Hornsea Project Four: Environmental Statement (ES)

PINS Document Reference: F1.3
APFP Regulation 6(1)(b)(i)

F1.3: Cable Statement

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F1.3
Version A

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Glossary

Term	Definition
The Applicant	Orsted Hornsea Project Four Ltd.
Commitment	A term used interchangeably with mitigation and enhancement measures. The purpose of Commitments is to reduce and/or eliminate Likely Significant Effects (LSEs), in EIA terms. Primary (Design) or Tertiary (Inherent) are both embedded within the assessment at the relevant point in the EIA (e.g. at Scoping, Preliminary Environmental Information Report (PEIR) or ES). Secondary commitments are incorporated to reduce LSE to environmentally acceptable levels following initial assessment i.e. so that residual effects are acceptable.
Design Envelope	A description of the range of possible elements that make up the Hornsea Project Four design options under consideration, as set out in detail in the project description. This envelope is used to define Hornsea Project Four for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known. This is also often referred to as the "Rochdale Envelope" approach.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity, of the receptor or resource in accordance with defined significance criteria.
Energy balancing infrastructure (EBI)	The onshore substation includes energy balancing Infrastructure. These provide valuable services to the electrical grid, such as storing energy to meet periods of peak demand and improving overall reliability.
EIA Directive	European Union Directive 85/337/EEC, as amended by Directives 97/11/EC, 2003/35/EC and 2009/31/EC and then codified by Directive 2011/92/EU of 13 December 2011 (as amended in 2014 by Directive 2014/52/EU).
EIA Regulations	The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (as amended).
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Statement (ES).
Environmental Statement (ES)	A document reporting the findings of the EIA and produced in accordance with the EIA Directive as transposed into UK law by the EIA Regulations.
Export Cable Corridor (ECC)	The specific corridor of seabed (seaward of Mean High Water Springs (MHWS)) and land (landward of MHWS) from the Hornsea Four array area to

Term	Definition
	the Creyke Beck National Grid substation, within which the export cables will be located.
Haul Road	The track along the onshore ECC which the construction traffic would use to access work fronts.
Hornsea Project Four Offshore Wind Farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
High Voltage Alternating Current (HVAC)	High voltage alternating current is the bulk transmission of electricity by alternating current (AC), whereby the flow of electric charge periodically reverses direction.
High Voltage Direct Current (HVDC)	High voltage direct current is the bulk transmission of electricity by direct current (DC), whereby the flow of electric charge is in one direction.
Landfall	The generic term applied to the entire landfall area between Mean Low Water Spring (MLWS) tide and the Transition Joint Bay (TJB) inclusive of all construction works, including the offshore and onshore ECC, intertidal working area and landfall compound. Where the offshore cables come ashore east of Fraisthorpe.
Link boxes	The underground metal box placed within a plastic or concrete pit where the metal sheaths between adjacent export cable sections are connected and earthed installed within a ground level manhole or inspection chamber to allow access to the link box for regular maintenance or fault-finding purposes.
Maximum Design Scenario (MDS)	The maximum design parameters of each Hornsea Four asset (both on and offshore) considered to be a worst case for any given assessment.
National Grid Electricity Transmission (NGET) substation	The grid connection location for Hornsea Four.
Onshore substation (OnSS)	Comprises a compound containing the electrical components for transforming the power supplied from Hornsea Project Four to 400 kV and to adjust the power quality and power factor, as required to meet the UK Grid Code for supply to the National Grid. If a HVDC system is used the OnSS will also house equipment to convert the power from HVDC to HVAC.
Order Limits	The onshore limits within which Hornsea Project Four (the 'authorised project') may be carried out.
Orsted Hornsea Project Four Ltd.	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
Planning Inspectorate (PINS)	The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs).
The Secretary of State (SoS) for Business, Energy and Industrial Strategy	The ultimate decision maker with regards to Hornsea Four's application for Development Consent.

Term	Definition
Trenchless Techniques	Also referred to as trenchless crossing techniques or trenchless methods. These techniques include Horizontal Directional Drilling (HDD), thrust boring, auger boring, and pipe ramming, which allow ducts to be installed under an obstruction without breaking open the ground and digging a trench.
Wind turbine generator	All the components of a wind turbine, including the tower, nacelle, and rotor.

Acronyms

Acronym	Definition
CBRA	Cable Burial Risk Assessment (CBRA)
CFD	Contract for Difference
CFE	Controlled Flow Excavation
DCO	Development Consent Order
EC	European Community
EBI	Energy Balancing Infrastructure
EIA	Environmental Impact Assessment
ES	Environmental Statement
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
JB	Joint Bays
NGET	National Grid Electricity Transmission
NSIP	Nationally Significant Infrastructure Project
OnSS	Onshore Substation
PEIR	Preliminary Environmental Information Report
PINS	Planning Inspectorate
SoS	Secretary of State
TBJ	Transition Joint Bay
UK	United Kingdom

Units

Unit	Definition
Km	*Kilometre*
kV	*Kilovolt*
GW	*Gigawatt*
MW	*Megawatt*

1 Introduction

1.1.1.1 Orsted Hornsea Project Four Limited (the 'Applicant') is proposing to develop Hornsea Four Offshore Wind Farm (hereafter 'Hornsea Four'). Hornsea Four will be located approximately 69 km from the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone. Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall and on to an onshore substation (OnSS) with energy balancing infrastructure (EBI), and connection to the electricity transmission network (see **Volume A1, Chapter 4, Project Description**).

1.1.1.2 This Cable Statement has been prepared by the Applicant 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 Development Consent Order (DCO) for the construction of an offshore generating station, to provide details of the proposed route (please refer to **Section 2**) and method of installation for any cable (please refer to **Section 4** and **Section 5**). This Cable Statement forms part of the suite of documents submitted to the Secretary of State (SoS) in support of the application for a DCO for Hornsea Four.

