RWE Renewables UK Dogger Bank South (West) Limited

RWE Renewables UK Dogger Bank South (East) Limited

Dogger Bank South Offshore Wind Farms

Preliminary Environmental Information Report

Chapter 05 – Project Description

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Glossary

Term	Definition
Accommodation Platform	An offshore platform (situated within either the DBS East or DBS West array area) that will provide accommodation and mess facilities for staff when carrying out maintenance activities for the Projects.
Array Cables	Cables which link the wind turbine generators to the offshore substation/converter/collector platform(s).
Collector Platforms (CPs)	Receive the AC power generated by the wind turbines through the array cables, collect it and transform the voltage for onward transmission to the Offshore Converter Platforms (OCPs).
Dogger Bank South (DBS) Offshore Wind Farms	The collective name for the two Projects, DBS East and DBS West.
Electrical Switching Platform (ESP)	The electrical switching platform (if required) will provide a link to a co-ordinated east coast transmission system which is planned to run from Scotland to England, as per National Grid ESO's Holistic Design Network. This platform may be located either within one of the array areas (alongside a converter station) or mid-way along the export cable corridor (likely next to the Reactive Compensation Platform if required).
Haul Road	The track used by traffic to access different sections of the onshore export cable corridor for construction.
Horizontal Directional Drill (HDD)	HDD is a trenchless technique to bring the offshore cables ashore at the landfall and can be used for crossing other obstacles such as roads, railways and watercourses onshore.
Jointing Bays	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.

Term	Definition
Inter-Platform Cables	Cables linking offshore platforms.
Landfall	The point on the coastline at which the offshore export cables are brought onshore, connecting to the onshore export cables at the Transition Joint Bay.
Link Boxes	Below ground structures housing cable equipment, located along the onshore export cable corridor alongside the jointing bays.
Offshore Converter Platforms (OCPs)	Offshore Converter Platforms (OCPs) will be required for the HVDC option. The OCPs are fixed structures located within the array area that collect the AC power generated by the wind turbines and convert the power to DC, before transmission through the offshore export cables to the Project's onshore grid connection points.
Offshore Development Area	The Offshore Development Area encompasses the wind farm site and the options for the offshore transmission works.
Offshore Export Cables	The cables which would bring electricity from the offshore substation platform(s) to the landfall.
Offshore Export Cable Corridor	This is the area which will contain the offshore export cables (and potentially the ESP and / or RCP) between the offshore substation/converter platforms and Transition Joint Bays at the landfall.
Offshore Substation Platform (OSPs)	Offshore Substation Platforms (OSPs) will be required for the HVAC option. These are fixed structures located within the array areas that contain electrical equipment to aggregate the power from the wind turbines, followed by conversion into a more suitable voltage for transmission through the offshore export cables to the Project's onshore grid connection points.

Term	Definition
Onshore Development Area	The Onshore Development Area for PEIR is the boundary within which all onshore infrastructure required for the Projects will be located including landfall, onshore export cable route, accesses, construction compounds and onshore substations. The Onshore Development Area is to be refined through the consultation and engineering review process.
Onshore Export Cables	Onshore export cables take the electricity from the Transition Joint Bay to the onshore substations.
Onshore Export Cable Corridor	This is the area which includes cable trenches, haul roads, spoil storage areas, and limits of deviation for micro-siting. For assessment purposes, the cable corridor does not include the onshore substations, Transition Joint Bays or temporary access routes; but includes construction compounds (purely for the cable route).
Onshore Substations	A compound containing electrical equipment required to transform and stabilise electricity generated by the Projects so that it can be connected to the electricity transmission network. There will be one onshore substation for each Project.
Onshore Substation Zone	Parcels of land within the Onshore Development Area where the onshore substation infrastructure (including the haul roads, temporary construction compounds and associated cable routeing) may be located. Two substation zones are presented in PEIR referred to as Substation Zone 1 and Substation Zone 4.
Reactive Compensation Platform (RCP)	A Reactive Compensation Platform (RCP) will be required for a HVAC solution. The RCP will host the shunt reactors required to provide reactive compensation, in order to limit the electrical losses which occur with HVAC transmission over long distances.

Term	Definition
Safety Zones	Legislated under the Energy Act 2004, safety zones are rolling buffer areas which protect construction activities by preventing unauthorised vessels from entering their boundary.
Scoping Opinion	The report adopted by the Planning Inspectorate on behalf of the Secretary of State.
Scoping Report	The report that was produced in order to request a Scoping Opinion from the Secretary of State.
Scour Protection	Protective materials to avoid sediment erosion from the base of the wind turbine foundations and offshore platform foundations due to water flow.
The Applicant	RWE Renewables UK Dogger Bank South (West) Limited and RWE Renewables UK Dogger Bank South (East) Limited as the owners of DBS West and DBS East respectively are the named undertakers that will have the benefit of the Development Consent Order. References in this document to obligations on, or commitments by, 'the Applicant' are given on behalf of RWE Renewables UK Dogger Bank South (West) Limited and RWE Renewables UK Dogger Bank South (East) Limited.
The Projects	DBS East and DBS West (collectively referred to as the Dogger Bank South offshore wind farms).
Topic Specific Study Area	Area where potential impacts from the Projects could occur, as defined for each individual EIA topic.
Transition Joint Bay (TJB)	The Transition Joint Bay (TJB) is an underground structure at the landfall that houses the joints between the offshore export cables and the onshore export cables.
Turbine String	Term referring to how array cables are installed in individual lengths from one turbine to its neighbour, forming a string (or collection) circuit.

Acronyms

Term	Definition
AfL	Agreement for Lease
AIS	Air Insulated Switchgear
CAA	Civil Aviation Authority
CBS	Cement Bound Sand
CP	Collector Platform
CoCP	Code of Construction Practice
COMAH	Control of Major Accident Hazards
CSIMP	Cable Specification, Installation and Monitoring Plan
CTV	Crew Transfer Vessel
DBS	Dogger Bank South
DCO	Development Consent Order
DP	Dynamic Positioning
DTS	Distributed Temperature Sensing
EIA	Environmental Impact Assessment
ES	Environmental Statement
ESO	Electricity System Operator
ESP	Electrical Switching Platform
GBS	Gravity Base Structures
GIS	Gas Insulated Switchgear
GW	Gigawatt

