

Norfolk Boreas Offshore Wind Farm Design and Access Statement

DCO Document 8.3

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Glossary of Acronyms

AIS	Air Insulated Switchgear
CABE	The Commission for Architecture and the Built Environment
CRS	Cable Relay Station
DAS	Design Access Statement
DCO	Development Consent Order
EIA	Environmental Impact Assessment
ES	Environmental Statement
HDD	Horizontal Directional Drilling
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
kV	Kilovolts
MW	Megawatts
NPSs	National Policy Statements
NSIP	Nationally Significant Infrastructure Project
OLEMS	Outline Landscape and Ecological Management Strategy
PEIR	Preliminary Environmental Information Report
SCADA	Supervisory Control and Data Acquisition
SuDS	Sustainable Urban Drainage
VWPL	Vattenfall Wind Power Limited

Glossary of Terminology

Array cables	Cables which link wind turbine to wind turbine, and wind turbine to offshore electrical platforms.
Cable logistics area	Existing hardstanding area to allow the storage of cable drums and associated materials and to accommodate a site office, welfare facilities and associated temporary infrastructure to support the cable pulling works.
Cable pulling	Installation of cables within pre-installed ducts from jointing pits located along the onshore cable route.
Ducts	A duct is a length of underground piping, which is used to house electrical and communications cables.
Interconnector cables	Offshore cables which link offshore electrical platforms within the Norfolk Boreas site
Jointing pit	Underground structures constructed at regular intervals along the onshore cable route to join sections of cable and facilitate installation of the cables into the buried ducts
Landfall	Where the offshore cables come ashore at Happisburgh South
Landfall compound	Compound at landfall within which HDD drilling would take place
Link boxes	Underground chambers or above ground cabinets next to the cable trench housing low voltage electrical earthing links.
Mobilisation area	Areas approx. 100 x 100m used as access points to the running track for duct installation. Required to store equipment and provide welfare facilities. Located adjacent to the onshore cable route, accessible from local highways network suitable for the delivery of heavy and oversized materials and equipment.
National Grid new / replacement overhead line tower	New overhead line towers to be installed at the National Grid substation.
National Grid overhead line modifications	The works to be undertaken to complete the necessary modification to the existing 400kV overhead lines.
National Grid overhead line temporary works	Area within which the work will be undertaken to complete the necessary modification to the existing 400kV overhead lines.
National Grid substation extension	The permanent footprint of the National Grid substation extension.
National Grid temporary works area	Land adjacent to the Necton National Grid substation which would be temporarily required during construction of the National Grid substation extension.
Necton National Grid substation	The grid connection location for Norfolk Boreas and Norfolk Vanguard
Norfolk Boreas site	The Norfolk Boreas wind farm boundary. Located offshore, this will contain all the wind farm array.
Norfolk Vanguard	Norfolk Vanguard offshore wind farm, sister project of Norfolk Boreas.
Offshore cable corridor	The corridor of seabed from the Norfolk Boreas site to the landfall site within which the offshore export cables will be located.
Offshore electrical platform	A fixed structure located within the Norfolk Boreas site, containing electrical equipment to aggregate the power from the wind turbines and convert it into a suitable form for export to shore.
Offshore export cables	The cables which transmit power from the offshore electrical platform to the landfall.

Offshore service platform	A platform to house workers offshore and/or provide helicopter refuelling facilities. An accommodation vessel may be used as an alternative for housing workers.
Onshore 400kV cable route	Buried high-voltage cables linking the onshore project substation to the Necton National Grid substation.
Onshore cable route	The up to 35m working width within a 45m wide corridor which will contain the buried export cables as well as the temporary running track, topsoil storage and excavated material during construction.
Onshore cables	The cables which take power and communications from landfall to the onshore project substation.
Onshore infrastructure	The combined name for all onshore infrastructure associated with the project from landfall to grid connection.
Onshore project area	The area of the onshore infrastructure (landfall, onshore cable route, accesses, trenchless crossing zones and mobilisation areas; onshore project substation and extension to the Necton National Grid substation and overhead line modifications).
Onshore project substation	A compound containing electrical equipment to enable connection to the National Grid. The substation will convert the exported power from HVDC to HVAC, to 400kV (grid voltage). This also contains equipment to help maintain stable grid voltage.
Overhead Line	An existing 400kV power line suspended by towers.
Project interconnector cable	Offshore cables which would link either turbines or an offshore electrical platform in the Norfolk Boreas site with an offshore electrical platform in one of the Norfolk Vanguard offshore wind farm sites.
Running track	The track along the onshore cable route which the construction traffic would use to access workfronts.
The Applicant	Norfolk Boreas Limited
The project	Norfolk Boreas Wind Farm including the onshore and offshore infrastructure.
Transition pit	Underground structures that house the joints between the offshore export cables and the onshore cables
Trenchless crossing compound	Pairs of compounds at each trenchless crossing zone to allow boring to take place from either side of the crossing.
Trenchless crossing zone	Areas within the onshore cable route which will house trenchless crossing entry and exit points.
Workfront	A length of onshore cable route within which duct installation works will occur, approximately 150m.

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1 INTRODUCTION

1.1 Purpose of the Design and Access Statement

1. The purpose of this Design and Access Statement (DAS) is to provide details of the use, layout, scale and appearance of the Norfolk Boreas Offshore Wind Farm (the 'project'). The DAS supports the application for a Development Consent Order (DCO) for the project and should be read in conjunction with the DCO and supporting documentation.
2. The application is based on realistic worst-case parameters for the project. The design will continue to be developed post-consent and a detailed design will be submitted for approval in accordance with DCO Requirement 16 and any principles included within this DAS.
3. The project is described in more detail in section 3 of this DAS and in Chapter 5 Project Description of the Environmental Statement (ES) (document reference 6.1.5). The onshore project area is shown in Figure 1 to 3 and the offshore project area in Figure 4.
4. Given that offshore above-ground infrastructure will be a minimum of 73km offshore, they will not be visible from the coast. Therefore, the DAS focuses on demonstrating the design and development of the Norfolk Boreas permanent onshore above-ground infrastructure such as the onshore project substation and National Grid substation extension including overhead line modifications.
5. The DAS explains the principles and concepts that have influenced the form and appearance of the elements of the onshore project area and provides a tool to communicate how the requirements for good design and access provision have been considered, and will be considered for the detailed design of the onshore project substation in due course.
6. Information contained in the ES has been used to inform the preparation of this DAS, and reference should be made to the ES for full details of both the offshore and onshore project components and their relationship to the receiving environment, particularly:
 - Chapter 2 Need for the Project (document reference 6.1.2);
 - Chapter 3 Policy and Legislative Context (document reference 6.1.3);
 - Chapter 4 Site Selection and Assessment of Alternatives (document reference 6.1.4); and
 - Chapter 5 Project Description (document reference 6.1.5).

2 PLANNING CONTEXT AND GUIDANCE

2.1 National Policy Statements

7. National Policy Statements (NPSs) form primary planning policy documents that are specifically provided for by the Planning Act 2008 to guide decision making on Nationally Significant Infrastructure Project (NSIP) applications. The application for the project will be determined in accordance with relevant NPSs.
8. Further detail on the planning policies associated with the project is found in ES Chapter 3 Policy and Legislative Context (document reference 6.1.3).
9. The three NPSs that hold particular relevance for offshore wind and its associated onshore development are:
 - Overarching NPS for Energy (EN-1, July 2011) (Department of Energy and Climate Change (DECC) 2011a);
 - NPS for Renewable Energy Infrastructure (EN-3, July 2011) (DECC 2011b); and
 - NPS for Electricity Networks Infrastructure (EN-5, July 2011) (DECC 2011c).