1.1.1.3 The DCO for Hornsea Four would authorise, among other things, the construction, operation, maintenance and decommissioning of the following electrical infrastructure, as shown in **Figure 1:**

- Offshore wind turbines;
- Offshore accommodation platforms;
- Array cables linking the individual turbines to offshore substations;
- Connection works to existing National Grid Electricity Transmission (NGET) substation at Creyke Beck;
- OnSS and EBI; and
- High Voltage Alternating Current (HVAC) or/and High Voltage Direct Current (HVDC) transmission systems.

1.1.1.4 Hornsea Four may use HVAC or HVDC transmission or could use a combination of both technologies in separate electrical systems. Hornsea Four is applying for consent for both HVAC and HVDC transmission to allow for suitable flexibility to ensure a low cost of energy to the UK consumer and to facilitate successful completion of Hornsea Four in a competitive market. The DCO would therefore authorise the following electrical infrastructure:

HVAC:

- Offshore transformer substation(s);
- Offshore interconnector cables(s);
- Offshore export cable(s);
- Offshore HVAC booster station(s)
- Onshore export cable(s); and
- Onshore substation.

HVDC:

- Offshore transformer substation(s);
- Offshore interconnector cables(s);
- Offshore HVDC converter substation(s);
- Offshore export cables(s);
- Onshore export cables(s); and
- Onshore HVDC converter substation.

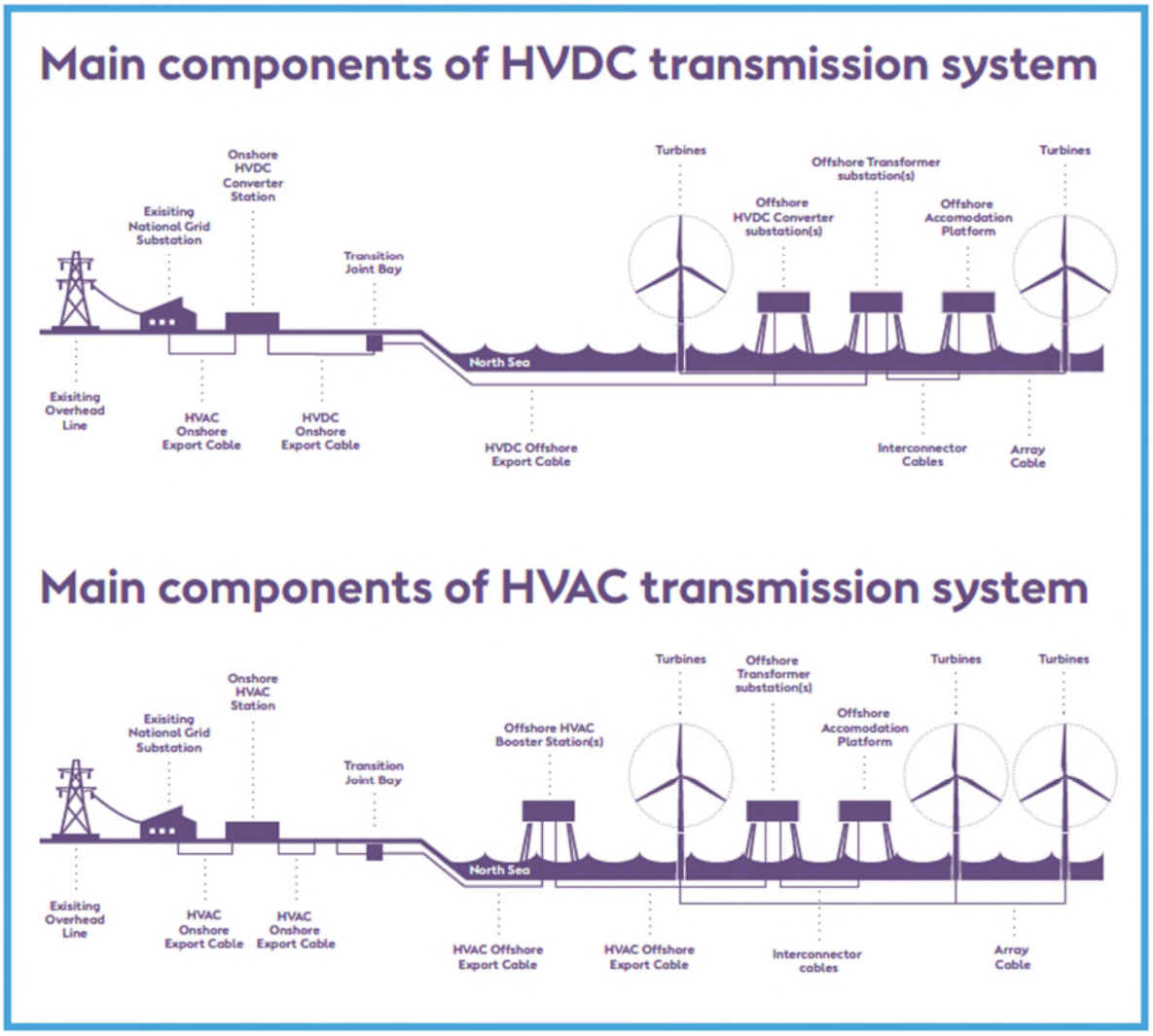


Figure 1: Main components of Hornsea Four (indicative only).

1.1.1.5 The offshore Export Cable Corridor (ECC) extends from the proposed landfall east of Fraisthorpe in East Riding of Yorkshire, offshore in an easterly direction to the Hornsea Four array area, as shown in **Figure 2.** For further details please refer to **Section 2.2.** The Hornsea Four onshore ECC runs in a south-westerly direction from the landfall to the proposed OnSS

site location near Creyke Beck, as shown in Figure 3. For further details please refer to Section 2.3.

1.1.1.6 The Grid Connection Agreement for the connection between Hornsea Four and Creyke Beck is in place. The projected connection is anticipated in 2027 and 2028.

