, power flows enter London from all directions, to the extent that flows across LE1 reduce and limited constraints are seen.

2.29 However, with an increased number of interconnectors, and (in some scenarios) increased likelihood of them exporting power in future years, LE1 can become a higher demand area, with any locally generated power feeding straight into the interconnectors. As such, the circuits entering LE1 from the north can become overloaded as power is drawn into and through London toward the south and east.

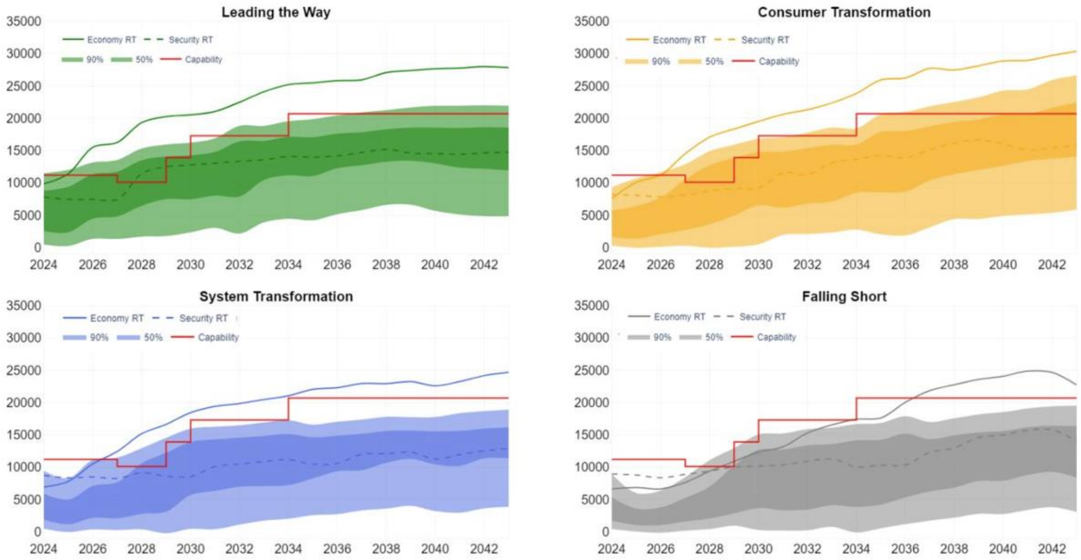

Figure 6. *Extract from National Grid 2023 ETYS*

2.30 Across all four scenarios in the FES, the SQSS economy required transfer grows beyond existing boundary capability from 2023 and the expected power flows are less than the required transfer and the uncertainty of interconnector activity can be seen in the wide range of the boundary flows.

How did we select the Culham Jet National Grid substation?

Step 3 – Identifying regional strain

2.31 The following requirements are particularly important when selecting the most suitable grid connection point (substation) with the Southwest region:

- Connection into the National Grid 400kV network.
- Availability of 400kV circuits.
- Located within a heavily constrained transmission area.
- Potential to secure a pre-2030 grid connection.

<u>Availability of a 400kV circuit</u>

2.32 The Culham Jet National Grid substation has a 400 kV circuit, which has enough capacity to allow large power flows. The provision of BESS at this location will help manage the future strain on the NG Southwest area by providing large amounts of MW (active power for use by the consumer), MVAr (reactive power for voltage support), MWs (Inertia for system stability) Hz (for grid regulation) and kA (fault current for system stability).

2.33 The Substation can accommodate the transfer of large amounts of electricity to and from the Proposed Development at a viable cost, which will provide valuable support to the grid, protecting customers at times when high demand places stress on the local and national electricity network.

Available grid connection

2.34 The applicant holds an agreement with National Grid Electricity Transmission (NGET) to connect its BESS to Culham Jet substation. This agreement states a connection date in Q3 2027. For NGET to facilitate the connection it is required to connect a second circuit from the existing Cowley / Didcot line to the existing Culham Jet substation. These works are included within this application for ease but would otherwise be subject to NGET's own consenting and land optioning requirements under statutory powers.

2.35 There are various obligations on both NGET and the applicant to develop and progress the project to keep the proposed connection date. i.e., the applicant is required to prove it is developing the project which includes obtaining a planning permission.

2.36 Consequently, the 2027 grid connection will contribute towards meeting the Government's net zero targets and also supporting secure and cheaper energy to the public, with these significant benefits resulting from this location.

Figure 7: East Culham Jet National Grid substation

How did we select the Site?

