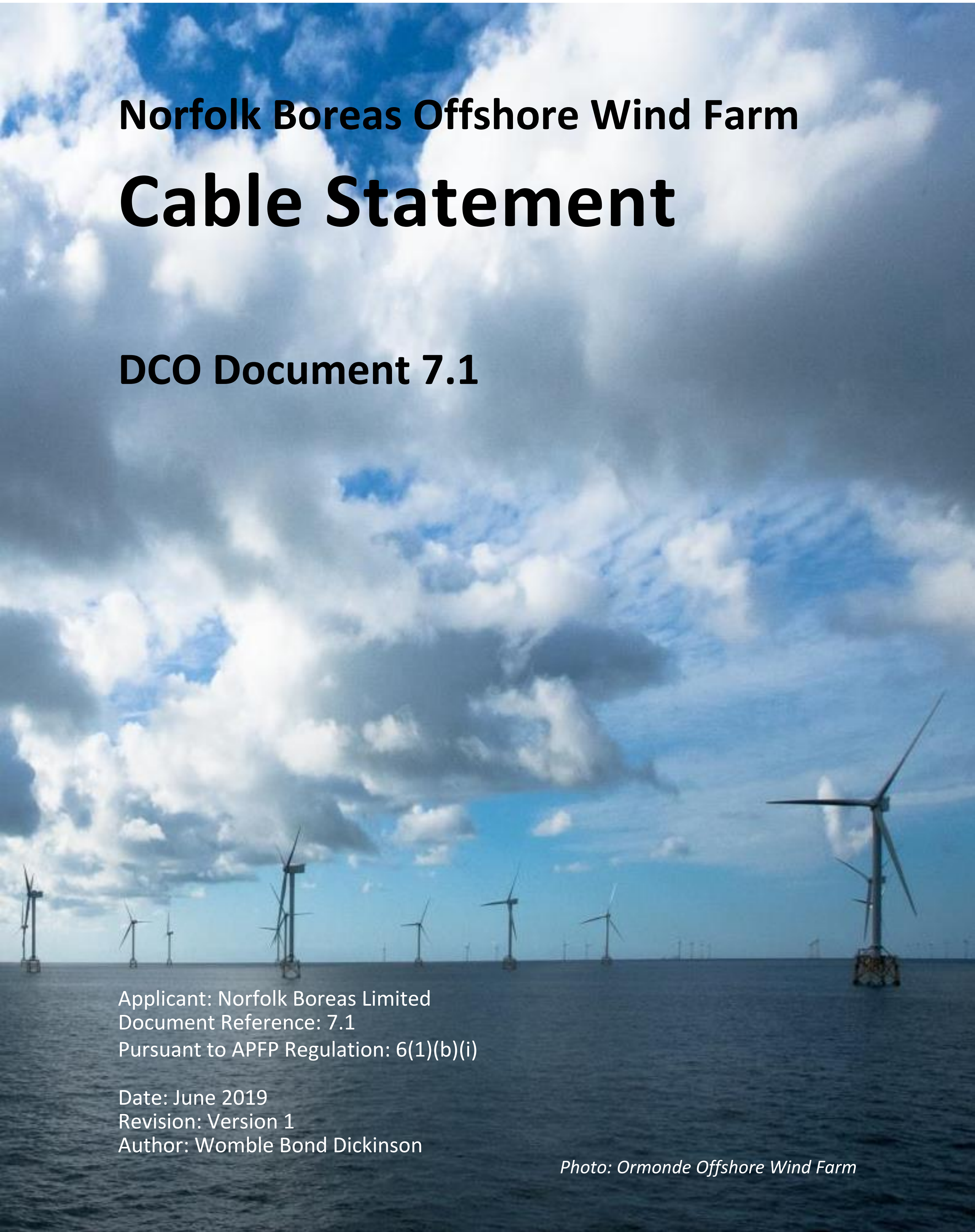
Norfolk Boreas Offshore Wind Farm

Cable Statement

DCO Document 7.1



Applicant: Norfolk Boreas Limited
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Norfolk Boreas Limited

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1. SUMMARY

1.1 Norfolk Boreas Limited (the **Applicant**) is planning to develop the Norfolk Boreas Offshore Wind Farm (the **Project**) with up to 180 turbines with a combined export capacity of up to 1,800 MW. The Project would be located approximately 73 km from the coast of Norfolk at its closest point to land, covering an area of approximately 725 km^2 in the southern North Sea.