1.2 Purpose

1.2.1.1 The information contained within this Statement on the proposed cable corridor and cable installation methods is intended to be a summary of the information contained within the Project Description chapter of the Environmental Statement (Volume A1, Chapter 4: Project Description).

2 Proposed Export Cable Corridor

2.1 Selection of the proposed export cable corridor

2.1.1.1 Consideration has been given to reasonable alternatives at every stage of Hornsea Four and a number of 'guiding principles' were inherently applied to the decision-making process for site selection, including for the onshore and offshore ECC, and these comprise:

- Select the shortest route (hence reduce environmental impacts by minimising footprint and electrical transmission losses (most efficient project));
- Avoid key sensitive features where possible and where not, seek to mitigate impacts;
- Minimise disruption to sensitive receptors (e.g. populated areas) by the early adoption of primary (intrinsic design) commitments; and
- Find a site large enough to accommodate the connection technology outlined within the design envelope (see Volume A1, Chapter 4: Project Description).

2.1.1.2 Further details are provided in Volume A1, Chapter 3: Site Selection and Consideration of Alternatives

2.2 Hornsea Four offshore export cable corridor

2.2.1.1 The Hornsea Four offshore ECC extends from the proposed landfall east of Fraisthorpe, in the East Riding of Yorkshire, offshore in an easterly direction to the Hornsea Four array area. The offshore ECC is approximately 109 km in length and 1.5 km in width typically with an additional 500 m either side for temporary works. (See Figure 3).

2.2.1.2 The detailed coordinates for the Hornsea Four offshore are included in the Volume D1, Annex 2.1: Offshore Order Limits and Grid Coordinates Plan.

2.3 Hornsea Four onshore cable corridor

2.3.1.1 The offshore export cables will make landfall east of Fraisthorpe where they will be joined to the onshore export cables at the transition joint bays (TJB). Cables will then connect to an onshore substation and then on to the National Grid substation at Creyke Beck to allow the power to be transferred to the National Grid, see **Figure 4.**

2.3.1.2 The extent of land required for onshore works, including the export cable and substations are shown in **Volume D1, Annex 4.2: Works Plans – Onshore**.

2.3.1.3 The Hornsea Four onshore ECC consists of an 80 m wide temporary easement (although a wider corridor of 120 m is provided for at the crossing of the National Rail Network at Beswick). The permanent easement width will be 60m except where obstacles are encountered such as the Network Rail Crossing near Beswick (where the permanent footprint is may be extended up to 120m to facilitate Horizontal Directional Drilling (HDD) of the railway line), and on the approach to the landfall and onshore substation. The onshore ECC is approximately 39 km in length, in addition to the 400 kV ECC (approximately 1 km), which connects into the NGET substation at Creyke Beck. The onshore ECC was designed with consideration of a wide range of human, biological and physical constraints as well as technical and commercial considerations (further details are provided in **Volume A1, Chapter 3: Site Selection and Consideration of Alternatives**. Furthermore, the route planning and site selection process incorporates some fundamental commitments to avoid or reduce impacts by avoiding sensitive, important or valuable features early in the project design. All commitments are presented within the Commitment Register (see **Volume A4, Annex 5.2**).

2.3.1.4 Onshore export cables will be installed with a mixture of open trench and HDD techniques. Following completion of the onshore cable installation, the working area will be reinstated to its previous condition (See **Table 7** in this document and Co10 of **Volume A4, Annex 5.2: Commitment Register**).

Hornsea Four

Figure 2

Landfall Location Plan

- Logistics Compound
- Landfall Compound Area
- Onshore Export Cable Corridor
- Landfall Connection Works
- Offshore Temporary Works Area
- Offshore Export Cable Corridor
- Temporary Access Track
- Temporary Access Track and Export Cable Corridor
- Temporary Access Construction Ramp

Coordinate system: British National Grid

Scale@A3: 1:12,500

0 125 250 500 Meters

0 500 1,000 2,000 Feet

REV	REMARK	DATE
	First Issue for PEIR	08/07/2019
A	Updated following PEIR consultations, for DCO	03/02/2020
B	Amended landfall extent to MHWS	26/08/2021

Landfall Location Plan
Document no: HOW040224
Created by: XDAOO
Checked by: JOHLE
Approved by: JULCA

Ørsted

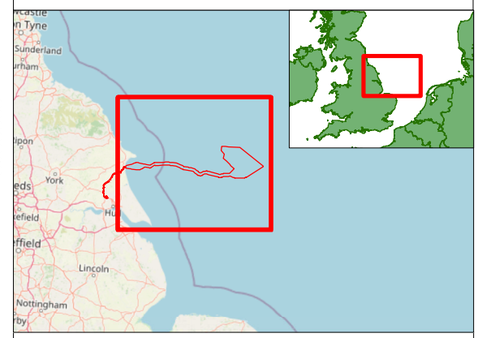
Date: 26/08/2021 Author: XDAOO Name: HOW040224_LandfallLocationPlan_RevB_20210826

Hornsea Four

Figure 3

Offshore ECC Route

- Order Limits
- Array Area
- HVAC Booster Station Works Area
- Offshore Export Cable Corridor



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 5 10 20 Kilometers

0 2.5 5 10 Nautical Miles

REV	REMARK	DATE
	First Issue for DCO	26/08/2021

Offshore ECC Route
Document no: HOW040510
Created by: XDAOO
Checked by: JOHLE
Approved by: JULCA