Step 4 – Identifying the most suitable site

2.37 In addition to finding the most suitable substation, the following criteria for the site were considered to assess whether there were any suitable sites that could viably connect to the Substation:

- As close to an existing National Grid substation as possible;
- An area large enough to accommodate up to 500W BESS infrastructure;
- Acceptability of environmental and planning constraints (e.g., Green Belt, agricultural land classification, ecological/landscape designations, heritage assets, flood risk, etc.);
- As much physical and visual separation from residential properties and settlements as possible; and
- Ease of access to the site for construction.

2.38 The Proposed Development has been strategically chosen for its location adjacent to the Culham Jet substation, which lies southeast of the site. Given the scale of the Proposed Development it is not possible to connect directly into an overhead line. This would be prohibitively expensive and ultimately costly to consumers. It has to connect directly into the substation and therefore the closer to the substation the better. This in turn reduces the length of cables, ensuring an efficient and viable connection to the National Grid, minimising electrical losses, disturbance and costs.

2.39 Short runs of underground grid connection also significantly minimise construction-related disruption and reduce electrical losses making the project more viable.

Alternate Identified Sites

Figure 8: Alternate Identified Sites

<u>Identified Site 1 (IS1)</u>

2.40 Site IS1 is an area of approximately 5.5 ha and is located within the Culham Science Centre.

2.41 In 2016 a 200MW BESS application was consented on the site application ref: P16/S2368/FUL, however, this application has not been developed.

2.42 The site abuts the Cuhlam Jet substation and provides the closest point of connection.

2.43 The topography of the Site is predominantly flat and good for a BESS development.

2.44 However, the site has been discounted because of its size, it is not able to accommodate a 500MW BESS scheme and allow for the landscaping and BNG improvements proposed. Statera was also unable to contract with the landowners and the site performs no better in heritage landscape or ALC metrics than the site proposed.

<u>Identified Site 2 (IS2)</u>

2.45 Site IS2 is an area of approximately 16 ha and is located on land to the east of Culham Science Centre.

2.46 The site is located within the Oxfordshire Green Belt.

2.47 This Site is comprised of 2 field parcels, which appear to serve arable purposes. Natural England ALC Mapping indicates that the area is grade 2 land. The area appears to be mostly farmed, therefore like with the application site, a BESS proposal in this location would also result in the temporary loss of full agricultural productivity of farmed agricultural land.

2.48 The topography of the Site is predominantly flat and good for BESS development.

2.49 The site is crossed with Public Rights of Way and is within 250m from residential dwellings.

2.50 There are a number listed buildings to the east of the site at Waterley Lane and to the south on High Street.

2.51 Overall, the site has been discounted because of its proximity to residential dwellings and greater distance from the point of grid connection. The site performs no better in heritage, landscape and or ALC metrics than the site proposed.

<u>Identified Site 3 (IS3)</u>

2.52 Site IS3 is an area of approximately 14 ha and is located on land to the north of Culham Science Centre.

2.53 The site is located within the Oxfordshire Green Belt.

2.54 This Site is comprised of 2 field parcels, which appear to serve arable purposes. Natural England ALC Mapping indicates that the area is grade 2 land. The area appears to be mostly farmed, therefore like with the application site, a BESS proposal in this location would also result in the temporary loss of full agricultural productivity of farmed agricultural land.

2.55 Although well screened the northern 9ha of the site lies within the Nuneham Registered Park and gardens, leaving only 5ha of land out with the Park and Garden to develop in, which is not enough space for a 500MW BESS development.

2.56 Proposed Development Site

2.57 The Proposed Development area is 26.8 ha and is located on land to the northwest of the of the Culham Science Centre as shown at figure 9 below:

Figure 9: *Satellite image of the redline boundary*

2.58 The site is comprised of open agricultural fields crossed by a tarmac track (Thame Lane, a non-public highway) as well as an existing farm track.

2.59 Electricity pylons traverse the Site from east to west, as well as northwards and are one of the dominant features in the landscape.

2.60 An ALC survey confirmed that the land is a mixture of Grade 2 and 3a. The land is currently farmed for hay and silage, therefore like the alternate identified sites a BESS proposal in this location would also result in the temporary loss of full agricultural productivity of farmed agricultural land.

2.61 The topography of the Site is predominantly flat and good for BESS development.

2.62 There are three Public Rights of Way (PRoW) that abut the site.

2.63 The key environmental and planning considerations in the vicinity of the Proposed Development are shown in Figure 8 below.