1.2 As the total export capacity would exceed 100 MW, the Project is deemed to be a Nationally Significant Infrastructure Project (**NSIP**), and therefore the Applicant is submitting an application to the Secretary of State under Section 37 of the Planning Act 2008 for a Development Consent Order (**DCO**) for the construction and operation of the Project.

1.3 The Applicant is considering constructing the Project in up to two phases.

1.4 This Cable Statement has been prepared in accordance with Regulation 6(1)(b)(i) of the Infrastructure Planning (Applications: Prescribed Forms and Procedures) Regulations 2009 (the **APFP Regulations**) which requires the applicant for a DCO for the construction of an offshore generating station to provide a statement regarding the route and method of installation of any cable connecting the generating station to the onshore electricity transmission network.

1.5 The Applicant's DCO application contains all of the electrical infrastructure required for the Project, summarised as follows:

1.5.1 The offshore electrical components for the Project consisting of array cables that transmit power to the electrical platforms, inter-connector cables that transmit power between the offshore platforms, project interconnector cables that transmit power from the wind turbine generators or the Project offshore platforms to a platform within the Norfolk Vanguard project and export cables that transmit the power from the wind turbine generators to landfall. The offshore electrical assets also consist of up to two offshore electrical platforms. Separate deemed marine licences (**DML**) are proposed for the generation and transmission assets and the project interconnector cables, as explained in the Explanatory Memorandum (Document 3.2).

1.5.2 At landfall, the electrical works consist of up to two pairs of marine cables laid in ducts installed under the cliff by long Horizontal Directional Drilling (**HDD**). An additional drill is included in the impact assessment worst case scenarios where applicable, to provide a contingency in the unlikely event of a HDD failure; and up to two onshore transition pits to house the connection between the offshore cables and the onshore cables.

1.5.3 Onshore connection works, subject to different scenarios dependent on whether Norfolk Vanguard proceeds, as described in Table 1:

Table 1: summary of the two scenarios

Scenario 1 *Norfolk Vanguard proceeds to construction and installs ducts and carries out other shared enabling works to benefit 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*
i. Pulling up to two pairs of HVDC cables and associated communication cables through pre-installed ducts ii. 12km (approx.) running track alongside the cable route iii. 300m extension to the access road installed by Norfolk Vanguard to the onshore project substation	i. Cable duct installation and pulling up to two pairs of HVDC cables and associated communication cables through ducts ii. Trenchless crossings (for example HDD) at various roads, railways and sensitive habitats iii. Mobilisation areas and compounds for trenchless crossings iv. 60km (approx.) running track alongside the cable route v. A47 junction improvement works to install a right turn/ filter and new exit at the Spicers Corner junction vi. 1.8km access road to the onshore project substation vii. Modification to the existing overhead line network in the vicinity of the Necton National Grid substation.

1.5.4 Jointing pits and link boxes to facilitate cable pulling, at intervals along the cable route;

1.5.5 Cable logistics area near Oulton to allow for the storage of cable drums and associated materials close to the cable route;

1.5.6 Construction of an onshore project substation in proximity to the existing Necton National Grid Substation together with associated equipment, a temporary construction compound and a mobilisation area at Spicers Corner;

1.5.7 Extension to the existing Necton National Grid Substation;

1.5.8 Up to 12 400kV underground cables between the new onshore project substation and the existing Necton National Grid Substation;

1.5.9 Temporary construction areas and access roads, together with works to secure vehicular and/or pedestrian means of access including the creation of new tracks, footpaths, and/ or widening, upgrades, creation of bell mouths, creation of temporary slip roads and improvements to existing tracks, footpaths and roads;

1.5.10 Planting to provide screening for permanent infrastructure.

1.6 The Grid Connection Agreement that has been secured by the Applicant is for a connection located at Necton in Norfolk. To facilitate the Project, an extension to the existing Necton National Grid substation would be required and modifications to the existing overhead lines would be required for Scenario 2.