Ørsted

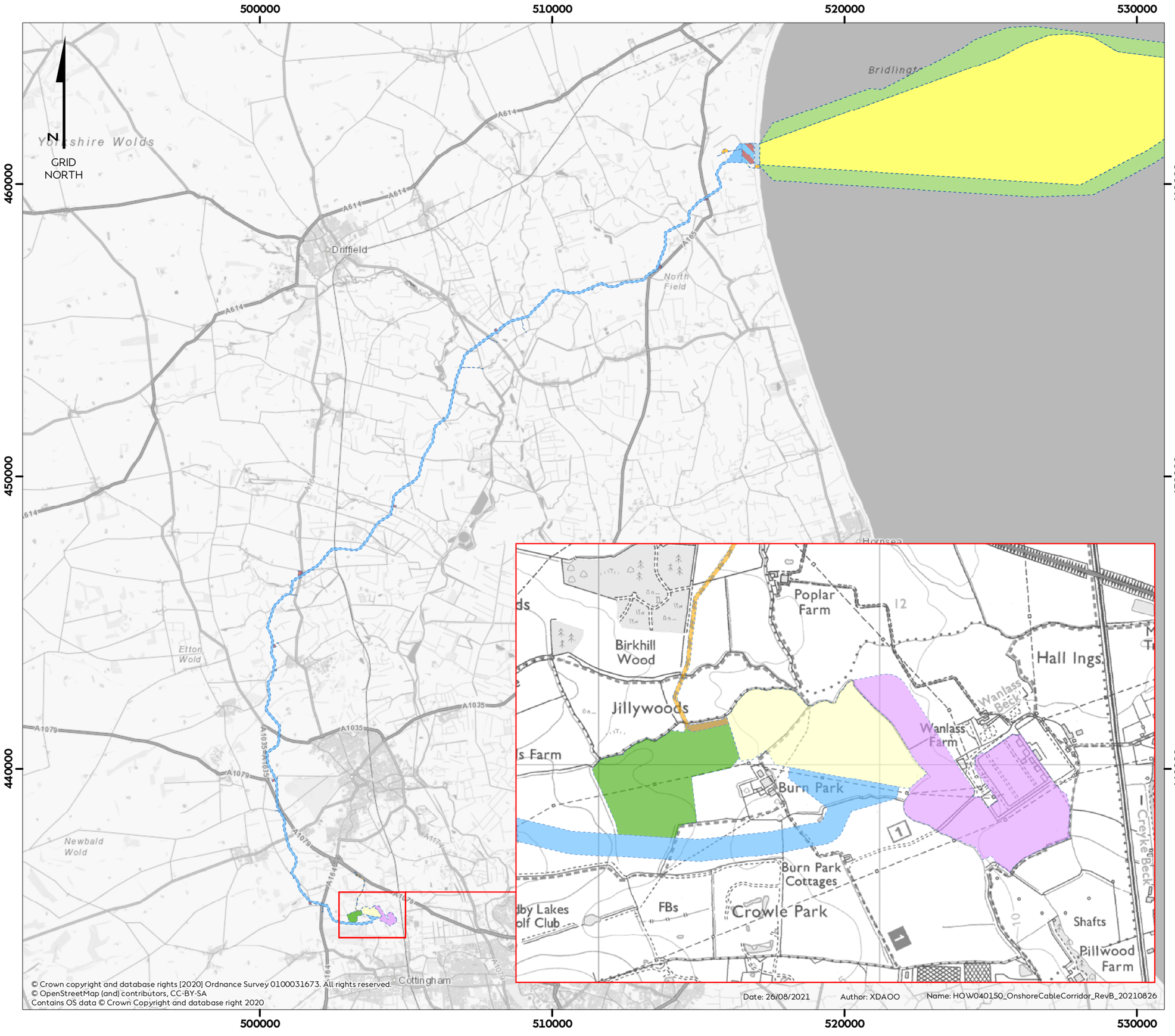
Date: 26/08/2021 Author: XDAOO Name: HOW040510_Offshore_ECC_Route_20210826

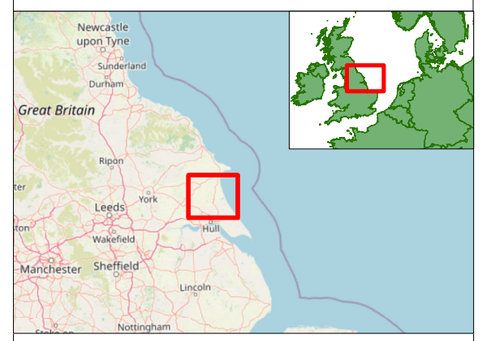
Hornsea Four

Figure 4

Onshore Cable Corridor

- Offshore Temporary Works Area
- Offshore Export Cable Corridor
- Landfall Compound Area
- Logistics Compound
- Onshore Export Cable Corridor
- Permanent Access Track
- Temporary and Permanent Access Tracks
- Temporary Access Track
- Landfall Connection Works
- Onshore Substation (Permanent Space)
- Onshore Substation (Temporary Works)
- Grid Connection Works





Coordinate system: British National Grid

Scale@A3: 1:125,000

0 1 2 4 Kilometres

0 0.5 1 2 Nautical Miles

REV	REMARK	DATE
	First Issue for PEIR	29/07/2019
A	Updated following PEIR consultations, for DCO	03/06/2020
B	Multiple changes to onshore project layers	26/08/2021

Onshore Export Cable Corridor
Document no: HOW040150
Created by: XDAOO
Checked by: JOHLE
Approved by: JULCA

Ørsted

Date: 26/08/2021 Author: XDAOO Name: HOW040150_OnshoreCableCorridor_RevB_20210826

3 Description of Grid Connection Works

3.1 Transmission System

3.1.1.1 The Development Consent application for Hornsea Four contains the electrical grid connection works. The wind farm transmission system is used to transport the power produced at the turbines and delivered by the array cables, to the UK National Grid. The system transforms the Medium Voltage (MV) power produced at the turbines to High Voltage at the offshore transformer substations (located in the Hornsea Four array area), and transports this via export cables and a number of other offshore and onshore components.

3.1.1.2 The transmission system is usually designed, paid for and constructed by the wind farm developer (Orsted Hornsea Project Four Ltd), but under the Energy Act 2004 and the Electricity (Competitive Tenders for Offshore Transmission Licences) Regulations 2009 such assets must be purchased by an Offshore Transmission Operator (OFTO), after the wind farm is constructed, in a transaction overseen by the Office of Gas and Electricity Markets (Ofgem). It is also possible that the transmission asset may be designed, procured and installed by the OFTO, however the design and installation parameters are still to be consented through this application.