2.1.1 Overarching NPS for Energy (EN-1)

10. Existing policies set out within EN-1 make clear the requirements for good design in energy projects. Paragraph 3.7.1 of EN-1 explains that much of the new electricity infrastructure that is needed will be located in places where there is no existing network infrastructure. It acknowledges that this is likely to be the case for many wind farms, or where there may be technical reasons why existing network infrastructure is not suitable for connecting the new generation infrastructure.

2.2 Guidance

11. There is no specific guidance provided for the preparation of a DAS in relation to NSIPs.
12. This DAS has been prepared in line with The Commission for Architecture and the Built Environment guidelines (CABE, 2007). The bullet points below outline the key parameters set out in the CABE guidelines:
 - Use – the purpose of the onshore project substation and how it will fit within the surrounding environment;
 - Amount – size and volume of the onshore project substation and its constituent elements;
 - Layout – the relationship between the onshore project substation and the surrounding buildings;

- Scale – the physical size and shape of the onshore project substation development;
 - Appearance – the physical look of the onshore project substation specifically the design and materials;
 - Landscaping – how mitigation proposals will be applied to screen the development from wider views; and
 - Access – including how access will be achieved during construction and operation and how roads and watercourses will be crossed.
13. These parameters are discussed in section 5 of this DAS.

3 DESCRIPTION OF THE DEVELOPMENT

3.1 The Project

14. The Norfolk Boreas Offshore Wind Farm comprises an area of 725km² located approximately 73km from the Norfolk coastline within which wind turbines would be located. The offshore wind farm would be connected to the shore by offshore export cables installed within the offshore cable corridor from the wind farm to a landfall point at Happisburgh South, Norfolk. From there, onshore cables would transport power over approximately 60km to the onshore project substation near Necton, Norfolk.
15. Once built, Norfolk Boreas would have an export capacity of up to 1,800 megawatts (MW), with the offshore components comprising:
 - Wind turbines;
 - Offshore electrical platforms;
 - Offshore service platform;
 - Met masts;
 - Measuring equipment (LiDAR and wave buoys);
 - Array cables;
 - Interconnector cables or project interconnector cables; and
 - Export cables.
16. The key onshore components of the project are as following:
 - Landfall;
 - Onshore cable route, accesses, trenchless crossing technique (e.g. Horizontal Directional Drilling (HDD)) zones and mobilisation areas;
 - Onshore project substation; and
 - Extension to the Necton National Grid substation and overhead line modifications.
17. The onshore and offshore project areas are shown on Figure 1 to 4. A full description of the project for offshore and onshore elements can be found in Chapter 5 Project Description of the ES (document reference 6.1.5).

3.1.1 Development Scenarios

18. Vattenfall Wind Power Limited (VWPL), the parent company of Norfolk Boreas Limited, is also developing Norfolk Vanguard, a 'sister project' to Norfolk Boreas. The Norfolk Vanguard project is approximately one year ahead of Norfolk Boreas in its development programme having submitted its DCO in June 2018. In order to minimise impacts associated with onshore construction works for the two projects, Norfolk Vanguard are seeking consent to undertake duct installation and some

enabling works for both projects at the same time. This is the preferred option and considered to be the most likely however, Norfolk Boreas needs to consider the possibility that Norfolk Vanguard may not proceed to construction.

19. In line with the Norfolk Boreas ES (document reference 6.1) this DAS considers the following two alternative scenarios:
- **Scenario 1** – Norfolk Vanguard proceeds to construction, and installs ducts and other shared enabling works for Norfolk Boreas.
 - **Scenario 2** – Norfolk Vanguard does not proceed to construction and Norfolk Boreas proceeds alone. Norfolk Boreas undertakes all works required as an independent project.
20. Table 3.1 outlines the key elements of onshore construction works to be carried out by Norfolk Boreas under each scenario. Full details of the scenarios are presented on Chapter 5 of the ES (document reference 6.1.5) including a further detailed comparison provided in Appendix 5.1 (document reference 6.3.5.1).

Table 3.1 Overview of key onshore construction elements for Scenario 1 and Scenario 2 to be undertaken by Norfolk Boreas

Onshore elements	Scenario 1	Scenario 2
Landfall		
Landfall compounds	✓	✓
Cable duct installation via HDD	✓	✓
Transition pits and link boxes	✓	✓
Cable pulling	✓	✓
Onshore Cable Route		
Pre-construction works	✓ (limited as majority completed by Norfolk Vanguard)	✓
Cable duct installation via open cut trenching	✗ (installed by Norfolk Vanguard)	✓
Cable duct crossings (e.g. hedgerows, underground services, roads or tracks, watercourses)	✗ (installed by Norfolk Vanguard)	✓
Trenchless crossings (e.g. HDD) and associated trenchless compounds	✗ (installed by Norfolk Vanguard)	✓
Mobilisation areas	✗ (not required)	✓
Running track	✓ (approx. 12km)	✓ (approx. 60km)
Accesses	✓	✓
Cable pulling	✓	✓

Onshore elements	Scenario 1	Scenario 2
Cable logistics area	✓	✓
Jointing pits and link boxes	✓	✓
Onshore Project Substation		
Pre-construction works	✓	✓
A47 junction improvement	✗ (installed by Norfolk Vanguard)	✓
Access road to onshore project substation	✓ (extension of road installed by Norfolk Vanguard by approx. 300m)	✓ (approx. 1.8km)
Construction of onshore project substation	✓	✓
Temporary construction compound and mobilisation area MA1a	✓	✓
Screening	✓	✓
National Grid Substation Extension and Overhead Modifications		
Pre-construction works	✓	✓
Extension to existing Necton National Grid Substation	✓ (easterly direction)	✓ (westerly direction)
National Grid Overhead line modifications	✗ (installed by Norfolk Vanguard)	✓
Screening	✓	✓

21. Table 3.2 provides a list of key onshore parameters and their associated characteristics for the project.

Table 3.2 Indicative onshore project characteristics

Parameter	Characteristic
Landfall	
Landfall	Happisburgh South
Onshore Cable Route	
Export cable route length (km)	60 (approximate)
Number of onshore cable trenches	Up to two (<i>scenario 2 only</i>)
Number of ducts	Up to two (<i>scenario 2 only</i>)
Jointing Pits	Up to 150
Onshore Project Substation	
Onshore project substation area (m x m)	Up to 250 x 300
Number of substations within compound	One substation (comprised of two converter halls)
Onshore project substation tallest building (m)	Up to 19 (HVDC converter hall)

Parameter	Characteristic
Onshore project substation tallest structure (m)	Up to 25 (Lightning protection mast)
Onshore project substation fence height (m)	Up to 3.5
National Grid substation extension	
Grid connection location	Necton National Grid substation
National Grid substation extension area (m x m)	Up to 135 x 150 (<i>Scenario 1</i>) Up to 200 x 150 (<i>Scenario 2</i>)
National Grid substation extension tallest structure (m)	Up to 15 (Outdoor AIS busbar and landing gantries)
Overhead Line Modifications (Scenario 2 only)	
Net number of permanent new towers	1
Tallest new tower (m)	Up to 55m

22. Under Scenario 1 some of the power generated by the wind turbines may be transmitted via subsea project interconnector cables to an offshore electrical platform located within either of the Norfolk Vanguard offshore wind farm sites. This energy would then be transmitted to shore via Norfolk Vanguards export cable.
23. Given that offshore infrastructure such as wind turbines, offshore electrical and service platforms will be a minimum of 73km offshore, they will not be visible from the coast. Therefore, any requirement for a landscape and visual impact assessment in relation to offshore infrastructure has been scoped out of the Environmental Impact Assessment (EIA). As such, this DAS considers the onshore infrastructure only.