2. INTRODUCTION

2.1 This Cable Statement has been prepared by Norfolk Boreas Limited (the **Applicant**) pursuant to Regulation 6(1)(b)(i) of the Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 (the **APFP Regulations**).

2.2 This Statement forms part of the application to the Secretary of State for the Project for a Development Consent Order (**DCO**) to construct and operate an offshore generating station with up to 180 turbines and an export capacity of up to 1,800 MW. As the export capacity of the Project would exceed 100 MW it is a Nationally Significant Infrastructure Project (**NSIP**) as defined under sections 14(1)(a) and 15(3) of the Planning Act 2008.

2.3 The Project would be located more than 73 km from the coast of Norfolk, occupying an offshore Project area of approximately 725 km^2 in the southern North Sea.

2.4 The offshore Project area is located in the northern half of the former Zone 5 (East Anglia Zone) in the North Sea, which is being developed as two individual wind farms – Norfolk Boreas and its sister project, the Norfolk Vanguard offshore wind farm (**Norfolk Vanguard**); both of which require the appropriate statutory consents and approvals. Norfolk Vanguard comprises the first stage of development of this area, for which a DCO application was submitted in June 2018 and a decision is expected in December 2019. The Project is the second to be proposed.

2.5 Further information on the location and design of the Project is set out in the accompanying Environmental Statement (Volume 1, Chapter 5 Project Description) (Document 6.1).

2.6 This Statement provides details of the proposed offshore and onshore cable routes and cable installation (and pull-through) methods and is intended to provide a summary of the detailed information set out in the Chapter 5 Project Description of the Environmental Statement.

3. DESCRIPTION OF GRID CONNECTION WORKS

3.1 The Applicant's application for a DCO (the **Application**) contains all of the electrical cable works required for the Norfolk Boreas Offshore Wind Farm (the **Project**).

Electrical solution

3.2 The Applicant would deploy a High Voltage Direct Current (**HVDC**) transmission technology for the Project. HVDC cabling would be used between the offshore electrical platform(s) and the onshore project substation, with High Voltage Alternate Current (**HVAC**) array cabling; between the offshore Project area and the offshore electrical platforms; and for the interface cabling between the onshore project substation and the existing Necton National Grid substation. Electrical platforms would also be connected with HVAC and/ or HVDC cables known as interconnector cables. Project interconnector cables would transmit power from the wind turbine generators or the Project offshore platforms to a platform within the Norfolk Vanguard project.

3.3 There are three main HVDC electrical solutions being considered for the Norfolk Boreas Project and they relate to the number of electrical platforms which would be installed across the Norfolk Boreas and Norfolk Vanguard projects. The maximum infrastructure required for the three main solutions being considered is set out below:

3.3.1 Solution (a) 4x900MW electrical platforms: Two offshore electrical platforms within the Norfolk Boreas site, up to one pair of DC interconnector cables and up to a single AC interconnector cable connecting the electrical platforms located within the Norfolk Boreas site and up to two pairs of DC export cables connecting the electrical platforms within the Norfolk Boreas site to landfall at Happisburgh South, North Norfolk. The other 2x900MW electrical platforms would be located within the Norfolk Vanguard site and would be consented under the Norfolk Vanguard Development Consent Order.

3.3.2 Solution (b) 3x1,200MW electrical platforms (only possible under Scenario 1): One offshore electrical platform within the Norfolk Boreas site, up to one pair of DC project interconnector cables and up to a single AC project interconnector cable connecting the electrical platform within the Norfolk Boreas site to an electrical platform within Norfolk Vanguard East, up to eight AC cables connecting turbines located in the southern part of the Norfolk Boreas site to the electrical platform within Norfolk Vanguard East and one pair of DC export cables connecting the electrical platform within the Norfolk Boreas site to landfall at Happisburgh South, North Norfolk. The other 1 x1,200MW electrical platform would be located within Norfolk Vanguard West. The electrical platforms located within the Norfolk Vanguard site would be consented under the Norfolk Vanguard Development Consent Order.