Term	Definition
HAT	Highest Astronomical Tide
HDD	Horizontal Directional Drilling
HV	High Voltage
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
km	Kilometres
kV	Kilovolt
LAT	Lowest Astronomical Tide
MCA	Maritime and Coastguard Agency
MCZ	Marine Conservation Zone
MGN	Marine Guidance Notice
MHWS	Mean High Water Springs
MW	Megawatts
NPPF	National Planning Policy Framework
NRA	Navigational Risk Assessment
NSIP	Nationally Significant Infrastructure Project
OCP	Offshore Converter Platform
Ofgem	Office of Gas and Electricity Markets
OFTO	Offshore Transmission Owner
OSP	Offshore Substation Platform
O&M	Operations and Maintenance

Term	Definition
PEIR	Preliminary Environmental Information Report
RCP	Reactive Compensation Platform
ROV	Remotely Operated Vehicle
SAC	Special Area of Conservation
SCADA	Supervisory Control and Data Acquisition
SF6	Sulphur Hexafluoride
SVC	Static Var Compensator
TCE	The Crown Estate
THLS	Trinity House Lighthouse Service
TJB	Transition Joint Bay
UPS	Uninterruptible Power Supply
UXO	Unexploded Ordnance

5 Project Description

5.1 Introduction

1. This chapter of the Preliminary Environmental Information Report (PEIR) provides a description of the key components of the proposed Dogger Bank South (DBS) East and DBS West offshore wind farms (herein 'the Projects') as well as details of how the Projects will be constructed, operated, maintained and decommissioned. These details inform and underpin the assessments that have been undertaken, although **Chapters 8 – 30** should be referred to for details of the worst case scenarios that apply for each topic assessment.
2. The Projects will have a combined maximum number of 200 turbines. The closest point to the coast is 100 kilometres (km) from DBS West and 122km from DBS East (**Figure 5-1**).
3. The proposed onshore construction works consist of installation of buried onshore export cables, from a landfall on the East Riding of Yorkshire coastline near Skipsea to (up to) two newly constructed onshore substations before onward onshore cable routeing to a proposed new National Grid substation near Creyke Beck, to the south of Beverley.
4. The key offshore components comprise:
    - Wind turbines;
    - Offshore platforms, including offshore substation platforms (OSPs), offshore converter platforms (OCPs), collector platforms (CPs), a Reactive Compensation Platform (RCP), an Electrical Switching Platform (ESP) and/or an Accommodation Platform (hereafter collectively referred to as offshore platforms unless specified);
    - Foundation structures for wind turbines and offshore platforms;
    - Array cables;
    - Inter-platform cables;
    - Offshore export cables from the array areas to the landfall; and
    - Scour/cable protection (where required).

5. The key onshore components comprise:

- Landfall and associated transition joint bays;
- Onshore export cables installed underground from the transition joint bays (TJBs) to the onshore substations and associated joint bays and link boxes;
- Onshore substations and onward 400 kilovolt (kV) connection to a proposed new National Grid substation near Creyke Beck, to the south of Beverley;
- Trenchless crossing locations (e.g. Horizontal Directional Drilling (HDD));
- Construction and operational accesses; and
- Construction compounds.

5.1.1 Project Development Scenarios

6. As set out in **Chapter 1 Introduction**, whilst the Projects are each Nationally Significant Infrastructure Projects (NSIPs) in their own right, a single application for development consent will be made to address both wind farms, and the associated transmission infrastructure. A single planning process and Development Consent Order (DCO) application is intended to provide for consistency in the approach to the assessment, consultation and examination. While a single DCO application will be made for both Projects, separate Deemed Marine Licences will be requested as schedules to the DCO to cover the array areas and associated transmission infrastructure for each of the Projects. This approach allows each Project to retain rights to their own particular assets should ownership of each Project change over time.

7. The Applicant will develop DBS East and DBS West transmission infrastructure as co-ordinated projects in accordance with the high-level intentions of the Holistic Network Design as presented by National Grid Electricity System Operator (ESO). Where practicable the two Projects will co-locate infrastructure to reduce the overall environmental impact and disruption.

8. Whilst the Projects will be the subject of a single DCO application (with a combined Environmental Impact Assessment (EIA) process and associated submissions), each Project is assessed individually, so that mitigation is Project specific (where appropriate). As such, the assessments cover the possibility that:

- DBS East or DBS West are developed in isolation; or
- Both DBS East and DBS West are developed, either concurrently or sequentially.

9. There are currently two possible electrical solutions being considered for DBS West, HVAC or HVDC. Due to the distance of the array area offshore DBS East will be an HVDC project. Therefore, there are two possible electrical solutions for the Projects:

- One HVDC project and one HVAC project; or
- Two HVDC projects.

10. Offshore the most significant difference between an HVAC solution and an HVDC solution is that if an HVAC electrical solution is used, a RCP will be required along the offshore export cable. In addition, the combined HVAC and HVDC solution will require six export cables offshore, with only four export cables being required for two HVDC projects.

11. In order to ensure that a robust assessment has been undertaken, all development scenarios and options have been considered to ensure the realistic worst case scenario for each topic has been assessed. Further details are provided within the worst case tables in **Chapters 8** - **30**.

12. There are different parameters required for the onshore substations depending on which electrical solution is selected. Therefore, there are four possible development scenarios within the onshore substation zones that could be taken forward:

- Two HVDC substations in Substation Zone 4;
- One HVDC substation in Substation Zone 1 and one HVAC substation in Substation Zone 4;
- One HVDC substation in Substation Zone 4 and one HVAC substation in Substation Zone 1; or
- One HVDC substation in Substation Zone 1 and one HVDC substation in Substation Zone 4.

13. The development scenarios within the onshore substation zones are illustrated in **Figure 5-2**.

14. The EIA considers the appropriate realistic worst case associated with the different development scenarios and presents the results accordingly. The information provided in this chapter is designed to clearly show how the project design envelope would differ depending on which scenario may be taken forward.

15. In summary, the following principles set out the framework for how the Projects may be developed:

- DBS West and DBS East may be constructed at the same time, or at different times;
- If built concurrently, both Projects could be constructed in five years;
- If built non-concurrently, either Project could be built first;
- If built non-concurrently, each Project would require a five year period of construction;
- If built non-concurrently, it is anticipated that there would be up to a two year lag between the start of construction for the first project and the start of construction for the second project; and
- Assuming a maximum construction period per Project of five years, and taking the above into account, the maximum construction period over which the construction of both Projects could take place is seven years.

16. The impact assessments therefore consider the following development and build out scenarios:

- Build DBS East or DBS West in isolation;
- Build DBS East and DBS West concurrently – reflecting the maximum peak effects; and
- Build DBS East and DBS West sequentially with a gap of up to two years between the start of construction of each Project – reflecting the maximum duration of effects.

17. The individual, concurrent and sequential construction scenarios all allow for flexibility to build out the Projects using a phased approach. This will allow the Projects to adapt to National Grid Electricity Transmission Operator's development plans for the onshore grid connection points.