4 SITE SELECTION PROCESS

4.1 Introduction

24. The siting, design and refinement of the project has followed a site selection process, taking account of environmental, physical, technical, commercial and social considerations and opportunities, as well as engineering requirements. This has been undertaken with the aim of identifying sites that will be environmentally acceptable whilst also enabling, in the long-term, benefits of the lowest energy cost to be passed onto the consumer. A multi-disciplinary design team was formed to undertake the site selection process which included a team of specialists comprising engineers and EIA consultants whose expertise were drawn upon throughout the site selection process (see Statement of Competence, document reference 6.3.6.1).
25. The site selection process is shown in Plate 1, and outlined in more detail in Chapter 4 Site Selection and Assessment of Alternatives (document reference 6.1.4). Each stage of site selection forms part of an iterative design process undertaken to identify the most suitable locations and configuration for project infrastructure. The framework for the site selection process is based upon a set of robust design principles and engineering requirements.
26. The details of how sensitive site selection has shaped the final project design are also discussed in section 5 of this DAS.

4.2 Consultation

27. VWPL, on behalf of both Norfolk Boreas and Norfolk Vanguard has undertaken pre-application engagement with stakeholders, communities and landowners to inform the submitted project design and communicate decisions on refinements (for further information see the Consultation Report (document reference 5.1)). The Norfolk Vanguard and Norfolk Boreas Scoping reports (Royal HaskoningDHV, 2016 and 2017) and Norfolk Vanguard and Norfolk Boreas Preliminary Environmental Information Reports (PEIRs) (Norfolk Vanguard Limited, 2017 and Norfolk Boreas Limited, 2018) set out the process for the development of the onshore and offshore elements of the project showing a series of search areas for the landfall, onshore cable corridor, cable relay station (CRS) locations (no longer required) and onshore project substation locations.
28. The refinements in the project layout and configurations have been communicated to relevant audiences through the informal and formal pre-application stages between Norfolk Vanguard scoping in October 2016 and the Norfolk Boreas DCO application (June 2019), and feedback received has been taken into consideration where possible.

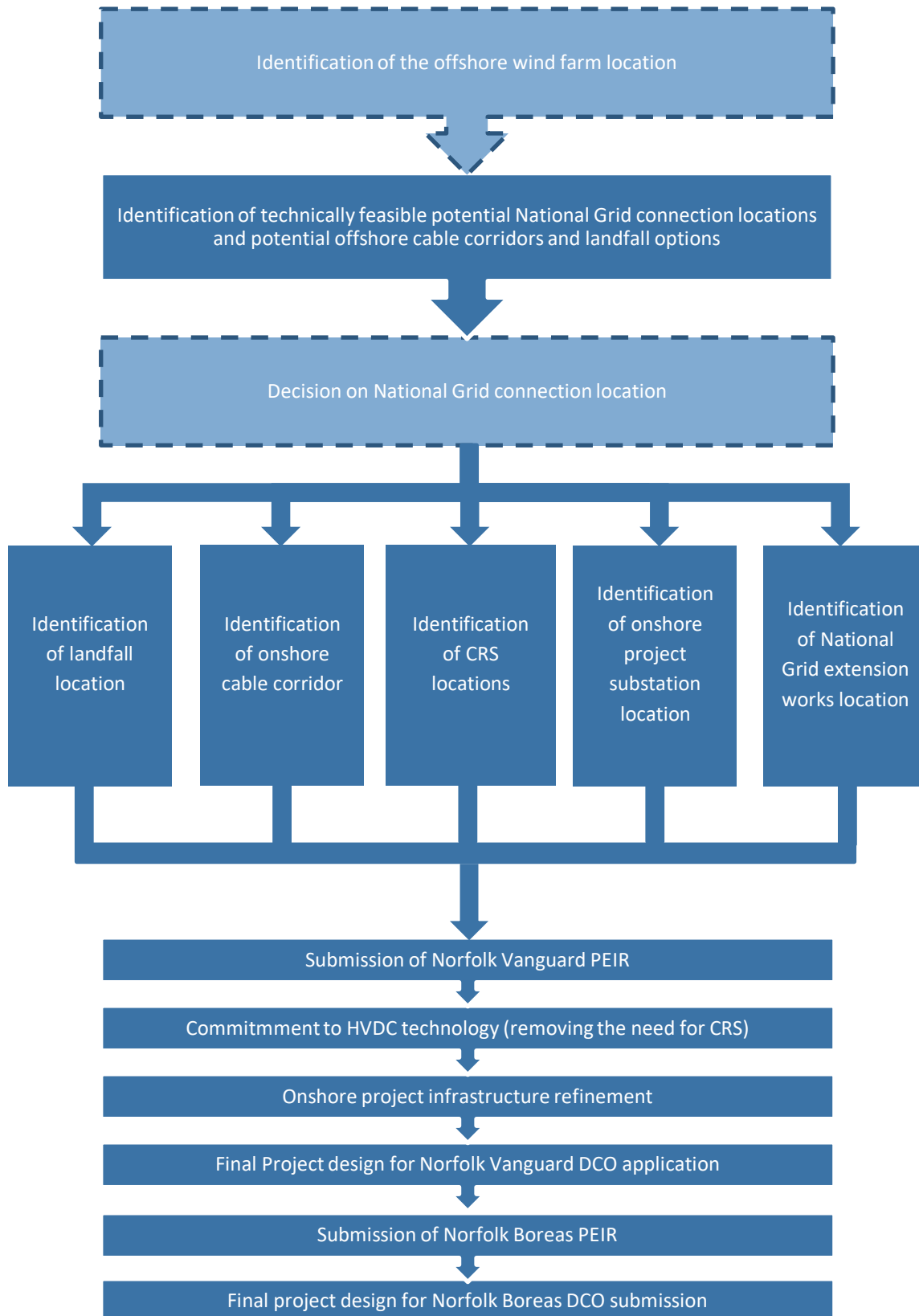


Plate 1 Site selection process Norfolk Boreas and Norfolk Vanguard¹

1 Strategic decisions regarding fundamental project locations, denoted by hatched lines, such as the offshore wind farm location and grid connection point have been made in conjunction with the Crown Estate and National Grid respectively.

4.3 Design Considerations

4.3.1 Consideration of Alternatives Influencing the Project Design

29. A number of alternatives have been considered as part of the design decision-making process to date. Assessment of alternatives has been considered from the outset of the project, and were reported within the Norfolk Vanguard and Norfolk Boreas Scoping reports (Royal HaskoningDHV, 2016 and 2017) and Norfolk Vanguard and Norfolk Boreas PEIRs (Norfolk Vanguard Limited 2017 and Norfolk Boreas Limited, 2018), and alternatives have been considered throughout the refinement of the project.
30. As project design is an iterative process, and a multidisciplinary approach, alternatives have been considered incorporating engineering, buildability, cost, environmental, landowner, community, and stakeholder considerations to inform the final design.
31. The early strategic project consideration of alternatives which fed directly into the site selection process are detailed in Table 4.1.