3.3.3 Solution (c) 2x1,800MW electrical platforms: One offshore electrical platform within the Norfolk Boreas site, up to one pair of DC project interconnector cables and a single AC project interconnector cable connecting the electrical platform within Norfolk Boreas with an electrical platform within Norfolk Vanguard West and up to one pair of DC export cables connecting the electrical platform within the Norfolk Boreas site to landfall at Happisburgh South, North Norfolk.

3.4 A variation of solution (c) above is also being considered. Electrically this variant would be similar to solution (c), but in terms of physical infrastructure would be more similar to solution (a).

3.5 The Applicant is considering constructing the Project in up to two phases.

Offshore works

3.6 Array cables would collect and transfer power generated by the wind turbine generators to the offshore electrical platform(s). The cables connect the wind turbine generators together into strings, with the number of wind turbine generators connected together depending on factors such as the generation capacity of each wind turbine generator on the relevant cable network, distance between wind turbine generators and the cable sizes available. The strings of wind turbine generators would then in turn be connected to the offshore electrical platforms.

3.7 Up to two offshore electrical platforms would collect electricity from the wind turbine generators and transport it to landfall via up to four HVDC subsea export cables.

3.8 The subsea export cables would connect the offshore development to a landfall at Happisburgh South, North Norfolk. The offshore cable corridor is approximately 100 km in length from the edge of the Project site to the landfall location.

Onshore works at the landfall

3.9 The transition pits, where the offshore cables join the onshore cables, would be located at the landfall at Happisburgh South, North Norfolk. To enable the export cables from the Project to be brought through to the transition pits, long horizontal directional drilling (**HDD**) would be utilised from up to two HDD rigs, with up to two ducts installed to accommodate the cables. Up to two onshore transition pits located in the vicinity of each other would be required.

Onshore cable route

3.10 Under Scenario 1, the onshore cable ducts for the Project would be laid by Norfolk Vanguard. Norfolk Boreas has the same landfall location as Norfolk Vanguard, and (the same as Norfolk Vanguard) would also connect to the National Grid onshore transmission network at Necton. Norfolk Boreas would follow the same cable route as Norfolk Vanguard.

3.11 Therefore, the application for Norfolk Boreas includes, under Scenario 1, any further works to pull the onshore cables through (previously laid) onshore ducts. Cable pulling under Scenario 1 would not require trenches to be re-opened (apart from for the creation of joint pits and pulling chambers), with the cables being pulled through pre-installed ducts from jointing pits located along the onshore cable route.

3.12 Under Scenario 2, all onshore cable route infrastructure would be installed by the Project.

3.13 The onshore cable route would run between the onshore transition pits and the onshore project substation located near to Necton in Norfolk. The route is approximately 60km long in a predominantly westerly direction from Happisburgh South, North Norfolk, passing through mainly agricultural land. The onshore cable route is 45m wide (with a 35m working width) and would contain the main HVDC onshore export cables installed within cable ducts, as well as a running track, and topsoil and subsoil storage areas. The onshore cable route is shown on the Land Plans (Onshore) (Document 2.2)

3.14 The onshore cable route requires up to 2 trenches, within which cable ducts are installed.

Onshore project substation

3.15 The proposed site for the onshore project substation is located to the east of the existing Necton National Grid substation and for Scenario 1 to the west of the Norfolk Vanguard onshore project substation. For Scenario 2, the onshore project substation would be located on the footprint of the Norfolk Vanguard onshore project substation site. The project substation is shown on the Land Plans (Onshore) (Document 2.2).

3.16 For both scenarios, the onshore project substation would comprise a compound containing up to two converter buildings and electrical equipment to enable connection to the National Grid.

The substation would convert the exported power from HVDC to HVAC, to 400kV (grid voltage). The substation also contains equipment to help maintain stable grid voltage.

3.17 The onshore project substation would be located within a single compound that would not exceed 7.5ha. The total number of buildings housing the principal electrical equipment within the compound would not exceed two and their total footprint would not exceed 110 metres in length and 70 metres in width. Heights of buildings within the compound would not exceed 19 metres above existing ground level, and outdoor electrical equipment (e.g. lightning protection masts) would not exceed a height of 25 metres above existing ground level. The worst case parameters have been assessed and included in the draft DCO.