5.1.2 Flexibility and the Project Design Envelope

18. The project design envelope described in this chapter provides for a reasoned minimum and maximum extent for each parameter. The detailed design of the Projects will be developed and refined within this consented envelope prior to construction, with the final design lying between the minimum and the maximum extent of the consent. This approach to the EIA, also known as the 'Rochdale Envelope' approach, is further described in **Chapter 6 EIA Methodology**.

19. The information presented in this chapter outlines the options and flexibility required along with the range of potential design and activity parameters upon which the subsequent impact assessment chapters are based. The envelope will continue to evolve throughout the EIA process, prior to being fixed at a point between the consultation on the draft assessments presented in this PEIR and completion of the Environmental Statement (ES) that will be submitted alongside the DCO application.

20. The need for flexibility in the consent is a key aspect of any large development, but is particularly significant for offshore wind projects where technology continues to evolve quickly. The project design envelope must therefore provide sufficient flexibility to enable the Applicant and its contractors to use the most up to date, efficient and cost-effective technology and techniques in the construction, operation, maintenance and decommissioning of the Projects.

21. Key aspects of the Projects for which flexibility in the project design envelope is required include:

- Wind turbine capacity, including parameters such as maximum tip height and foundation type, to benefit from improvements in technology prior to offshore construction;
- Construction and maintenance methodologies, as above, to enable competitive procurement and the most cost-effective option to be adopted post-consent; and
- The development scenarios detailed in section 5.1.1, namely that either DBS East or DBS West are developed in isolation, or DBS East and DBS West are both developed, either concurrently or sequentially.

22. This chapter outlines the full range of parameters for the aspects of the Projects where flexibility is required.

5.1.3 Site Description

5.1.3.1 Offshore

23. The Projects are located in the Dogger Bank region of the southern North Sea, with the closest point to the coast being 100km from DBS West and 122km from DBS East. The Offshore Development Area includes the Projects array areas as defined by The Crown Estate Agreements for Lease (AfL) areas plus a 1km temporary construction area buffer and the offshore export cable corridor with a 500m temporary construction area on both sides of the offshore export cable corridor (**Figure 5-3**). The offshore export cable corridor also widens to approximately 3km at the Langeled pipeline crossing location, and widens to a maximum of 4km when approaching the possible landfall locations.

24. The minimum and maximum water depths within the array areas at the time of the site-specific geophysical survey ranged from 14.2m to 41.8m below the lowest astronomical tide (LAT)) (Fugro, 2023). The bathymetric profile across the array areas indicates that the seabed rises from north-west to south-east up the western flank of Dogger Bank and then becomes broadly flat across the top of the bank before falling again on the southern flank (see **Plate 5-1**).

25. The seabed along the offshore export cable corridor gently slopes from the proposed landfall location where water depths are shallow to a maximum of -60m LAT about 8km offshore. Water depths then shallow to a minimum of -15m LAT as the offshore export cable corridor approaches the array areas (see **Plate 5-2**).

26. The geology of the array areas is expected to comprise a sequence of Pleistocene sands and clays, overlain by Holocene marine sands. The thickness of the Pleistocene and Holocene sediments beneath the Projects' array areas is typically approximately 100m and bedrock is characterised by undifferentiated Mesozoic claystone, mudstone, siltstone and potentially chalk.