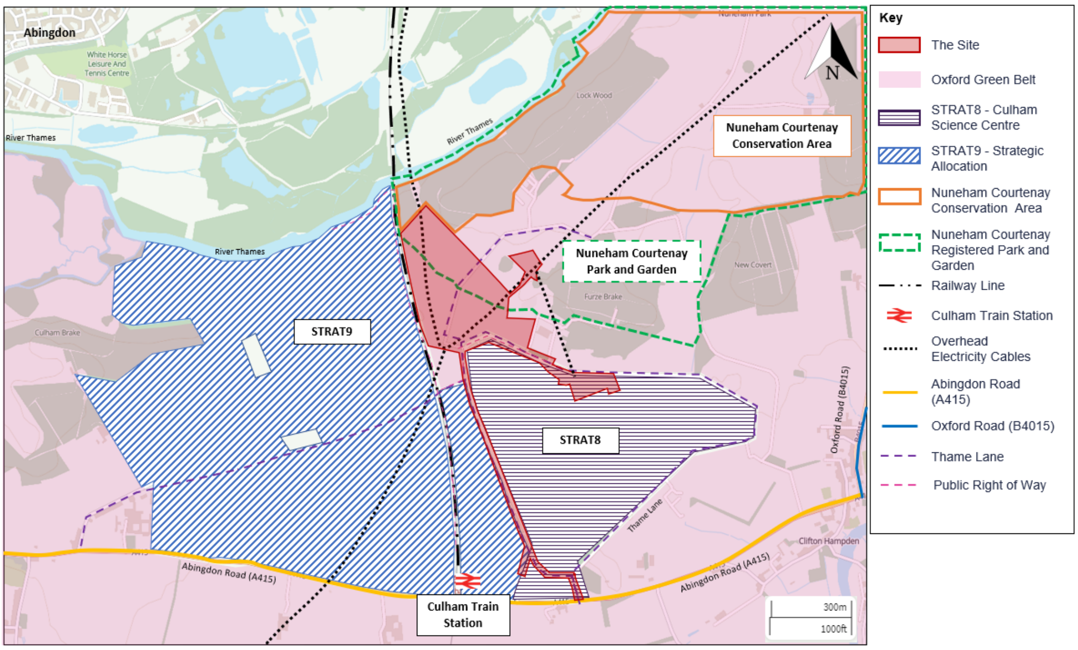

Figure 10 – Key environmental and planning considerations in the vicinity of Culham substation

2.64 The entire site is located within the Oxford Green Belt. A full Green Belt Assessment accompanies this application.

2.65 The Proposed Development is situated away from existing settlements. Furthermore, as explained in the LVIA, the Site would only be visible from a limited number of publicly accessible viewpoints.

2.66 There are no heritage assets located within the site, a Heritage Impact Assessment has been submitted as part of the application.

2.67 The following heritage assets are located within 1km of the site boundary:

- Nuneham Courtenay Registered Park and Garden: NHLE 1000122 (Grade I);
- Nuneham Courtenay Conservation Area;
- Culham Station Ticket Office: NHLE 1059789 (Grade II*) listed building;
- Thame Lane Bridge: NHLE 1409238 (Grade II) listed building;
- Fullamoor Farmhouse: NHLE 1449039 (Grade II) listed building; and
- Station House: a locally listed building.

2.68 The 500MW BESS infrastructure requires 7 hectares of the 26.8 hectare site (26%). The remaining 16 hectares are being set aside to re-establish the Nuneham registered park and garden with new woodland and grassland habitats and provide a significant 50% uplift in biodiversity.

2.69 An historical tree belt to the north of the site will be restored using 170 new native trees, re-establishing parts of the Nuneham Courtenay Park and Garden. New permissive paths across the site will provide access to the parkland and views over the Thames Valley, benefiting people working within the neighbouring UKAEA site.

2.70 The construction program is anticipated to last 18 months, the short construction program enables the 2027 grid connection.

3 CONCLUSION

3.1 Statera has carried out a thorough site selection process to identify a suitable site for the Proposed Development. Alternative sites were considered against criteria that were specifically identified to ensure that the primary objectives of the scheme could be met.

3.2 The process of site selection began by identifying the future national needs. The NGESO 2022 ETYS 2030/31 power flow map clearly identifies the B9 area as a region needing voltage and power flow support in the coming decade. Developments on the east coast and the East Anglia regions, such as the locations of offshore wind generation connection and the network infrastructure requirements, will affect the transfer requirements and capability of boundary B9. Culham substation was identified along with a number of other 400kV substations to need a new circuit/network changes by 2030/31.

3.3 In identifying the most suitable grid connection point (substation) within the Midlands to South of England region, Statera considered the ability to connect to either the National Grid 275kV or 400kV networks, the availability of grid connection before 2030, and a location within a heavily constrained transmission area.

3.4 In addition to finding the most suitable substation, Statera also considered the proximity of sites to an existing National Grid substation, a site of sufficient size to accommodate the infrastructure, the acceptability of environmental and planning constraints, the physical and visual separation from nearby properties and settlements and site access for construction.

3.5 For the reasons above the Proposed Development site was selected.