3.18 The onshore project substation would be connected to the existing Necton National Grid substation by means of underground cables laid directly into the ground or installed into pre-laid ducts.

4. CONSENTING OF GRID CONNECTION

4.1 Part 1 of Schedule 1 of the draft DCO describes the works for which development consent is being sought.

Offshore works

4.2 The wind turbine generators, up to one offshore service platform, up to two meteorological masts, and a network of subsea array cables form part of the Generating Station NSIP set out within Work No. 1.

4.3 Up to two offshore electrical platforms comprise Work No. 2 and the cable connections between the offshore electrical platforms and the subsea export cables seaward of mean low water between the offshore electrical platforms and the landfall at Happisburgh South (to seaward of mean low water) comprise Work Nos. 3A and 4A.

4.4 Up to 3 Project interconnector cables between the offshore electrical platforms and Norfolk Vanguard comprise Work No. 3B which only arises in the event of Scenario 1.

Intertidal area

4.5 The subsea export cables between mean low water and mean high water at Happisburgh South comprise Work No. 4B.

4.6 Works numbered 2, 3A, 3B, 4A and 4B are considered to be "associated development" to the Generating Station NSIP within Section 115 of the Planning Act 2008, in that they are not an aim in themselves but are required to export the electricity generated by the turbines.

Onshore works

4.7 The Applicant has included its onshore works, from mean high water to the onshore project substation and the extension to the existing National Grid substation, as "associated development" within its DCO application to the Secretary of State.

4.8 The export cables from mean high water to the transition pits at Happisburgh South comprise Work No. 4C and the underground cables running from the transition pits to the Applicant's onshore project substation comprise Work Nos. 5, 6 and 7. The works for the underground cables from Work No. 5 to Work No. 7 differ between Scenario 1 and Scenario 2, with Scenario 1 requiring the cables to be pulled-through pre-installed ducts, and Scenario 2 requiring the laying of cables in ducts.

4.9 The onshore project substation including associated surface water management, embankments, boundary treatments, bunding, and landscaping, comprise Work Nos. 8A to 8B.

4.10 The connection of up to 12 interface cables from the onshore project substation to the extended National Grid substation at Necton comprise Work No. 9.

4.11 The extension to the existing Necton National Grid substation (in an easterly direction for Scenario 1 and in a westerly direction for Scenario 2) and additional surface water management, bunding, embankments, boundary treatments and landscaping associated with the extension comprise Work No.s 10A, 10B and 10C.

4.12 The removal of one existing pylon and construction of two new permanent pylons, in the event of Scenario 2, comprises Work No. 11A. The overhead line modification works at the Necton National Grid substation, in the event of Scenario 2, comprise Work No.11B.

4.13 An extension from the existing access connecting the A47 to the Norfolk Vanguard onshore project substation, in the event of Scenario 1, comprises Work No. 12A.

4.14 The permanent accesses connecting the A47 to the onshore project substation and the Necton National Grid substation extension, in the event of Scenario 2, comprise Work No.12B.

5. DESCRIPTION OF GENERATING EQUIPMENT

5.1 The wind turbine generators consist of three primary components; the tower, the nacelle and the rotor. The rotor is the device which, through circular motion, extracts the energy from the wind. The nacelle houses the equipment that can turn rotational motion into electrical energy. The tower supports the nacelle and gives the rotor the necessary height.

5.2 The capacity of the Project will depend on the number of wind turbine generators that are installed and their individual rating. The Project would consist of up to 180 wind turbine generators, with an export capacity of up to 1,800 MW.

5.3 In the UK, offshore wind farm developers such as the Applicant can either construct the offshore transmission assets themselves or opt for an Offshore Transmission Owner (**OFTO**) to do so. OFTO assets generally consist of the onshore infrastructure required to connect to the national electricity transmission system, the offshore export cables and offshore electrical stations.

5.4 If the Applicant constructs the assets itself, then it must transfer the assets to an OFTO post-construction and pre-operation. OFTOs are selected on a competitive basis through a tender process. It is anticipated that the Applicant would opt for the generator build option which means that the offshore transmission assets would be transferred to an OFTO post construction and pre-operation.