Plate 5-1 Array Areas Bathymetry Overview

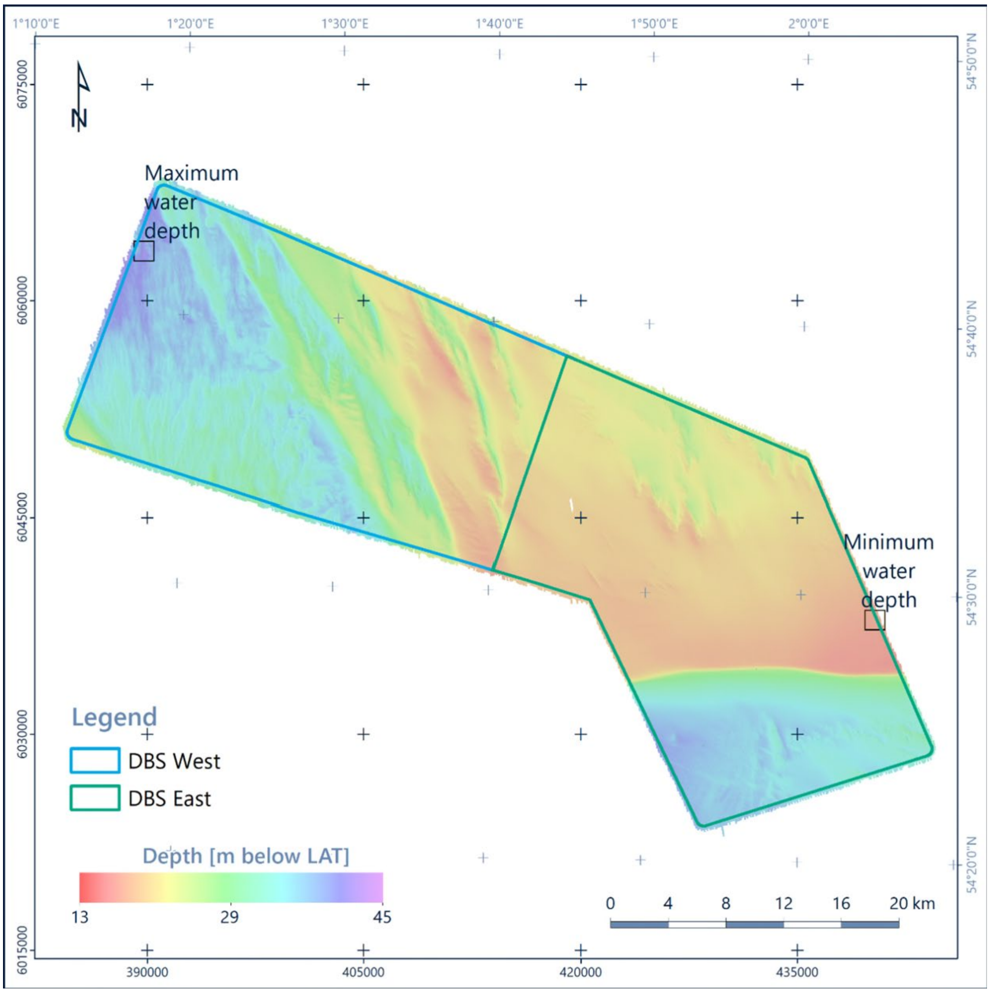
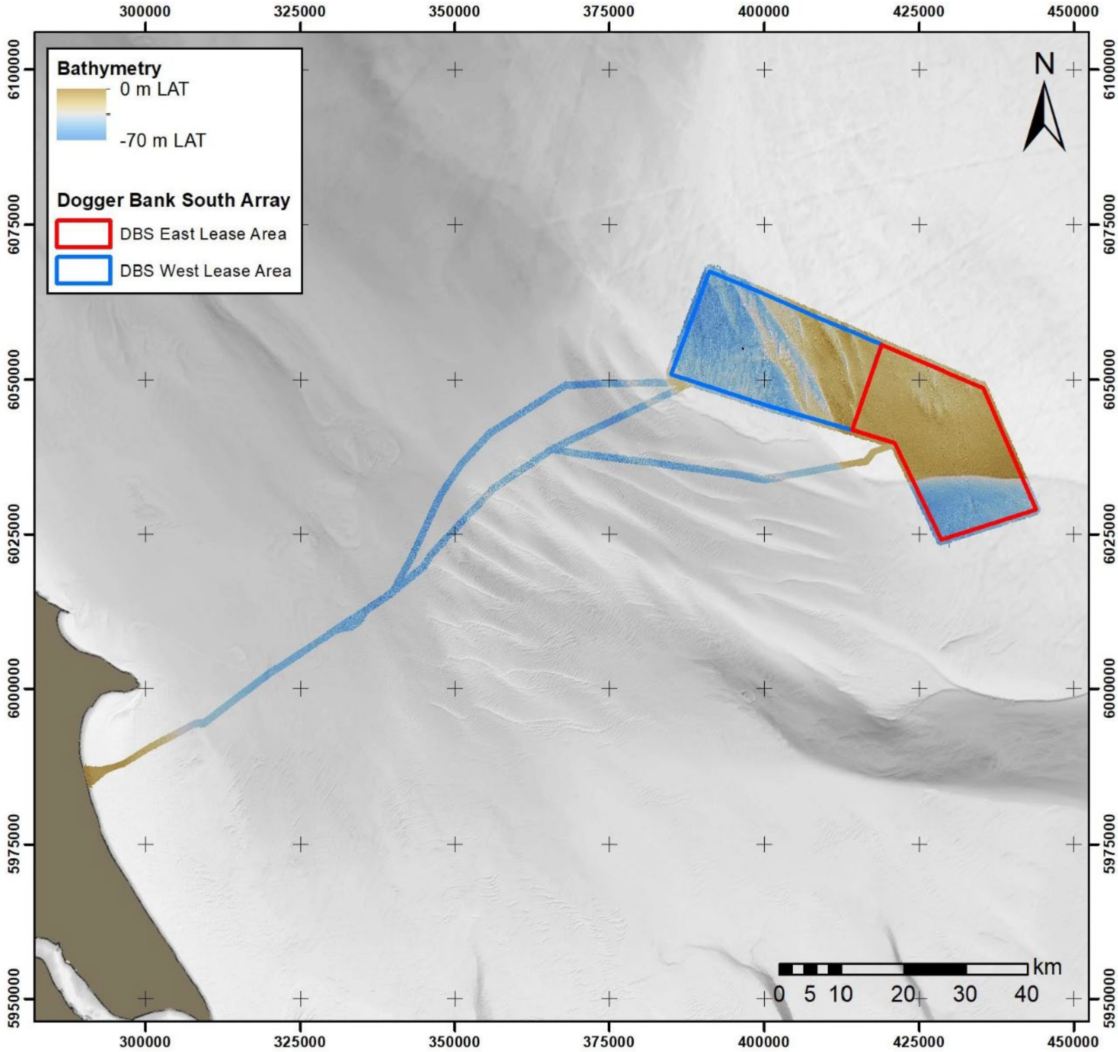


Plate 5-2 Offshore Export Cable Corridor Bathymetry Overview



27. The shallow geology along the offshore export cable corridor is expected to predominantly comprise a surficial layer of transgressive and marine Holocene sands, increasing in thickness from west to east. To a variable spatial and vertical extent, Holocene sediments are expected to form a cover overlying glacial deposits of the Weichselian glaciation, including Dogger Bank Formation, Botney Cut Formation, and Bolders Bank Formation, often as channel infill deposits. These deposits are in turn expected to be typically underlain by Pleistocene deposits to the east, and undifferentiated Triassic/Jurassic mudstones and Upper Cretaceous Chalk bedrock in central and western parts of the corridor, with Chalk dominant towards landfall. Locally, in central and western areas of the corridor, bedrock is expected to outcrop and/or subcrop within the depth of interest for cable installation. Where pre-Weichselian Pleistocene deposits are present, these are expected to comprise sands, gravelly sands and clays, likely to derive from the Eem, Egmond Ground and Swarte Bank Formations, and Early to Middle Pleistocene formations of the Yarmouth Roads and Markham's Hole, increasing in thickness from west to east, thus resulting in an increased depth to bedrock towards the array. There is potential for peat/organic rich material to be present within periglacial deposits of the Dogger Bank/Botney Cut Formations and transgressive early Holocene sand deposits, particularly towards landfall where peat is locally observed onshore.

28. The array areas of both Projects lie within the boundaries of the Dogger Bank Special Area of Conservation (SAC) and Southern North Sea SAC. The offshore export cable corridor passes through the Dogger Bank SAC, Southern North Sea SAC and Holderness Inshore Marine Conservation Zone (MCZ). The offshore export cable corridor routes approximately 700m north-west of the Holderness Offshore MCZ and 3km south-east of the Flamborough Head SAC as it approaches the coast.

5.1.3.2 Onshore

29. The onshore site selection process has sought to avoid settlements, sensitive habitats and taken into account other technical and environmental constraints (see **Chapter 4 Site Selection and Assessment of Alternatives**). As a result, the landfall, onshore export cable corridor and onshore substation zones are located in predominantly agricultural areas. There are a number of towns and villages in proximity to the proposed Projects infrastructure including Skipsea, Sigglesthorne, Catwick, Long Riston, Routh, Tickton, Walkington and Beverley (**Figure 5-4**).

30. From the possible landfall locations at Skipsea, the onshore export cable corridor travels west, crossing Hornsea Road (B1242), and continuing to Dunnington Lane before turning and heading south past Dunnington, Nunkeeling, Catfoss, and across West Road (A1035) at Sigglesthorne.