3.2 Project capacity

3.2.1.1 Hornsea Four will have a maximum of 180 wind turbine generators. The total number and dimensions of turbines would not exceed that stated within **Volume A1, Chapter 4: Project Description** that accompanies this application for Development Consent. The Environmental Impact Assessment (EIA) for Hornsea Four is not directly linked to the wind turbine generator capacity and is therefore not considered necessary to constrain the Design Envelope and as such is not referred to as a fixed parameter within the Project Description (**Volume A1, Chapter 4: Project Description)** or draft DCO (**Volume C1.1 Draft Development Consent Order)** for Hornsea Four. The ultimate capacity of Hornsea Four will be determined at the time of Final Investment Decision (FID) and/or Contract for Difference (CFD) auction, the grid connection capacity and available technology as constrained by the Design Envelope presented in this chapter.

3.3 HVAC/HVDC transmission systems

3.3.1.1 There are a range of transmission system designs that can be used to transport the power from the Hornsea Four array area to the UK National Grid. These fall under two primary transmission types; HVAC or HVDC. Both transmission types have a range of relative benefits and drawbacks. Offshore wind farms have traditionally used HVAC connections in the UK; however, HVDC connections become more technically and/or economically viable in the context of far from shore projects and have been used on a number of projects in Germany. Hornsea Four requires flexibility in transmission system choice to ensure that anticipated changes in available technology and project economics can be accommodated within the Hornsea Four design and will make a decision on which transmission type to use during the detailed design phase (post consent). For this reason, both technologies are

included in this application for Development Consent. An overview of the main differences between the HVAC and HVDC component requirements are outlined in **Table 1**.

3.3.1.2 Hornsea Four is also applying for EBI in relation to the onshore HVDC converter or HVAC substation. The EBI would have the capability of energy balancing for the windfarm to buffer forecasted production with actual production reducing the reliance on energy produced from gas-fired power plants that is currently the main source of balancing energy. Further information regarding EBI is outlined in **Volume A1, Chapter 2: Planning and Policy Context**.

Table 1: Infrastructure required for HVAC and HVDC systems.

Component	HVAC	HVDC
Offshore transformer substation(s)	Y	N
Offshore interconnector cable(s)	M	M
Offshore HVDC converter substation(s)	N	Y
Offshore export cable(s)	Y	Y
Offshore HVAC booster station(s)	M	N
Onshore export cable(s)	Y	Y
Onshore HVDC converter/HVAC substation	Y	Y
Grid connection export cable	Y	Y
Table Key: Y – Required; M – May be required; N – Not required		

3.4 Circuit description

3.4.1.1 A circuit is an electrical system that allows the flow of electrons from one location to another. Typical HVAC transmission systems are three phase designs and require three conductors per electrical circuit to transport the power. Offshore these three conductors are usually combined into a single cable. Onshore these three conductors are usually housed within one cable per conductor (so three cables per circuit).

3.4.1.2 HVDC transmission systems require up to two conductors per circuit to transport the power. Offshore, these are generally housed in separate cables, but these cables may be installed together. Onshore these conductors are housed in separate cables.

3.5 Onshore substation

3.5.1.1 Hornsea Four will connect to the NGET 400kV substation at Creyke Beck, which is located near Cottingham, in the jurisdiction of east Riding of Yorkshire Council (ERYC). The proposed

permanent development area for the OnSS is located North of Cottingham with the nearest Southeast corner approximately 175 m west of the NGET 400 kV substation at Creyke Beck.

3.5.1.2 The onshore substation comprises a compound containing the electrical components for transforming the power supplied from Hornsea Four to 400 kV and to adjust the power quality and power factor, as required to meet the UK Grid Code for supply to the National Grid. If a HVDC system is used it will also house equipment to convert the power from HVDC to HVAC.

3.5.1.3 As set out in **Section 3.3**, Hornsea Four is applying for an EBI. All energy balancing equipment will be housed wholly within the footprint of the OnSS. The detailed design of the OnSS and EBI will be agreed in writing with ERYC as set out in **Volume F2, Annex 13: Outline Design Plan**.

4 Offshore Cable Installation

4.1 Cable installation methods

4.1.1 Pre-installation activities (offshore cables)

4.1.1.1 The indicative offshore activities that will be carried out during the pre-construction phase include:

- Geophysical and geotechnical surveys;
- Demarcation and installation of buoys;
- Boulder removal/placement;
- Sandwave removal;
- UXO clearance;
- Installation of scour protection;
- Dredging and pre-trenching activities;
- Pre-Lay Grapnel Run (PLGR);
- Seabed excavation; and
  Other non-impact piling construction activities.

4.1.1.2 Further details of each of these activities is provided in **Volume A1, Chapter 4: Project Description** that accompanies this application for Development Consent.

4.1.2 Array Cables

4.1.2.1 Cables carrying the electrical current produced by the turbines will link the turbines to an offshore transformer substation or offshore HVDC converter station. A small number of turbines will typically be grouped together on the same cable 'string' connecting those turbines to the substation, and multiple cable 'strings' will connect back to each offshore substation. There will be approximately 600 km of array cable required. Up to 10% of the

total array cable length may require protection due to unforeseen ground conditions and tool failure. The Maximum Design Scenario for Array Cables is displayed in **Table 2**.

4.1.2.2 Possible installation methods include jetting, vertical injection, cutting and ploughing whereby the seabed is opened and the cable laid within the trench using a tool towed behind the installation vessel. Alternatively, a number of these operations such as jetting, cutting or Controlled Flow Excavation (CFE) may occur post cable lay. It may also be necessary to install the cable by pre-trenching or rock cutting whereby a trench is opened in one operation and then the cable laid subsequently from another vessel. Hornsea Four may also need to undertake boulder removal and dredge the cable route prior to installation to level sandwaves that may hinder installation. The maximum design parameters for cable installation is outlined in **Table 3**.