Table 4.1 Strategic project alternatives considered

Alternatives considered	Decision	Benefit
<ul style="list-style-type: none"> Strategic approach to concurrently delivering Norfolk Boreas and Norfolk Vanguard; or No elements of Norfolk Boreas considered within the design envelope for Norfolk Vanguard 	<p>To take a strategic approach to delivering Norfolk Boreas and Norfolk Vanguard.</p>	<p>The decision to install cable ducts for Norfolk Boreas during the construction of Norfolk Vanguard, would allow the main civil works for the onshore cable route to be completed in one construction period and in advance of the delivery of cables for the pulling phase. This removes the requirement to reopen the land at a later date for the Norfolk Boreas construction, which minimises the construction periods thus reducing impacts on sensitive receptors, and minimising disruption.</p> <p>Co-location of onshore project substations will keep these developments contained within a localised area and, in so doing, will contain the extent of potential impacts.</p>
<ul style="list-style-type: none"> Overhead lines along the ~60km route from landfall to grid connection location Buried onshore cables within ducts along the ~60km route from landfall to grid connection location 	<p>Buried onshore cables within ducts</p>	<p>The environmental benefit of burying cables as opposed to overhead lines and pylons is a significant reduction of permanent visual impacts.</p>

Alternatives considered	Decision	Benefit
<ul style="list-style-type: none"> Ducts laid in a sectionalised approach to enable cable pull through at a later stage Open cut and direct lay of onshore cables along the full length of the cable route 	<p>Under Norfolk Boreas Scenario 2 ducts laid in a sectionalised approach to enable cables to be pulled through the ducts at a later stage. Under Scenario 1 ducts will be laid by Norfolk Vanguard (see above)</p>	<p>The environmental benefit of installing ducts and backfilling the trenches in discreet sections, rather than installing ducts along the entirety of the route before backfilling would minimise the amount of land being worked on at any one time and would also minimise the duration of works on any given section of the route.</p>
<ul style="list-style-type: none"> Deploy High Voltage Alternating Current (HVAC) transmission technology Deploy High Voltage Direct Current (HVDC) transmission technology 	<p>HVDC technology</p>	<p>The environmental benefits of selecting HVDC technology include the removal of the need for CRS infrastructure near the coast, a reduction in the overall area of land impacted (for example reduction in working width along the onshore cable route from 50m to 35m (for Scenario 2) and a reduction in the overall construction time.</p>
<ul style="list-style-type: none"> Undertake a short HDD at landfall exiting in the intertidal area Undertake a long HDD at landfall exiting in the subtidal area 	<p>Undertake a long HDD at landfall</p>	<p>The environmental benefits include not having to access or disturb the beach and therefore minimising impacts on tourism, potential archaeology and intertidal ecology.</p>

4.4 Identification of Onshore Project Substation Location

32. In order to identify the most appropriate location to site the onshore project substation, National Grid’s Guidelines on Substation Siting and Design (The Horlock Rules (National Grid, undated)) have been taken into consideration. These guidelines document National Grid’s best practice for the consideration of relevant constraints associated with the siting of substations. The Horlock Rules have been considered as part of the development of the onshore project substation location and those relevant to design are outlined within Table 4.2.

Table 4.2 Application of Horlock Rules (relevant to design) to onshore project substation

National Grid’s Approach to Design of Substations	Norfolk Boreas onshore project substation considerations
Design	
<p>In the design of new substations or line entries, early consideration should be given to the options available for terminal towers, equipment, buildings and ancillary development appropriate to individual locations, seeking to keep effects to a reasonably practicable minimum.</p>	<p>HVDC technology has been committed to which removes the requirement for a Cable Relay Station. In addition, onshore cable will be buried to avoid introducing new overhead power lines.</p> <p>Overhead line modification is unavoidable as part of the National Grid extension works, however the number of new towers has been minimised by replacing an existing tower. The net increase in new towers will be one, which will be located in proximity to existing towers to reduce the potential</p>

National Grid's Approach to Design of Substations	Norfolk Boreas onshore project substation considerations
	<p>proliferation of energy infrastructure (This work would only be undertaken by Norfolk Boreas Limited under Scenario 2 as under Scenario 1 the work would have been completed by Norfolk Vanguard Limited).</p> <p>Realistic worst case dimensions have been proposed for the substation infrastructure, taking into account the largest structure (the converter hall at up to 19m tall) as well as the tallest (Lightning protection mast at 25m).</p>
<p>Space should be used effectively to limit the area required for development consistent with appropriate mitigation measures and to minimise the adverse effects on existing land use and rights of way, whilst also having regard to future extension of the substation.</p>	<p>Permanent footprints for the onshore project substation are based on realistic preliminary layouts. During detailed design undertaken post consent, consideration will be given to space-efficient solutions where appropriate. The location of the onshore project substation has avoided direct impacts to Public Rights of Way.</p>
<p>The design of access roads, perimeter fencing, earth shaping, planting and ancillary development should form an integral part of the site layout and design to fit in with the surroundings.</p>	<p>A detailed landscape and visual impact assessment has been undertaken to support the application. This process has informed the approach to landscape planting to minimise potential visual impacts. The choice of substation site was driven by the existence of existing woodland, and the proposed landscape planting will reinforce these areas. The presence of access roads, perimeter fencing and ancillary development were taken into account as part of this assessment.</p>
Line Entry	
<p>In open landscape especially, high voltage line entries should be kept, as far as possible, visually separate from low voltage lines and other overhead lines so as to avoid a confusing appearance.</p>	<p>All new cabling between the landfall and the onshore project substation (approximately 60km) will be buried underground to avoid the introduction of new overhead lines in an open landscape.</p> <p>Modifications to the existing overhead line structures are required near Necton to accommodate the newly installed infrastructure. The net new number of towers required to accommodate the works is one, and will be in proximity to the existing corner tower (to the north east of the existing Necton National Grid substation) to minimise proliferation of energy infrastructure and additional clutter (This work would only be undertaken by Norfolk Boreas Limited under Scenario 2 as under Scenario 1 the work would have been completed by Norfolk Vanguard Limited).</p>
<p>The inter-relationship between towers and substation structures and background and foreground features should be studied to reduce the prominence of structures from main viewpoints. Where practicable the exposure of terminal towers on prominent ridges should be minimised by siting towers against a background of trees rather than</p>	<p>Overhead line modification is unavoidable as part of the National Grid extension works however, the number of new towers has been minimised by upgrading an existing tower. The net increase in new towers will be one, which will be located in proximity to existing towers to reduce the potential proliferation of energy infrastructure (This work</p>

National Grid's Approach to Design of Substations	Norfolk Boreas onshore project substation considerations
open skylines.	would only be undertaken by Norfolk Boreas Limited under Scenario 2 as under Scenario 1 the work would have been completed by Norfolk Vanguard).

33. Following this process under Scenario 1 the onshore project substation would be co-located alongside the Norfolk Vanguard onshore project substation.
34. Under Scenario 2, where Norfolk Vanguard does not proceed, the location that has been identified for the Norfolk Vanguard substation area would be a suitable location for the Norfolk Boreas onshore project substation.
35. However, if only one substation was to be built (as would be the case under Scenario 2) a small area of land to the east of the Norfolk Vanguard onshore project substation footprint would become of limited use for farming. Therefore, a wider area was considered for the location of the onshore project substation under Scenario 2 and it determined that a location approximately 150m further east than the footprint for the Norfolk Vanguard was preferable. Chapter 4 Site Selection and Assessment of Alternatives provides more information on the Scenario 2 onshore project substation location (document reference 6.1.4).

4.5 Design Principles and Recommendations

36. The final design of the onshore project substation and National Grid substation extension will be subject to detailed design phase which will happen post-consent. In order to minimise visual impacts as far as possible, the appropriate building design and materials will be considered, to ensure blending with the local environment and minimisation of impacts as far as possible (as outlined in Table 4.3).