6. OFFSHORE CABLE INSTALLATION

Phasing of construction

6.1 The Applicant is considering constructing the Project in up to two phases. The potential construction scenarios are presented in more detail in Chapter 5 of the Environmental Statement (Document 6.1).

Cable installation methods

Array cables

6.2 The array cables would be buried, where it is feasible to do so. Optimum burial depth may not be achieved in areas of rock outcrop, where there is a high frequency of boulders or at cable crossings. Where optimum burial depth is not achieved the cable may be protected to prevent movement of the cables, to prevent any risk to other marine users and to protect the cables from impacts arising from other marine activities such as fishing.

6.3 The array cables are expected to be installed from a cable laying vessel, which would be equipped with specialist cable handling equipment and would have support vessels in attendance as necessary, for example anchor handling. The cables are loaded on to cable carousels or cable drums, mounted on the deck of the vessel.

6.4 There are several different methods available for the installation of offshore cables, including the following:

- Ploughing

  This method consists of a forward blade cutting through the seabed whilst laying the cables behind. Usually the cable is simultaneously laid and buried; post lay burial using ploughs is not usual for a number of reasons including danger of damage to cable. Simultaneous laying and burial using cable plough is effective for export cables but has a number of difficulties for array cables. If cables are bundled, it can be technically challenging due to the bigger cross section area of bundled cable having to pass through the plough, therefore simultaneous laying and burying has been substituted by post lay burial on some projects. The cable plough lifts a section of the seabed deposit and places the cable below. The seabed deposit is then returned to its original position. In areas of very hard substrate, modifications to this technique may be used, including use of a rock cutter plough or vibrating share plough.

- Trenching or cutting

  This method consists of three operations. First, a trench is excavated or cut while placing the sediment and fill next to the trench. The cable is subsequently laid in the trench and lastly the sediment or fill is returned to the trench. Pre-lay cutting of trenches (or "pre-trenching") could also be used whereby a large trench is cut in one or multiple passes to the correct depth before the cable is laid back in trench at a later date. The trench can be backfilled naturally or if required with a backfill plough or other method of material replacement. The use of backfill ploughs is normally not favoured due to the danger of damaging the cable.

- Jetting

  Two methods of water jetting are typically available- lay the cable and jet at a later date or the lay the cable and jet at the same time. The cable is first laid on the seafloor. A Remotely Operated Vehicle (ROV) equipped with high pressure water jets then proceeds along the cable route, fluidising the seabed around the cable, allowing the cable to be lowered into the trench. The fluidised sediment subsequently settles back onto the seabed. In shallow waters a vertical injector could be used. This is a large jetting and cutting plough which is strapped to the side of a barge and the cable is laid in the foot of the trench. The burial depth is controlled by means of raising or lowering the tool and horizontal positioning, by means of adjusting the barge anchor.

6.5 The extent to which these cable burial techniques would be used will be dependent upon the results of detailed pre-construction seabed surveys of the final cable route and the associated cable burial assessment process.

6.6 The DML within the draft DCO require the submission and approval of a cable specification, installation and monitoring plan, which must include a cable laying plan and proposals for monitoring the offshore cables during the operational lifetime of the Project (condition 14(1)(g) of the Generation Assets DML; condition 9(1)(g) of the Transmission Assets DML; and condition 7(1)(f) of the Project Interconnector Assets DML).

Export cables

6.7 The same techniques described for array cable installation would be used to install the export cables between the offshore electrical platforms to the point offshore where the landfall ducts exit the seabed.

6.8 Export cables between the offshore electrical platforms and landfall may require a number of connections or joints along their length. Jointing of the offshore export cable would be undertaken at sea. Each jointing connection would require approximately ten days for completion. Additional time would also be required to recover both ends of the cable to the vessel for jointing and to re-bury the cable following jointing. Due to the complexity of offshore jointing, the number of joints would be kept to a minimum.

Interconnector cables and project interconnector cables

6.9 The same techniques described for array cable installation above would be used to install the interconnector cables connecting the electrical platforms located within the Norfolk Boreas site, and project interconnector cables (in the event of scenario 1) connecting the electrical platform within the Norfolk Boreas site to an electrical platform within Norfolk Vanguard East.