31. The onshore export cable corridor then turns southwest and continues passing the village of Riston Grange, crossing Whitecross Road (A165) and again crossing Hornsea Road (A1035) as it heads west north of Tickton. The route then crosses Driffield Road (A164) to the north of Beverley before turning south crossing Constitution Hill (A1035) to the west of Beverley, down across York Road, Newbald Road, and Broadgate (B1230), before reaching the onshore substation zones located at Beverley Road along the A1079 and A164.

32. The onshore substations will be located in proximity to the onshore grid connection points. The onshore substations will contain the necessary electrical and auxiliary equipment and components for transforming the power from the wind farm to 400kV to meet the UK Grid Code for connection to the transmission grid.

33. The onshore gird connection points for the Projects' were determined by the Holistic Network Design (HND) process, the results of which were published in July 2022 and identified connections for both Projects to the UK electricity network would be made at a new National Grid substation in the vicinity of the existing National Grid Creyke Beck substation.

5.2 Consultation

34. The Applicant is undertaking an extensive programme of community and stakeholder consultation to inform the EIA process and the design of the Projects. Further details are provided in:

- **Chapter 6 EIA Methodology** – an overview of the consultation undertaken in the context of the wider EIA process; and
- **Chapter 7 Consultation** – summarises the consultation undertaken to inform and focus the approach to each technical aspect of the EIA. Specific details of how the Projects have taken account of the comments received are provided in each chapter of the PEIR where relevant.

35. Full details of the consultation process including wider community consultation will also be presented in the Consultation Report, which will be submitted as part of the DCO application.

36. **Table 5-1** summarises the key Scoping Opinion responses that relate specifically to the development of the project description at the PEIR stage. Further details are provided in the relevant technical chapters.

Table 5-1 Summary of Key Scoping Opinion Responses Related to the Development of the Project Description at the PEIR Stage

Reference	Comment	Project Response
Scoping Opinion		
2.1.1	"The Scoping Report does not confirm when a decision would be made on the approach to the consenting strategy, and whether the Dogger Bank South (East) and Dogger Bank South (West) projects, which comprise the Proposed Development, will be constructed concurrently or sequentially. It will be critical for the ES to clearly explain the implications of this decision, for example in relation to the description of the development, the phasing of construction and operation, the assessment of the cumulative effects of the two NSIPs, and the timings and security of any environmental mitigation and monitoring proposed. Careful consideration should be given to the presentation of this information to enable the relationship between the two projects to be clearly understood."	Whilst the Projects will be the subject of a single DCO application (with a combined Environmental Impact Assessment (EIA) process and associated submissions), each Project is assessed individually, so that mitigation is specific to each development scenario. As such, the assessments cover the possibility that: • DBS East or DBS West are developed in isolation; or • Both DBS East and DBS West are developed, either concurrently or sequentially. In order to ensure that a robust assessment has been undertaken, all development scenarios and options have been considered to ensure the realistic worst case scenario for each topic has been assessed. Further details are provided within the worst case tables in **Chapters 8 - 30**.
2.2.1	The Scoping Report makes reference to the potential use of a multipurpose interconnector, private offtake, integration with future hydrogen infrastructure or a combination of these in place of a 'conventional' connection (see Table 2.3 below). It goes on to present information based on the assumption of a conventional grid connection to the connection point listed in Paragraph 3. It does not provide any further information on the alternative connection methods. It is unclear to what degree the options being considered will be established prior to the production of the ES. The Inspectorate considers that the connection method should be presented in the ES to avoid an assessment based on an array of differing environmental options and effects, which would make a robust assessment, compliant with the requirements of Regulation 14 of the EIA Regulations difficult to achieve. The Inspectorate expects the ES supporting the application for the Proposed Development to describe the preferred option for connection and the assessment of the likely significant effects to be carried out on that basis.	The options taken forward for further assessment are detailed within this chapter and summarised in sections 5.3 and 5.3.1. The consideration of alternative options is detailed in **Chapter 4 Site Selection & Assessment of Alternatives**. Connection to the national grid via a third party's infrastructure (e.g. a multi purpose interconnector) remains as a potential connection option. Based on current information it is assumed that this option would fit within the Projects' redline boundary and envelope and any likely significant effects would therefore be the same as the assessed options.

Reference	Comment	Project Response
2.2.2	The ES must clearly explain the anticipated construction phasing between the two Dogger Bank South projects (East and West). In particular, to what extent the projects would be constructed concurrently or sequentially and how this has informed the worst-case scenario assessed in the ES. The Inspectorate acknowledges the statement in Paragraph 67 in this regard, however, advises the applicant to ensure all assumptions around construction phasing on which the ES is based are clearly explained.	The assessments cover the possibility that: • DBS East or DBS West are developed in isolation; or • Both DBS East and DBS West are developed, either concurrently or sequentially. Section 5.7 provides an indicative construction programme for each development scenario, for both the offshore and onshore works. In order to ensure that a robust assessment has been undertaken, all development scenarios and options have been considered to ensure the realistic worst case scenario for each topic has been assessed. Further details are provided within the worst case tables in **Chapters 8 - 30**.
2.2.3	The information in Section 1.5 of the Scoping Report provides a generalised project description, with some indicative parameters provided in Table 1-2. Paragraph 33 of the Scoping Report States that "The Projects' design envelope allows for up to 300 10-Megawatt (MW) wind turbines (up to 150 for each Project). Turbine numbers will reduce if higher capacity wind turbines are installed". However, it also states that 10MW is likely to be at the lower end of the design envelope. Table 1-2 provides indicative parameter information related to the size of the turbines, but it is not clear if this is based on a 10MW turbine or an unstated higher capacity turbine. This should be clarified in the ES.	Minimum and maximum turbine parameters are detailed in section 5.4.2**.**
2.2.3	Table 1-2 indicates that the onshore cable corridor would consist of one main corridor, to be split in two at pinch points or on approaches to substations. It is not clear how the maximum cable corridor width stated in Table 1-2 accommodates this approach. The Inspectorate considers that the presence of multiple cable corridors has the potential to introduce effects over a wider area than specified, and that the ES must ensure that the corridor width reflects that to which the assessment of significant effects has been based." The ES must clearly define the parameters of the Proposed Development, including in relation to the number, height, blade	The preferred onshore export cable corridor and parameters are detailed in sections 5.6.1.1 and 5.6.1.2. The onshore export cable corridor options have been reduced as a result of further engineering feasibility, consultation with stakeholders and a review of constraints. The decision making is outlined within **Chapter 4 Site Selection and Alternatives.** Parameters for the offshore and onshore components of the Projects are detailed in section 5.4 and 5.6 respectively. The realistic worst-case scenario for each topic is provided in their respective chapters.