Table 4.3 Design Principles for the onshore project substation and National Grid substation extension

Principle	Description
1	Continue to engage relevant authorities on detailed design and landscaping proposals as detailed design progresses.
2	Actively seek appropriate building design and materials (e.g. building materials, shape, layout, coloration and finishes).
3	<p>The design of the onshore project substation will be within the parameters set out in Requirement 16 of the DCO, namely:</p> <ul style="list-style-type: none"> • The total number of buildings housing principal electrical equipment must not exceed two; • Buildings must not exceed a height of 19m; • External electrical equipment must not exceed 25m; • The total footprint of each building housing the principal electrical equipment must not exceed 110m by 70m; and • The fenced compound area must not exceed 250m by 300m.
4	<p>The design of the National Grid substation extension will be within the parameters set out in Requirement 16 of the DCO, namely:</p> <ul style="list-style-type: none"> • The total net number of new overhead line towers must not exceed one, and must not exceed a height of 55m; • Buildings and external electrical equipment must not exceed a height of 15m; and • The fenced compound area (excluding accesses) must not exceed 135 metres by 150 metres in the event of scenario 1, or exceed 200 metres by 150 metres in the event of scenario 2.
5	Landscaping to minimise the visual impacts, and respond to local landscape character and biodiversity will be undertaken and considered with building design and layout of ancillary structures. Delivery of this principle will be guided by implementation of the Outline Landscape and Ecological Management Strategy (OLEMS) (document reference 8.7).
6	A detailed Sustainable Urban Drainage (SuDS) drainage strategy will be developed, in accordance with the Outline Operational Drainage Plan (Document reference 8.21).

5 ONSHORE PROJECT DESIGN

5.1 Introduction

37. The onshore cables will be buried underground in ducts. The only potential above ground infrastructure associated with the onshore cable route is the inclusion of link boxes, which are considered within this DAS. Other than link box design, the DAS focuses on the design and development of the Norfolk Boreas onshore project substation and National Grid substation extension (including overhead line modifications).
38. There will be no permanent above ground infrastructure associated with the landfall, therefore this aspect of the project is not considered further within this DAS.
39. As set out in section 2.2, the approach within any DAS is to consider the use, amount, layout, scale, appearance, landscaping (where relevant) and access of the permanent above ground infrastructure.
40. Where aspects related to the onshore project design would differ under Scenario 1 or Scenario 2, this is explicitly stated and design elements under both scenarios provided. This includes;
 - Access to the onshore project substation (section 5.3.4);
 - Overhead line modifications at the Necton National Grid substation and the scale, location and layout of the National Grid substation extension (section 5.4.2); and
 - Strategic landscaping and planting schemes at the onshore project substation and Necton National Grid substation (section 5.5).

5.2 Link Boxes Design

5.2.1 Use, Amount, Scale, Layout and Appearance

41. The onshore cable route will be approximately 60km in length, from the landfall to the onshore project substation near Necton. Sections of cabling would be connected together in jointing pits along the route and link boxes would be required in proximity (within 10m) to a subset of jointing pit locations. Link boxes would be the only potential permanent above ground feature associated with the onshore cable route.
42. Link boxes would not be required at all jointing pit locations and can typically be placed at 5km intervals. Separate link boxes are required for each cable circuit, with the maximum number of cable circuits required for the project being two. The precise number and placement of the link boxes would be determined as part of the detailed design post-consent.

43. The link boxes, with maximum dimensions of 1.5m x 1.5m, would either be buried to ground level within an excavated pit, with access provided via a secured access panel (refer to Plate 2) or alternatively, above ground link box cabinets (1.2m x 0.8m x 1.8m) may be utilised which are typically sited on a 0.15m deep concrete slab.
44. There is no requirement for permanent lighting at link boxes.



Plate 2 Example below ground link box following reinstatement (Source: Rey Wind Farm, VWPL.)

45. Prior to the installation of any link box, (if reasonably requested by the landowner, or relevant tenant) the Applicant shall consult with the landowner/tenant as to the location and level of any relevant link box. Where reasonably practicable (and subject to reasonable engineering requirements or construction requirements) the Applicant shall comply with the landowner/tenant's requests as to location and level of the relevant link box. Unless there are reasonable engineering requirements, construction requirements or specific requirements by the landowner/tenant the link box shall be located in or within 2 metres from a field boundary hedge (measured from the centre of the hedge nearest to the link box) or other boundary structure and shall be laid level with or below the surface of the Easement Strip.

5.2.2 Access

46. Access to link boxes is only required for periodic testing purposes. Where possible, the link boxes would be located close to field boundaries and in already accessible locations. No additional formal access is proposed to each link box.

5.3 Onshore Project Substation Design

5.3.1 Use

47. The onshore project substation converts the High Voltage Direct Current (HVDC) electrical power from the Norfolk Boreas export cables to High Voltage Alternating Current (HVAC) which is the appropriate voltage system required for connection to the National Grid. Filtering, switchgear and associated protection and control equipment is also located at the onshore project substation to comply with the technical requirements of the National Grid and allow safe operation of the Norfolk Boreas connection.

5.3.2 Amount, Scale

48. The onshore project substation will consist of up to two converter stations, each having a power transfer capability of between 800MW and 1,000MW. The two converter stations will be located within the single onshore project substation footprint.
49. As such, the onshore project substation will consist of:
- 2x converter buildings - housing DC filter equipment and power electronics to convert HVDC to HVAC power for connection to National Grid;
 - 2x outdoor HVAC compounds – each compound will contain one or more 400kV transformers, plus HVAC filters, busbars and cable sealing ends;
 - Control building – housing SCADA and protection equipment;
 - Access roads – for operation and maintenance access to equipment; and
 - Associated connections between equipment via overhead busbar and cabling, including buried earthing system.
50. The largest equipment within the onshore project substation will be the converter buildings which will not exceed a height of 19m. The tallest structure within the onshore project substation would be the lightning protection masts at a height of 25m. All other equipment will not exceed a height of 13m. The total land requirement for the onshore project substation to the perimeter fence is 250m x 300m. Permanent palisade fencing will be installed around the onshore project substation compound up to a height of 2.4m with an additional 1m of electrical pulse fencing. Table 5.1 details how each of these design parameters are secured.
51. The final appearance of the onshore project substation is subject to detailed design post consent. For the purposes of the DAS, indicative maximum parameters (as set in DCO Requirement 16) have been provided with reference to a Rochdale Envelope approach in terms of realistic worst case design parameters.

Table 5.1 Onshore Project Substation Design Parameters

Commitment	Secured in
The total number of converter buildings housing the principal electrical equipment must not exceed two	dDCO requirement 16. (1)
Buildings must not exceed 19 metres above existing ground level	dDCO requirement 16. (5)
Total footprint of the buildings housing the principal electrical equipment must not exceed 110 metres by 70 metres	dDCO requirement 16. (6)
External electrical equipment must not exceed a height of 25m above existing ground level	dDCO requirement 16. (5)
The fenced compound area for the onshore project substation must not exceed 250 metres by 300 metres	dDCO requirement 16. (7)
That outside electrical equipment, other than lightning protection masts, will not exceed 13m	Design and Access Statement
The permanent fencing around the onshore project substation will be up to height of 2.4m with an additional 1m of electrical fence	Design and Access Statement

5.3.3 Layout and Appearance

52. In addition to the main converter buildings, the onshore project substation compound would contain electrical equipment including power transformers, switchgear, harmonic filters, cables, lightning protection masts, control buildings, communications masts, backup generators, access, fencing and other associated equipment, structures or buildings. The onshore project substation would have a compact layout, with the majority of equipment contained in agricultural style buildings.
53. The onshore project substation would be enclosed by a fence surrounding the compound, the fence will be galvanised steel finish or material of similar or reduced light reflectivity. Other infrastructure and equipment would be included within the compound such as interconnecting cables, access tracks, hard standing, car parking, water tanks, communications mast, diesel generators and welfare facilities.
54. The onshore project substation would be connected to the existing Necton National Grid substation by means of HVAC underground cables.
55. An indication of the typical appearance and layout of a HVDC substation is shown on Plate 3 along with the maximum height controls as detailed in Table 5.1.