6.10 Interconnector cables, or project interconnector cables between offshore electrical platforms may require a number of connections or joints along their length. Jointing of the interconnector cables would be undertaken at sea. Each jointing connection would require approximately ten days for completion. Additional time would also be required to recover both ends of the cable to the vessel for jointing and to re-bury the cable following jointing. Due to the complexity of offshore jointing, the number of joints would be kept to a minimum.

Cable protection

6.11 In some cases the above installation techniques may not be able to be applied and it may be necessary to use alternative methods for installing the cables where they cannot be buried. Details of some of the techniques employed are given below:

- Concrete mattresses

  These are prefabricated flexible concrete coverings that are laid on top of the cable. Grout or sand filled bags could be used as an alternative to concrete mattresses for smaller scale activities.

- Rock Placement

  Rock placement involves the laying of a rock layer on top of the unburied cable to offer protection from and to fishing gear and vessel anchors.

- Frond mattresses

Frond mattresses could be used to provide protection by stimulating the settlement of sediment over the cable. This method develops a sandbank over time protecting the cable but is only suitable in certain water conditions. This method may be used in close proximity to offshore structures although experience has shown that storms can strip deposited materials from the frond.

- Uraduct

  Uraduct is effectively a protective shell which comes in two halves and is fixed around the cable to provide mechanical protection. Uraduct is generally used for short spans at crossings or near offshore structures where there is a high risk from falling objects. Uraduct does not provide protection from damage due to fishing trawls or anchor drags.

6.12 Where cable crossings occur, they would be protected using the concrete mattress or rock placement methods for cable protection described above.

6.13 The deemed Marine Licences within the draft DCO require the Marine Management Organisation's (**MMO**) approval of a scour protection and cable protection plan providing details of the need, type, sources, quantity and installation methods for scour protection and cable protection, which must be updated and resubmitted for approval by the MMO if changes to it are proposed following cable laying operations (condition 14(1)(e) of the generation DML; condition 9(1)(e) of the transmission DML and condition 7(1)(e) of the project interconnector DML).

Cable landfall and directional drilling works

6.14 The offshore cables would be required to be installed under the beach to be jointed to the onshore cables at the transition pits on the landward side of the landfall site. To enable this installation, long HDD is proposed to be employed. Drilling would be carried out from a compound on the land side of the sea defences or cliffs. As the Applicant would be using a long HDD option, the drill emerges beyond the low water mark. The drill is then retrieved and a flexible duct is pulled into the drilled hole.

6.15 The cable is floated ashore from a cable laying vessel or barge lying as close to shore as possible on a high tide and the free end of the cable is attached to a pull-wire that passes through the HDD duct. An onshore winch is used to pull the end of the cable through the duct and into the transition pit.

7. ONSHORE CABLE INSTALLATION

Transition pits

7.1 Each cable circuit would require a separate transition pit to connect the offshore and onshore cables at the landfall which would be grouped together and staggered as necessary to be accommodated within the permanent cable route. The transition pit would comprise of an excavated area of 15m x 6m x 2m per circuit, with a reinforced concrete floor to allow winching during cable pulling and a stable surface to allow jointing.

7.2 Link boxes for each of the required transition pits may be utilised to allow the HVDC cable sheaths to be bonded to earth to maximise cable ratings. Link boxes would not be required at all jointing locations and can typically be placed at 5km intervals. The number and placement of the link boxes would be determined as part of the detailed design. The link box, with dimensions of 1.5m x 1.5m per circuit would be buried to ground level within an excavated pit, providing access via a secured access panel. 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.

Onshore cabling

7.3 For Scenario 1, the installation of up to four ducts for cables for Norfolk Boreas would already have been undertaken pursuant to the Norfolk Vanguard Order. Therefore, the cables for Norfolk Boreas would be pulled through those pre-installed ducts using either a single phase or two phased approach, to facilitate the commissioning of up to two phases of offshore wind turbine installation.