Reference	Comment	Project Response
	dimensions, foundation type and dimensions including depth of penetration, and capacity of turbines. The ES should be based on set parameters and include all project specific information on which the environmental assessments of the worst-case likely significant effects have been based. The ES should also consider the effects of any infrastructure that is to remain in situ following decommissioning.	
2.2.4	The 'Rochdale Envelope' approach is employed when there is a need to seek flexibility to address uncertainty. The Applicant should make every attempt to narrow the range of options and explain clearly in the ES which elements of the Proposed Development have yet to be finalised and provide the reasons. The description of the Proposed Development in the ES must not be so wide that it is insufficiently certain to comply with the requirements of Regulation 14 of the EIA Regulations. The need and justification to support the level of flexibility sought must be explained in the ES, including how it has been taken into account in the assessments through relevant parameters (temporal and spatial) and a defined worst-case for resulting environmental effects. It will be essential to ensure consistency throughout the ES and any other relevant assessments supporting the application from which the ES draws. It should be noted that if the Proposed Development materially changes prior to submission of the DCO application, the Applicant may wish to consider requesting a new scoping opinion.	The required flexibility in design envelope, and its justification, is outlined in section 5.1.2 and further detailed in **Chapter 6 EIA Methodology**. The design parameters necessary for a robust environmental assessment for each potential project scenario, namely DBS East and DBS West combined, or a Project in isolation, are presented in this chapter. Justification for the decisions made in narrowing the design envelope with regards to elements such as onshore/offshore cable routes, substation zones and cable landfalls is provided in **Chapter 4 Site Selection & Assessment of Alternatives**.

Reference	Comment	Project Response
2.2.5	Paragraph 42 identifies that the current options for the export cable technologies are for both projects to use High Voltage Direct Current (HVDC), or for one to use HVDC and the other to use High Voltage Alternating Current (HVAC). No reasons are given at present for the selection of either of these options (including the need for additional substations, converter platforms or reactive compensation platforms), or why the use of HVAC for both projects is not considered further. The ES should provide a justification of the technologies used and an assessment of alternatives, including an explanation as to how any additional construction that would result from either proposal is assessed within the ES.	Both HVDC and HVAC remain options under consideration, and worst case parameters are provided for all scenarios to allow for a robust assessment (see section 5.3, 5.4, 5.5 and 5.6). Justification of the technologies used, and an assessment of alternatives is provided in **Chapter 4 Site Selection & Assessment of Alternatives**.
2.2.6	Table 1-2 identifies the need for accommodation platforms. The Table also lists 'reactive compensation platforms' which are also mentioned in Paragraph 43. Any platforms incorporated in the Proposed Development must be described in the ES and effort should be made to refine the design and number of platforms used. The project description in the ES should also include any other applicable offshore elements, for example meteorological masts.	Details of the platforms that may be required are included in section 94. This includes the potential need for a RCP and accommodation platforms.
2.2.7	There is no mention in the Scoping Report of the intention to include any electricity balancing infrastructure as part of the Proposed Development. If such infrastructure is to form part of the Proposed Development, this must be included in the project description in the ES.	No battery storage is proposed for the Projects.

Reference	Comment	Project Response
2.2.8	The ES should demonstrate how the principles of 'good design', as set out in National Policy Statement (NPS) EN-1 and EN-3, have been applied to the Proposed Development including the onshore substations, and how this information has been taken into account within the assessments of likely significant effects.	The guidance of NPS EN-1 and EN-3 with regard to good design has been taken into consideration in the development of the Design Envelope. Selection of the proposed Projects and assessment of alternatives is detailed in **Chapter 4 Site Selection & Assessment of Alternatives**. Consideration of 'good design' in terms of embedding mitigation in the Projects design also occurs in the relevant receptor topics in **Chapters 8 - 30**.
2.3.1	The Inspectorate acknowledges the Applicant's description of work undertaken to date regarding site selection as set out in Section 1.6 of the Scoping Report. No reference to alternatives in relation to turbine array layout is made, however it is noted that Paragraph 35 in Section 1.5 discusses factors that will influence the final layout. The ES should explain how these factors have been considered within the discussion of alternatives, where alternative layouts have been assessed. The Inspectorate would expect to see a discrete section in the ES that provides details of the alternatives studied and the reasoning for the selection of the chosen option(s), including a comparison of the environmental effects, with reference to the Black-Red-Amber-Green ranking referenced in Paragraph 78.	The wind turbine layout will not be finalised until much closer to the time of construction, following completion of detailed pre-construction wind resource studies, site investigations and the selection of the preferred turbines and their foundations. Selection of the proposed project design and assessment of alternatives is detailed in **Chapter 4 Site Selection & Assessment of Alternatives.** Alternative layouts, and their impacts on shipping and navigation, are detailed in **Chapter 14 Shipping and Navigation** and the accompanying Navigational Risk Assessment (NRA) to that chapter.
2.3.2	Paragraph 92 of the Scoping Report indicates that the onshore cable corridor scoping boundary comprises five route variations. These routes are not provided, either within a figure or accompanying text, and as such it is not clear where the routes would be. Paragraph 97 indicates that there are three onshore substation location zones, which are also not represented on a figure. The ES should clearly describe any alternative cable routes and substation locations assessed, including the use of appropriate figures, and provide a justification for the chosen options.	The areas under consideration for the onshore export corridor routes and onshore substation are detailed in section 5.6.1 and displayed in **Figure 5-4**. Selection of the proposed infrastructure options and assessment of alternatives is detailed in **Chapter 4 Site Selection & Assessment of Alternatives.**
2.3.3	The Scoping Report describes the potential use of alternatives in the place of a 'conventional' connection (Section 1.1 Paragraph 5). The Inspectorate expects the ES supporting the application for	The options taken forward for further assessment are detailed within this chapter and summarised in sections 5.3 and 5.3.1. The consideration of alternative options is detailed in **Chapter 4 Site Selection & Assessment of Alternatives**.