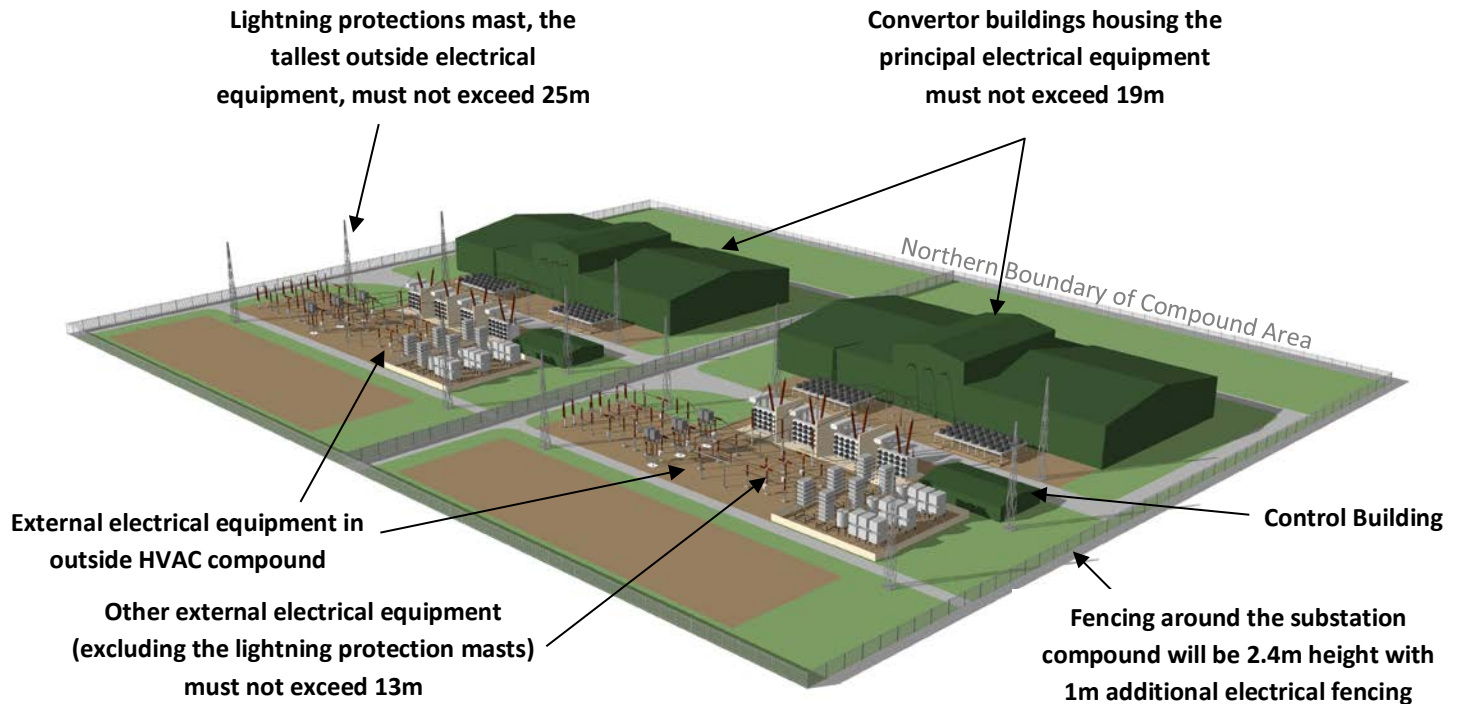


Plate 3 Indicative onshore project substation layout – HVDC

56. The layout of the onshore project substation will be finalised once contractors are appointed. There are differences in layouts offered by different contractors however the potential options being considered show the converter buildings located to the northern end of the site and the outdoor electrical equipment being located to the south. This has facilitated the development of an illustrative zoning plan, shown in Figure 9 Scenario 1 and Figure 10 Scenario 2, which identifies the following zones within the onshore project substation for each scenario:

- ‘Northern Zone’ containing the converter buildings, control buildings, lightning protection masts and some outside electrical equipment; and
- ‘Southern Zone’ containing outside electrical equipment.

57. Both zones may also contain fencing, access roads, hardstanding and below ground systems such as drainage and earth systems.

5.3.4 Access

58. The onshore project substation will be accessed from the A47. This will require carriageway works at Spicers Corner junction of the A47 to install a right turn filter and new exit from the A47, and installation of an access road to the onshore project substation as shown in Figure 3. Under Scenario 2 these works would be undertaken by Norfolk Boreas.

59. Under Scenario 1 the junction works and access road from the A47 (up to the Norfolk Vanguard substation) would have been installed by Norfolk Vanguard. Therefore, the access works required under Scenario 1 will be limited to the extension of this access road by approximately 300m to the Norfolk Boreas onshore project substation (Figure 2).
60. Consultation with highway stakeholders, including Highways England and Norfolk County Council, will continue to be undertaken post-consent to finalise the onshore project substation access strategy.
61. During operation, the onshore project substation would not be manned, however access would be required periodically for routine maintenance activities, estimated at an average of one visit per week.

5.3.5 Lighting

62. Normal operating conditions would not require lighting at the onshore project substation, although low level movement detecting security lighting may be utilised for health and safety purposes. Temporary lighting during working hours will be provided during maintenance activities only.

5.3.6 Design Process and Design Guide

63. To fulfil DCO Requirement 16(2) the Applicant proposes to follow the design process outlined below to provide Breckland Council further information to enable them to approve the layout, scale and external appearance of the onshore project substation once the details are available.
64. The Applicant will engage with Breckland Council to review the mitigation and landscape proposals and the architecture of the convertor building of the onshore project substation, at the time when further detailed design information is available. This will be undertaken through the production of a Design Guide.
65. The Design Guide will set out the mitigation measures to be applied in respect of the onshore project substation. The detailed design of the onshore project substation will integrate embedded mitigation in order to reduce potential effects on landscape character and visual amenity, on ecology and archaeology and on the communities in the local area. The Design Guide is primarily focussed on landscape design, rather than architectural design. The relationship between the architecture and the landscape is a fundamental consideration, and while the Design Guide does not aim to redesign the structural components of the onshore project substation, it does nonetheless review the potential to further integrate the onshore project substation within the landscape. In particular, it considers how mitigation planting helps to

integrate the onshore project substation into the landscape and explores the importance of colour in further enhancing this idea of integration.

66. It will enable some involvement in terms of local preferences to colour options for the convertor buildings that could ensure the substation developments are sensitive to place, with visual impacts minimised as far as practicable. It is also recognised that the local community have experience of growing trees and other plants in this local area. Through consultation on the Design Guide, the Applicant would welcome the opportunity to share local knowledge on native species that are suited to local conditions. This would ensure that the 'palette' of species selected would present the best opportunity for successful establishment and growth.
67. During the Design Process, plans could be used to show the view cones from the key views to the most prominent aspects and parts of the onshore project substation to share with stakeholders and detailed plans of these areas to show the special treatment in the landform modelling and planting that would enhance the mitigation potential.
68. An outline detailing the proposed content and structure of the Design Guide is presented in Appendix 1.