7.4 Jointing pits would be required along the cable route to allow cable pulling and jointing of two sections of cable.

7.5 Cable pulling would not require trenches to be reopened but would require the ground to be opened to construct the jointing pits. Cables would be pulled through the pre-installed ducts from jointing pits located along the onshore cable route. The joint pits would typically be located at approximately 800m intervals, although site specific constraints may result in shorter intervals where necessary. Access to and from the jointing pits would be required to facilitate the works which would be achieved through access to the onshore cable route directly from the public highways network (at crossing locations) or existing construction access routes where possible. In some locations, isolated sections of the running track would be left in place from Norfolk Vanguard and required to be reinstated to allow access to more remote jointing locations. This is anticipated to be in the order of 20% of the total cable route length.

7.6 To facilitate the cable pulling and jointing, the joining pit would be excavated and cable drums delivered by HGV low loader to the open jointing pit locations. The cable drum would be located adjacent to the jointing pit on a temporary hard standing and a winch attached to the cable, pulling the cable off the drum from one jointing pit to another, through the buried ducts, by employing a series of temporary rollers. Cable jointing would be conducted once both lengths of cable that terminate within it have been installed.

7.7 Link boxes are required in close proximity (within 10m) to a subset of jointing pit locations.

7.8 Under Scenario 2, the onshore cable route would require trenches (within which ducts would be installed to house the cable circuits); a running track to deliver equipment to the installation site from mobilisation areas; and storage areas for topsoil and subsoil next to the trenches.

7.9 The main cable installation method be through the use of open cut trenching with High Density Polyethylene (**HDPE**) ducts installed, backfilled and cables pulled though the pre-laid ducts at a later date. Up to two cable pull phases would be required depending on whether the single offshore phase or two offshore phase approach applies.

7.10 Topsoil would be stripped from sections of the onshore cable route and stored and capped to minimise wind and water erosion within the working width. The profile of the soil would be carefully maintained during the storage process. The cable trenches would then be excavated, typically utilising tracked excavators. The excavated subsoil would be stored separately from the topsoil, capped and the profile of the soil maintained during the storage process.

7.11 A stabilised backfill such as Cement Bound Sand (**CBS**) would be installed at the base of the trench. A duct for each cable and a separate duct or ducts for fibre optic cables would be laid on the CBS base and backfilled with CBS to a covering depth of 100mm. This approach ensures a consistent homogeneous medium for the dissipation of heat generated by the cables during operation.

7.12 The CBS backfill would be covered with high voltage cable warning tiles with integrated warning tape and the trench backfilled with subsoil material excavated from the trench. The stored topsoil would be replaced upon the backfilled subsoil to reinstate the trench to pre-construction condition, so far as reasonably possible.

7.13 Cables would be pulled through the installed ducts later in the construction programme in a staged approach as set out above. This approach allows the civil works to be completed in advance of cable delivery.

7.14 Once the cable ducts have been installed, the section would be back filled and the topsoil replaced before moving onto the next section, to minimise the amount of land being worked on at any one time.

7.15 The construction works for the cable pulling would be the same as identified above for Scenario 1.

7.16 Trenchless installation would be employed at certain locations, including at the A47, Wendling Carr County Wildlife Site (CWS), Wendling Beck and Little Wood CWS, Mid-Norfolk Railway, River Wensum, Marriotts Way CWS (South), Marriotts Way CWS (North) & Proposed Kerdiston CWS, Ørsted (Hornsea Project 3), River Bure, A140, Kings Beck, A149, Norwich to Sheringham Railway, Paston Way and Knapton Cutting CWS and B1145, North Walsham and Dilham Canal and Woodland South of Witton Hall.

Onshore project substation

7.17 The onshore project substation would consist of an HVDC substation. Construction would include a number of key stages, including earthworks, foundations, superstructure and equipment installation.

7.18 In November 2016, the Applicant secured a Grid Connection Agreement from National Grid for a connection located at Necton. The 400 kV HVAC cable route from the onshore project substation to the existing Necton National Grid substation would be installed in accordance with the main cable laying and installation works set out above, by means of underground cables laid directly into the ground, or installed into pre-laid ducts where pre-laid ducts have already been installed.

7.19 The only difference for the onshore project substation between the scenarios is the proposed location: for Scenario 2, the onshore project substation would be located approximately half-way between the footprints of the onshore project substations for Norfolk Vanguard and Norfolk Boreas under Scenario 1. This is illustrated in Figure 5.6 of the Environmental Statement (Document 6.1).