Table 2 : Maximum design parameters for array cables.

Parameter	Maximum design parameters
Total length of cable (km)	600
Voltage (kV)	170

Table 3: Maximum design parameters for cable installation.

Parameter	Maximum design parameters		
	Array cables	*Offshore interconnector cables*	*Offshore export cables*
Installation methodology	Surface lay, mechanical trenching, dredging, jetting, ploughing, controlled flow excavation, vertical injection, rock cutting.	Mechanical trenching, dredging, jetting, ploughing, controlled flow excavation, vertical injection, rock cutting.	
Burial depth; Vertical Injection (Ploughing and Controlled Flow Excavation) (m)	3 (2)		
Total length of cable (km)	600	90	654
Boulder and Sandwave Clearance width (m), per cable	40		
Cable installation width (m)	15 (NOTE: 15 m is within the 40 m not additional)		

Parameter	Maximum design parameters		
	Array cables	*Offshore interconnector cables*	*Offshore export cables*
Total seabed disturbed (full corridor width 1.5 km) (km^2)	9	1.4	9.8
Boulder Clearance - Seabed Disturbance (km^2)	18	2.7	19.5
Sand wave Clearance -- Seabed Disturbance (km^2)	18	2.7	19.5
Sandwave Clearance - Material Volumes (m^3)	769,000	115,000	834,000
Jetting excavation rate soft soil (soft or loose soil)	300 (125) m/hr		
Burial spoil: Vertical Injection (m^3)	1,326,000	199,000	1,438,000
Ploughing excavation rate medium soil (hard soil)	125 (55) m/hr		
Burial spoil: ploughing/controlled flow excavation (m^3)	3,600,000	540,000	3,903,000
Duration: total (months)	24	24	24

4.1.3 Offshore Interconnector cables

4.1.3.1 Hornsea Four may require cables to interconnect the offshore substations to provide redundancy in the case of cable failure elsewhere, or to connect to the offshore accommodation platform to provide power for operation. See Maximum design parameters for offshore interconnector cables in **Table 4**. The cables will have a similar design and installation process to the array and export cables.

Table 4 : Maximum design parameters for offshore interconnector cables.

Parameter	Maximum design parameters
Number of circuits/cables	6
Total length of cables/circuits (km)	90
Voltage (kV)	600

4.1.4 Export cables

4.1.4.1 Offshore export cables are used for the transfer of power from the offshore substations to the landfall point. For HVAC transmission systems, offshore export cables will carry electricity from the offshore transformer substations to the offshore HVAC booster station(s), if these are included in the project design, and then on to the landfall. For HVDC transmission systems, offshore export cables will carry electricity from the offshore transformer substations to the offshore HVDC converter substations and then to the landfall.

4.1.4.2 The maximum design parameters for offshore export cables are presented in **Table 5.** The average width of the marine ECC is 1.5 km for permanent cables and 500 m ether side for temporary works, though this varies in a few locations along the ECC, notably at landfall, within the HVAC search area and array-side of the ECC where the ECC fans out to meet the array.

4.1.4.3 Hornsea Four requires flexibility in type, location, depth of burial and protection measures for export cables to ensure that anticipated physical and technical constraints and changes in available technology and project economics can be accommodated within the Hornsea Four design.

4.1.4.4 The installation method and target burial depth will be refined post consent based on a cable burial risk assessment (CBRA) which will support the development of a Cable Specification and Installation Plan as secured in the Deemed Marine Licences (see **Volume C1.1 Draft Development Consent Order including Draft Deemed Marine Licences**). Typically, the cable will be buried between 1 and 2 m. The CBRA will inform cable burial depth (see the Maximum Design Scenarios (MDS) outlined in **Volume A1, Chapter 4: Project Description**), which will be dependent on ground conditions (see **Table 8** in **Volume F2, Chapter 4: Outline Marine Written Scheme of Investigation**) as well as external risks. This assessment will be undertaken post-consent.

4.1.4.5 Possible installation methods include jetting, vertical injection, cutting and ploughing whereby the seabed is opened and the cable laid within the trench using a tool towed behind the installation vessel. Alternatively, a number of these operations such as jetting, cutting or Controlled Flow Excavation (CFE) may occur post cable lay.

4.1.4.6 Cables will be buried below the seabed wherever possible (see Co 83 of **Volume A4, Annex 5.2: Commitment Register**), with exceptions where this is not technically feasible, or where third-party assets are crossed. Up to 10% of the total export cable length may require protection due to ground conditions, burial tool breakdown, burial tool change or other unforeseen circumstances (excluding cable protection due to cable crossings). Further details on cable protection pro-rata values are provided in **Volume A4, Annex 4.8: Pro-rata Annex**.

Table 5: Maximum design parameters for offshore export cables.

Parameter	Maximum design parameters	
	HVAC	*HVDC*
Number of circuits	6	4
Voltage (kV)	400	600
Maximum number of cables	6	
Length per cable – including export cable within the Hornsea Four array area (km)	109	
Total length of cables (km)	654	
Length of Hornsea Four offshore cable corridor (km) (excluding within array)	99	
Width of Hornsea Four offshore cable corridor temporary works buffer (km)	0.5	

4.1.5 Cable Protection

4.1.5.1 The preference for cable protection is to achieve the required cable burial depth as determined through the CBRA. Array, interconnector and export cables will need to be made protected where the cable crosses obstacles such as exposed bedrock, pre-existing cables or pipelines that mean the cable cannot be buried. The cable protection methods considered are:

- rock placement (rock protection);
- mattresses;
- fronded mattresses and;
- rock bags and seabed spacers split pipe.