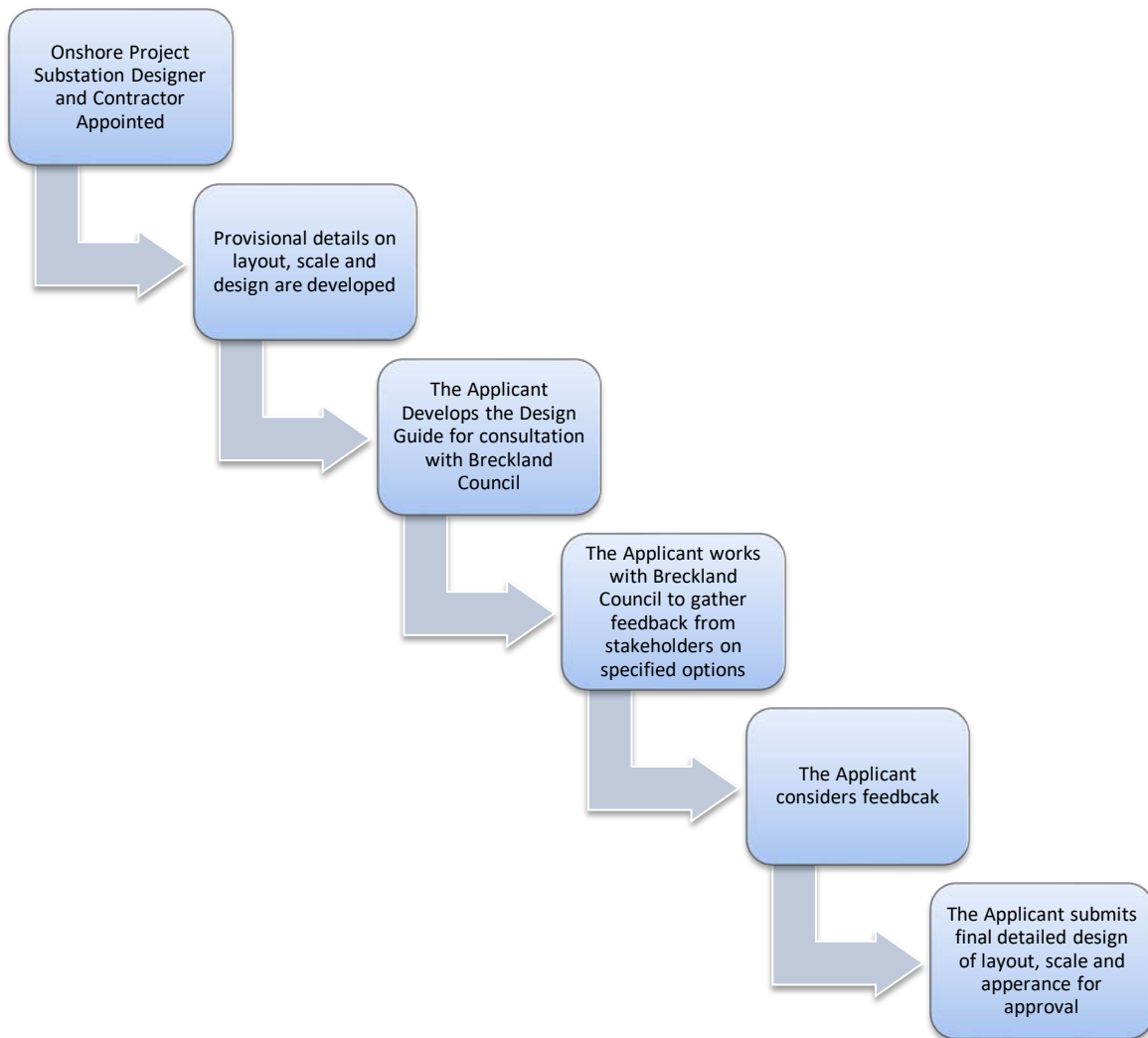


Plate 4 Onshore Project Substation Design Process

69. The Applicant will follow the design process as set out in Plate 4. Once the onshore project substation designer and contractor have been appointed the provisional details on the layout, scale and design can be developed. This will facilitate the production of the Design Guide, as detailed in Appendix 1, which will guide the detailed design of the onshore project substation and set out the proposals for embedded mitigation, highlighting how potential effects will be reduced.
70. This Design Guide will be shared with Breckland Council. The Applicant will work with Breckland Council to agree what aspects highlighted in the Design Guide are open to influence by local parties, such as the different colour options for the convertor buildings, for example – thereby determining the purpose and parameters of any potential consultation process.
71. The proposed onshore project substation design, and the contextual information provided by landscape architects as described in the Design Guide, will also inform a refreshed stakeholder analysis focussing on who to involve in any consideration of

options highlighted in the Design Guide, e.g. how might the detailed design affect different stakeholder groups and should there be engagement with those groups as part of any focussed dialogue process?

72. Engagement could take place with, for example, relevant landowners, Necton PC, Holme Hale PC, closest residents, and other residents / resident's groups likely to have an interest in determination of aspects that can help mitigate visual impacts as far as possible. Stakeholders would be refined in light of the information provided by the Design Guide, and in collaboration with Breckland Council.
73. Following this, Breckland Council and the Applicant would determine what type of process would best enable the desired engagement – and deliver enhanced local understanding of the constraints and opportunities associated with different mitigation approaches, to help ensure the most locally appropriate and sustainable decisions are made with respect to any options highlighted in the Design Guide.
74. The Applicant and Breckland Council would work together to deliver the process, and review its effectiveness – ensuring learning from previous engagement is taken on board.
75. The feedback on the Design Guide would then be considered before the final details of the design, layout, scale and approaches are produced and submitted to Breckland Council for approval.

5.4 National Grid Substation Extension and Overhead Line Modifications

5.4.1 Use

76. The existing Necton National Grid substation would require an extension to accommodate the Norfolk Boreas connection points. The National Grid substation extension would need to accommodate circuit breakers and associated busbar structures which allow connection onto the existing 400kV overhead line for generation to be transmitted onto the wider National Grid system.

5.4.2 Amount, Layout, Scale and Appearance

77. The existing Necton National Grid substation would require an extension to accommodate the Norfolk Boreas connection points. The National Grid substation extension would need to accommodate circuit breakers and associated busbar structures which allow connection onto the existing 400kV overhead line for generation to be transmitted onto the wider National Grid system.
78. The Necton National Grid substation will be extended in an easterly (Scenario 1, Figure 2) or westerly (Scenario 2, Figure 3) direction to accommodate new Air Insulated Switchgear (AIS) bays installed along the busbar extension for Norfolk

Boreas. The substation extension will be similar in appearance to the existing National Grid substation near Necton as it is simply an extension to the existing busbar and AIS bays. The maximum height of the outdoor busbar bays at the substation is estimated to be 15m.

79. Under Scenario 1, extension works to the west of the Necton National Grid substation would have been undertaken to accommodate the Norfolk Vanguard connection points, and a further extension to the east would be required to accommodate Norfolk Boreas. The extension would be 135m to accommodate five new AIS bays for Norfolk Boreas.
80. Under Scenario 2, the Necton National Grid substation outdoor busbar will be extended in a westerly direction to a total length of 200m with seven new AIS bays installed along the busbar extension.
81. In addition to the existing Necton National Grid substation itself, modifications to the existing overhead line structures adjacent to the substation would be required to provide a double turn-in arrangement². Under Scenario 1 these works would have been completed by Norfolk Vanguard to accommodate both projects.
82. Under Scenario 2 two new overhead line towers will be required in proximity to the existing corner tower (to the north east of the existing Necton National Grid substation) with a maximum height of 55m. The existing corner tower will be demolished such that the net new number of towers will be one.

5.4.3 Access

83. The existing Necton National Grid substation has an existing access from the A47. This would continue to be used during operation.
84. The operational Necton National Grid substation will be owned and operation by National Grid and would be unmanned. Maintenance of the substation would be undertaken approximately every three years. Visual checks would be undertaken on a monthly inspection visit to the site.

5.4.4 Lighting

85. During operation, the Necton National Grid substation would not be illuminated under normal operating conditions. Temporary site lighting would be provided during working hours when conducting maintenance activities only.