Reference	Comment	Project Response
	the Proposed Development to describe the preferred option for connection and an assessment of the alternatives considered.	Connection to the national grid via a third party's infrastructure (e.g. a multi purpose interconnector) remains as a potential connection option. Based on current information it is assumed that this option would fit within the Projects' redline boundary and envelope and any likely significant effects would therefore be the same as the assessed options.
2.3.4	The ES should provide specific information on where any restricted working widths or seasonal restrictions are to apply during construction. The choice of construction methodology e.g., through open-cut trench or Horizontal Directional Drilling (HDD) or other trenchless methods, should be justified and explained in the ES. The Inspectorate advises that effort is made to commit to a construction method particularly in sensitive locations, and for the ES assessment to be based on the chosen method rather than introduce unnecessary uncertainty by retaining multiple options.	The construction methods under consideration for offshore, landfall, and onshore elements are detailed in sections 5.4, 5.5, and 5.6, respectively.
2.3.4	The Inspectorate would expect the ES to explain how the outcomes of consultation with stakeholders has been used to refine the site selection options. This is likely to be particularly important where options for micro-siting infrastructure are limited by the presence of other existing or planned infrastructure proposals.	The outcomes of stakeholder consultation and how these outcomes are addressed are tabulated in a consultation table such as this for each chapter of this PEIR. Consultation pertaining to site selection is displayed in **Chapter 4 Site Selection & Assessment of Alternatives.**
Other Consultation		
MoD	The landfall and onshore elements of the proposal, described in section 1.5.2 and 1.5.3 of the Scoping Report, identifies landfall at one of two sites close to Skipsea and an 80km² area within which two substations may be sited and an export cable will connect landfall with onshore substations. As the proposal matures MOD would hope to be consulted in order that any impact on MOD assets can be identified.	The latest proposed landfall options are detailed in section 5.5. The MOD will be further consulted following further refinement of the landfall and onshore cable route options.

Reference	Comment	Project Response
Natural England Annex B	In the majority of instances our original comments remain relevant (Annex C) as the scoping report continues to be too high level to advise with more specific technical detail. The focus of our advice is therefore on the transmission assets as the generation scoping remains mostly unchanged.	Noted.
Natural England Annex C 1	Please consider definitions of temporal scale, duration, and spatial extent carefully. Please also consider the different phases of the development when defining the significance of an impact.	The maximum and minimum limits of parameters in the project design envelope are detailed in this chapter, allowing assessment to proceed on a worst case scenario basis in the relevant topics in **Chapters 8 - 30**.
Natural England Annex C 3	At this point in time the onshore search area is too large for Natural England to meaningfully comment on. We therefore advise that nothing is scoped out at this stage and request that the Project consider the best practice EIA guidance provided in Annex A. We recommend that further information is provided for consultation once the transmission asset locations are known.	Noted, and the onshore elements of the Projects have now been refined and presented in this chapter. Where impacts are proposed to be scoped out, either due to refinement of onshore export cable corridor options, or through additional baseline information, this scoping out is given further justification for the relevant topic in **Chapters 8 – 30**.

5.3 Overview of the Projects

37. Each Project will consist of between 48 and 100 wind turbines. Therefore, taken together, there will be between 95 and 200 wind turbines installed across both Projects[1]. The locations of the Project array areas and offshore export cable corridors are shown on **Figure 5-3**.

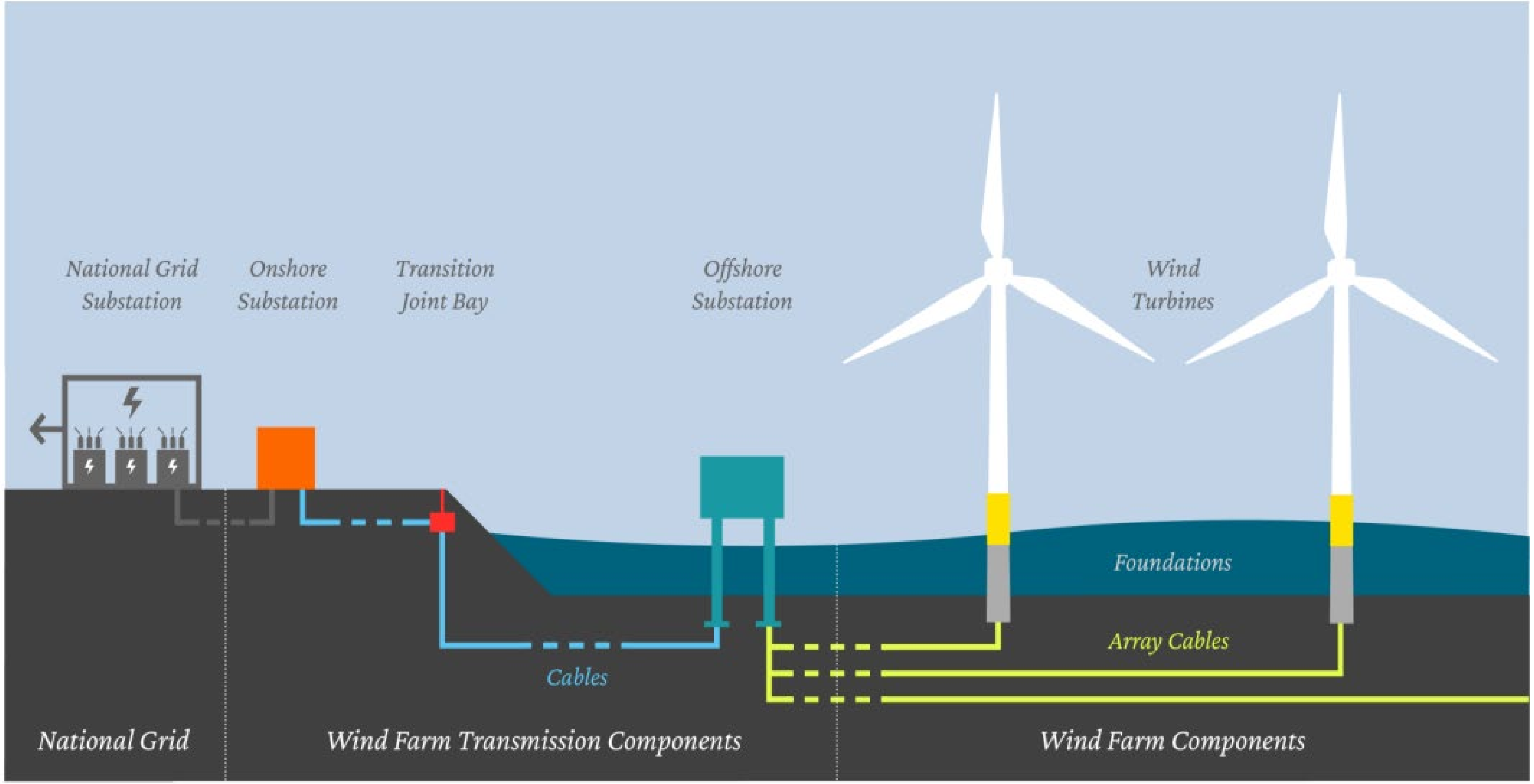
38. Depending on the development scenario (section 5.1.1), the array areas will be connected to one another via inter-platform cables, with a maximum of eight electrical platforms combined between both Projects. An offshore export cable corridor will connect the array areas with the landfall at Skipsea. This will consist of up to six individual cables. In the worst case scenario, these circuits will be installed within individual separate trenches. An onshore export cable corridor will link the landfall with the newly constructed onshore substations before onward onshore cable routeing to a proposed new National Grid substation near Creyke Beck, to the south of Beverley.