4.1.5.2 Where cables need to be installed across other cables or pipelines already in place the design and methodology will be reassessed. Within the Hornsea Four offshore ECC and array area there are several existing assets, and others planned, primarily oil and gas pipelines that connect to production wells in the North Sea. The design and methodology of these crossings will be confirmed in agreement with the asset owners, however it is likely that a berm of rock will be placed over the existing asset for protection, known as a pre-lay berm, or separation layer. The Hornsea Four cable will then be covered by a second post lay berm to ensure that the export cable remains protected and in place. For further information refer to the Project Description (**Volume A1, Chapter 4**). For maximum design scenarios for rock placement and cable protection during cable installation please refer to **Table 6**.

Table 6: Maximum design parameters for cable protection.

	Maximum design parameters		
Parameter	*Array cables*	*Offshore interconnector cables*	*Offshore export cables*
Height of post-lay/remedial rock berm (m): Typical design (fishing gear protection)/Maximum design (anchor strike protection)	1.5/(2.7)		
Height of pre-lay rock berm (m)	0.3		
Post-lay width of rock berm at seabed (m): Maximum design (anchor strike protection) / typical design (fishing gear protection)	10.4 (20.2)		
Pre-lay length of rock berm at seabed (m)	25.3		
Post-lay length of rock berm at seabed (m)	500		
Percentage of route requiring protection (%)	10		
Replenishment during operation (% of construction total)	25		
Cable rock protection: maximum rock size (m) (if required to protect from anchor strike)	0.25 (0.5)		
Rock protection area (m^2)	624,000	94,000	792,000
Pro-rata (per cable circuit) rock protection area (m^2)			132,000
Rock protection volume (m^3)	522,000	78,000	849,000
Pro-rata (per cable circuit) rock protection volumes (m^3)			141,500
Number of crossings	32		54
Cable/pipe crossings: pre- and post-lay rock berm area (m^2)	204.000		344,000
Cable/pipe crossings: pre- and post-lay rock berm volume (m^3)	221.000		372,000

4.1.6 Landfall works

4.1.6.1 During intertidal works, a landfall logistics compound (200x200m) is required on the onshore side of the Hornsea Four intertidal area. This will house the TJB works as well as any HDD works required, including supporting equipment and facilities.

4.1.6.2 The offshore export cables are connected to the onshore export cables at six TJBs (to connect the six offshore and onshore cable circuits), located onshore a short distance landward behind the HDD entry points within the landfall HDD compound.

4.1.6.3 TJBs are pits dug and lined with concrete, in which the jointing of the offshore and onshore export cables takes place. They are constructed to ensure that the jointing can take place in a clean, dry environment, and to protect the joints once completed. Once the joint is completed the TJBs are covered and the land above reinstated. It is not expected that the TJBs will need to be accessed during the operation of Hornsea Four.

4.1.6.4 Hornsea Four has committed to HDD, or other trenchless techniques, for the installation of cables at landfall, (see Co 187 of **Volume A4, Annex 5.2: Commitments Register**). As a minimum, Hornsea Four will cross the active coastal cliff using HDD, or other trenchless technique. It may be possible to carry out the HDD to beyond the Hornsea Four intertidal area and install the rest of the cable using an offshore installation spread. The technical feasibility of the length of the HDD approach will require confirmation via an intrusive geotechnical survey campaign.

4.1.6.5 Landfall works include:

- Construction of Landfall Compound;
- HDD Works;
- Construction of Transition Joint Bays;
- Installation of Offshore Export Cables;
- Installation of Onshore Export Cables;
- Transition Jointing Offshore / Onshore Cables;
- Backfilling of Joint Bays; and
- Reinstatement Works.

4.1.6.6 HDD Works include offshore works:

- Excavation of HDD exit pit;
- Potential sheet piling of cofferdam;
- Pull-in of HDD duct from offshore towards the TJB (may conclude in opposite direction); and
- Capping and burial of HDD duct end.

4.1.6.7 Further details of the landfall cable installation method are provided in **Volume A1, Chapter 3: Project Description**.

5 Onshore Cable Installation

5.1 Cable installation methods

5.1.1 Pre-installation activities (onshore ECC)

5.1.1.1 A number of activities may be carried out prior to the cable installation to prepare the onshore ECC Ground investigations, including:

- Soil surveys;
- Drainage Management (see **Volume F2, Chapter 6: Outline Onshore Infrastructure Drainage Strategy**);
- Ecological surveys (see **Volume F2, Chapter 3: Outline Ecological Management Plan**);
- Archaeological surveys (see **Volume F2, Chapter 10: Outline Onshore Written Scheme of Investigation**);
- Hedgerow removal and vegetation clearance (see **Volume F2, Chapter 3: Outline Ecological Management Plan**);
- Demarcation fencing for the cable easement (see **Volume F2, Chapter2: Outline Code of Construction Practice**);
- Access points off the highway installed; and
- Temporary haul road constructed.

5.1.1.2 Further details of each of these activities is provided in **Volume 1, Chapter 4: Project Description** that accompanies this application for Development Consent.

5.1.2 Onshore ECC permanent works

5.1.2.1 Onshore export cables will be installed with a mixture of open trench and HDD techniques. Following completion of the onshore cable installation, the working area will be reinstated to its previous condition landfall (See **Table 7** in this document and Co10 of **Volume A4, Annex 5.2: Commitment Register**).

5.1.2.2 Where possible and practical, less intrusive construction methods will be adopted for example by using HDD to cross environmentally sensitive water courses, major roadways and railways (see Co2 of **Volume A4, Annex 5.2: Commitment Register**).

5.1.2.3 The cables will be buried within ducts, where technically feasible, in multiple separate trenches (up to six trenches, each containing one circuit), however in some circumstances some trenches may be combined to aid installation.