² Each overhead line tower carries two 400kV circuits. In this arrangement, both circuits are turned into the substation busbar structure.

5.5 Onshore project substation and National Grid Substation Extension Landscaping

86. The onshore project substation site benefits from some substantial existing hedgerows and woodland blocks within the local area, which was a key consideration for the site selection of the onshore project substation. These would provide mitigation of landscape and visual effects from the outset and can be strengthened during the early phases of the project to ensure robust screening. However, Norfolk Boreas Limited has committed to planting to further screen the onshore project substation and National Grid substation extension.
87. The extent and location of mitigation planting incorporated into the design reflects the location of the infrastructure under each scenario:
- Scenario 1: onshore project substation to the east of the Norfolk Vanguard substation (Figure 5) and the extension of the National Grid substation in an easterly direction (Figure 7).
 - Scenario 2 the onshore project substation further west (Figure 6) and the extension of the National Grid substation in a westerly direction (Figure 8).
88. Under both scenarios, planting would mostly comprise of indigenous woodland species and would be located around the onshore project substation and along the southern edge of the National Grid substation extension. Owing to the dimensions of the onshore project substation site, the National Grid substation extension, and the temporary works areas, construction activities would be required to level existing contours. The earthworks required for the cut and fill to create the level platform may produce surplus soil which could be used to form subtle earthwork bunds of up to 2m along the western side of the onshore project substation. This would help to give an incremental increase to the overall height of screening along this sensitive boundary which is not constrained by planting restrictions associated with underground cables.
89. Under both scenarios, the mitigation planting would be designed to comprise a mix of faster growing 'nurse' species and slower growing 'core' species. Nurse species, such as alder, birch, and pine would grow quicker, so that after 20 years they would be 8m in height. They would provide shelter to bring on core species, such as oak, beech and horse chestnut, so that after 20 years they would be up to 6m in height. The nurse species would be sufficiently fast growing to provide substantial screening of the onshore project substation after 20 years. The core species would outlive the nurse species and characterise the woodland structure over the longer term.
90. The proposed landscaping is described in more detail in the OLEMS (document 8.7), with regard to the re-establishment of hedgerows and tree planting. The landscaping

works will be designed in detail post-consent in accordance with DCO Requirement
18.

6 SUMMARY

91. This DAS forms part of the suite of documents submitted as part of the DCO application for the project, and sets out the various principles, concepts and considerations incorporated into the design of the onshore electrical transmission works.
92. The design of the project is part of an ongoing process in which Norfolk Boreas Limited is committed to optimising the quality of the design. The design-development process has been informed by consultation particularly in relation to site selection, design evolution and accessibility considerations.
93. Although indicative at this stage, the design for the onshore project substation and National Grid substation extension will set out to achieve a high standard of design whilst at the same time balancing the operational requirements of the facility with the character and appearance of the existing environment.
94. There will be no requirement for public access to the onshore project substation or National Grid substation extension, and appropriate security measures will be installed to prevent unauthorised access to the onshore electrical transmission works once operational.
95. Integration of the building into the local landscape will be further assisted by detailed landscape design including planting using a selection of appropriate indigenous species to increase site biodiversity.

7 REFERENCES

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8 APPENDIX 1 OUTLINE FOR THE NORFOLK BOREAS DESIGN GUIDE

Outline for the Norfolk Boreas Design Guide

Team

The Design Guide will be prepared by Norfolk Boreas Limited (the Applicant) and will combine input from specialist consultants. This part of the Norfolk Boreas project will enable the team to undertake the detailed design of the onshore project substation and ensure that embedded mitigation is integral in this process. The Design Guide will be presented as an A3 document, and will combine text and figures to explain the proposals

Overview

The Design Guide will set out the mitigation measures to be applied in respect of the onshore project substation for Norfolk Boreas offshore wind farm. The detailed design of the onshore project substation will integrate embedded mitigation in order to reduce potential effects on landscape character and visual amenity, on ecology and archaeology and on the communities in the local area.

Structure

The Design Guide will be structured into three parts:

- the first will outline the aims, the approach, and the scope of the design guide, outlining how it will guide the detailed design of the onshore project substation;
- the second will focus on the existing conditions, demonstrating how a responsive and holistic approach to the existing environment and the communities within it will help with successful integration; and
- the third section will present proposals for landscape mitigation in respect of the onshore project substation, highlighting how potential effects will be reduced.

Aim, Approach and Scope

The aims of the Design Guide will be as follows;

- To present a document that provides clarity and certainty regarding the development of the detailed design of the proposals;
- To provide a means by which the local authority and stakeholders can provide feedback;
- To draw on the depth and breadth of knowledge collected by the team through the ES process and to use this understanding as the basis for the development of the detailed design; and
- To enable collaborative working between the design team members to develop proposals following an integrated and holistic approach.

The approach will be to develop locally specific mitigation measures based on a review of existing good practice precedents, detailed analysis of local landscape conditions and

consideration of how the onshore project substation infrastructure can be best integrated into the existing rural landscape.

The Design Guide will be primarily focussed on landscape design, rather than the substation architecture due to the technical and functional requirements. The relationship between the architecture and the landscape is a fundamental consideration, and while the Design Guide does not aim to redesign the structural components of the onshore project substation, it does nonetheless review the potential to further integrate the onshore project substation within the landscape. In particular, it considers how mitigation planting helps to integrate the onshore project substation into the landscape and explores the importance of colour in further enhancing this idea of integration and explores the importance of colour in further enhancing this idea of integration. The options proposed will ensure that the onshore project substation is sensitive to place, with visual impacts minimised as far as practical by the use of appropriate design, planting and modifications to landscape topography and hydrology. The Design Guide will be developed in parallel with the operational drainage strategy, which will be in accordance with the principles of the Sustainable Drainage Systems (SuDS), as detailed in the Outline Operational Drainage Plan (Document reference 8.21). A holistic approach will look to identify the best options which would integrate the drainage systems with the indigenous and proposed landscaping.

Existing Conditions

As its starting point, the Design Guide will use the findings from the ES, in order to highlight sensitive receptors with potential to be affected by the project. The approach will then be to develop the design, taking into account how the detail of the design can best mitigate potential effects.

The landscapes of the site and surroundings work as a system comprised of different interrelated layers: from the underlying geology which influences local soil types and land uses, to the habitat networks which support local flora and fauna, and to the functional uses of areas around the onshore project substation. Designing with an understanding of these layered landscapes will help ensure that the final design will integrate well with each of these layers and ensure mitigation measures are specific and relevant to the local landscape context.

Embedded Mitigation

The Design Guide will set out the design principles which will guide the detailed design of the onshore project substation and demonstrate how these principles are to be implemented. It will present the various mitigation measures in respect of ecology and hydrology and landscape, and the visual amenity of the local communities.

Embedded mitigation will include the detailed design of the built features, considering the layout of the site and the colour and texture of the materials to be used. It will also include the detailed design of the landscape features, including tree, hedgerow and grassland planting, earthworks, water attenuation ponds and drainage, and how these are integrated to form a robust landscape framework.

The technical and functional requirements of the substation preclude alterations to the substation architecture. However, it does allow an opportunity to consider the colour of the cladding of the convertor buildings in order to establish an appropriate colour which integrates the convertor buildings within the existing landscape most effectively through different seasons.

The Design Guide will include a colour comparison study, where a range of existing colours in the landscape at the site are sampled and compared as potential colour options, which can be used to colour cladding material for the convertor buildings.

Indicative photomontage images of the onshore project substation will be presented using a computer model to compare each colour option in relation to the baseline conditions on the site and the prevailing colours in the landscape. Feedback can then be gathered from the local authority and stakeholders on the different colour options, which can be considered as part of the final design.