5.1.2.4 Other onshore ECC permanent works may consist of:

- Up to six cable circuits for HVAC or up to four for HVDC;
- Various crossings, located where necessary to pass obstructions;
- Joint Bays (JBs) will be required along the Hornsea Four onshore export cable corridor, these are typically concrete lined pits, which provide a clean, dry and safe environment for jointing the sections of cable together. JBs are similar to TJB (though typically smaller) and will be completely buried, with land above reinstated; and
- Link boxes will also be required along the Hornsea Four onshore ECC. These are smaller pits, compared to JBs, which house connections between the cable shielding, joints for fibre optic cables and other auxiliary equipment. Link boxes will be located between 750 m to 3000 m as stated in the Maximum Design parameters for JBs and Link boxes (for further information see Project Description **Volume A1, Chapter 4**). Land above the link boxes will also be reinstated, however, they may need manhole covers for access during the operational phase.

5.1.3 Cable installation methodology

5.1.3.1 Onshore export cable burial target depth will be 1.2 m deep, 1.5 m wide at the base and 5 m wide at the surface. These dimensions allow for the trench walls to be tapered as necessary for stability.

5.1.3.2 The subsoil will be excavated and stored adjacent to the cable trenches and segregated from the previously stripped topsoil. The trenches will be excavated using mechanical excavators, and the cable and fibre optic ducting will be installed into the open trench.

5.1.3.3 Imported backfill material will surround the cable ducting both below and above the ducting to ensure a consistent structural and thermal environment for the cables. The maximum volumes of imported stabilised backfill material (i.e. that not originating from the excavated trench) are presented in the Project Description (see **Volume A1, Chapter 4**). All excavated material from the trenches will remain on site, unless deemed unsuitable for re-use. Protective tapes or tiles and warning tapes will be installed within the trench to protect the cables from damage from third parties and to provide a warning of their presence.

5.2 Reinstatement

5.2.1.1 Following completion of the onshore cable installation, the working area will be reinstated to its previous condition. Hornsea Four has made a number of commitments with regard to reinstatement which are summarised in **Table 7** . For full details see **Volume A4, Annex 5.2: Commitment Register**.

Table 7: Hornsea Four commitments to reinstatement following the onshore cable installation.

Commitment	Hornsea Four Commitment
Co10	Tertiary: Post-construction, the working area will be reinstated to pre-existing condition as far as reasonably practical in line with DEFRA 2009 Construction Code of Practice for the Sustainable Use of Soils on Construction Sites PB13298 or latest relevant available guidance.
Co19	Tertiary: An Onshore Infrastructure Drainage Strategy will be developed for the permanent onshore operational development in accordance with the Outline Onshore Infrastructure Drainage Strategy. The Onshore Infrastructure Drainage Strategy will include measures to ensure that existing land drainage is reinstated and/or maintained. This will include measures to limit discharge rates and attenuate flows to maintain greenfield run-off rates at the Onshore Substation. The Onshore Infrastructure Drainage Strategy will be developed in line with the latest relevant drainage guidance notes in consultation with the Environment Agency, Lead Local Flood Authority and relevant Internal Drainage Board as appropriate.
Co27	Primary: Trees identified to be retained within the Onshore Crossing Schedule will be fenced off and worked around. Where works are required close to trees that will remain in situ, techniques will be used to safeguard the root protection zone.
Co28	Primary: Joint Bays will be completely buried, with the land above reinstated except where access will be required from ground level, e.g. via link box chambers and manholes.
Co30	Secondary: A Landscape Management Plan will be developed in accordance with the Outline Landscape Management Plan. The Landscape Management Plan will include details of mitigation planting at the onshore substation site, including the number, location, species and details of management and maintenance of planting. Where practical, landscape mitigation planting will be established as early as reasonably practicable in the construction phase.
Co61	Secondary: Prior to the commencement of works, the contractor (or project appointed Agricultural Liaison Officer) will undertake soil condition surveys and intrusive soil survey trial pits to identify and describe the physical and nutrient characteristics of the existing soil profiles. Such work will inform the reinstatement under Co10.
Co68	Secondary: All logistics compounds will be removed and sites will be reinstated when construction has been completed.
Co79	Primary: Disturbance to PRoWs will be temporary where reasonably practicable and PRoWs will be reinstated as soon as reasonably practical. A PRoW Management Plan will be developed in accordance with the Outline PRoW Management Plan. The PRoW

	Management Pan will include details of temporary and permanent diversions, closures, gated crossings and signage to be provided during construction.
Co157	Secondary: Fences, walls, ditches and drainage outfalls will be retained along the onshore export cable corridor and landfall, where possible. Where it is not reasonably practicable to retain them, any damage will be repaired and reinstated as soon as reasonably practical. The Environment Agency must be notified if damage occurs to any EA Main river or related flood infrastructure.
Co168	Tertiary: An Ecological Management Plan (EMP) will be developed in accordance with the Outline Ecological Management Plan (OEMP). The OEMP includes, but is not limited to pre-construction (Section 3), construction (Section 4) and post-mitigation measures (Section 5) relating to: habitats, hedgerows, birds, bats, badgers, otters, water voles, reptiles, great crested newts, terrestrial invertebrates, and other protected or notable species where relevant . The EMP will include details of any long-term mitigation and management measures relevant to onshore ecology and nature conservation. The EMP will be developed in consultation with the relevant responsible authorities.
Co172	Secondary: The bed and banks of watercourses will be reinstated to their pre-construction condition following the removal of any temporary structures. Culverts will not be used for temporary access track crossings across EA Main Rivers. Where a temporary access track crossing across an EA Main River may be required, clear span/ bailey bridges will be used. There will be no loss of cross-sectional area to Environment Agency (EA) Main rivers.
Co194	Enhancement: Where agreed with landowners, removed hedgerows and trees will be replaced with hedgerows of a more diverse and locally native species composition than that which was removed.
Co198	Enhancement: An Enhancement Strategy will be developed in accordance with the Outline Enhancement Strategy. The Outline Enhancement Strategy will include proposed measures to provide enhancement and will not inform the EIA process. Proposed enhancement measures include but are not limited to; provision of historic signage at landfall; improvements to PRoWs; wider biodiversity, hydrological and social enhancement measures across the onshore Order Limits.