39. An overview schematic of the key onshore and offshore project infrastructure is provided in **Plate 5-3**.

40. The earliest that construction could commence under any scenario is anticipated to be 2026 with the onshore construction works likely to commence first. Section 5.7 provides an indicative construction programme for each development scenario, for both the offshore and onshore works.

[1] In situations where a number does not divide equally between DBS East and DBS West (e.g. 95 large turbines), rounded up to higher number (e.g. 48 large turbines as opposed to 47.5).

Plate 5-3 Project Overview Schematic (N.B. not to scale)



5.3.1 Key Project Components

41. The following section provides an overview of the key offshore and onshore project components which are described in further detail in sections 5.4 to 5.6.

42. The key offshore components are:

- Offshore wind turbines and their associated foundations;
- Offshore platforms and their associated foundations;
- Scour protection around foundations; and
- Subsea cables comprising:
  - Offshore export cables (linking the OSPs/OCPs/CPs to the landfall);
  - Inter-platform cables;
  - Array cables (linking the wind turbines to the OSPs/OCPs/CPs);
  - External cable protection on subsea cables as required; and
  - Fibre optic communications cables (integrated within the power cables for HVAC, separate cables for HVDC)

43. The key components at the landfall are:

- Installation of up to seven ducts which would be installed using a trenchless technique such as Horizontal Directional Drill (HDD). This consists of three ducts per HVDC project (two power cable ducts plus a smaller duct for a fibre optic communications cable) and four ducts per HVAC project (for four HVAC cables). In a HVDC-only design scenario six ducts would be required, with four ducts for the power cables and two ducts for the fibre optic cables. Space is also allocated for an additional two HDDs for contingency purposes in the unlikely event of HDD failure in a concurrent/sequential design scenario, with one spare HDD for contingency for the Projects in isolation; and
- Up to six transition joint bays to house the connection between the offshore and onshore cables are required for the design scenario where there is both an HVDC and an HVAC Project, and up to four transition joint bays required for the design scenario where both Projects utilise an HVDC export system.

44. The key onshore components are:

- Ducts installed underground to house the electrical cables along the onshore cable corridor;
- Onshore cables installed within ducts;
- Joint bays and links boxes installed along the cable corridor;
- Trenchless crossing points at certain locations such as some roads, railways and sensitive habitats (e.g. rivers of conservation importance);
- Temporary construction compounds and accesses;
- Temporary bridges and culverts;
- Onshore substations and onward HVAC or HVDC connections to a proposed new substation at Creyke Beck; and
- Permanent operational substation and cable route access.

5.4 Offshore

5.4.1 Offshore Scheme Summary

45. A summary of the key elements of the offshore infrastructure is provided in **Table 5-2.**

Table 5-2 Offshore Scheme Summary

Parameter	Details		
	DBS East	DBS West	Combined
Indicative construction duration (years) (excluding landfall works)	5	5	5 (7 years if sequential build)
Anticipated design life (years)	30	30	30 (32 if sequential build)
Number of wind turbines[2]	48-100	48-100	95-200
Wind farm array area (km^2)	494.5	494.5	989
Closest point from array area to coast (km)	122	100	N/A
Length of export cable to landfall (per circuit) (km)	198 per circuit	158 per circuit	N/A
Maximum offshore cable length (km) for all cables (HVAC + HVDC)	396	632	1028
Maximum number of export cables and trenches (HVDC + HVAC)	2	4	6
Maximum total length of all array cables (km)	325	325	650
Indicative turbine rotor diameter – small turbines (m)	259		

[2] In situations where a number does not divide equally between DBS East and DBS West (e.g. 95 turbines), rounded up to higher number (e.g. 48 31.5MW turbines as opposed to 47.5).

Parameter	Details		
	DBS East	DBS West	Combined
Indicative turbine rotor diameter – large turbines (m)	375		
Maximum tip height above MHWS (m)	450		
Minimum lower blade tip clearance to MSL (m)	34		
Rotor swept area (km^2)	5.263	5.263	10.526
Minimum turbine spacing (centre to centre) (m)	830		
Rotor cut-out wind speed (m/s) (assumed)	>25		
Maximum inter-platform cable length (km)	55	99	385
Wind turbine foundation type options	Steel monopile, piled jacket, suction bucket jacket		
Maximum number of offshore platforms	6 (one of which may be located in the export cable corridor)	6 (one of which would be located on the export cable corridor)	11 (two of which could be located on the export cable corridor, not in the array areas)
Offshore platform foundation type options	Steel monopile, piled jacket, suction bucket jacket, gravity based foundation		

5.4.1.1 Maximum Spatial Footprints of Offshore Infrastructure

46. The spatial footprints caused by the construction or decommissioning works (generally assessed as temporary footprints) as well as those caused during the lifetime of the wind farms during operation are summarised in the following sections. All figures are presented on a worst case basis e.g. for wind turbine foundations, the maximum footprint described is that which would result from the installation of the highest possible number of suction bucket jacket foundations (all with scour protection), which is the scenario with the largest footprint on the seabed.

5.4.1.1.1 Temporary Construction Footprint

47. **Table 5-3** describes the maximum temporary construction footprints in the array areas and cable corridors. This includes seabed preparation for foundation installation and cable installation.

Table 5-3 Indicative Maximum Temporary Construction Footprints

Activity	Worst case scenario description	Footprint – DBS East	Footprint – DBS West	Footprint – DBS East and DBS West together
Seabed preparation – wind turbine foundations (m^2)	95 (total) large turbine suction bucket jacket foundations	94,248	94,248	186,532
Seabed preparation – Offshore platforms (m^2)	8 (total) OSP GBS foundations	15,394	15,394	30,798
Seabed preparation – other platforms (m^2)	3 (total or 2 per Project) GBS foundations	7,697	7,697	11,545
Maximum volume of drill arisings for turbines – large turbines (m^2)*	5% of 200 turbines requiring drilling	42,305	42,305	84,611

Activity	**Worst case scenario description**	**Footprint – DBS East**	**Footprint – DBS West**	**Footprint – DBS East and DBS West together**
Maximum volume of drill arisings for offshore platforms (m^3)*	5% of OSPs/OCPs and other platforms requiring drilling	3,563	3,563	7,125
Jack up vessel footprint – wind turbine and offshore platform installation (m^2)	6 jack-up locations per turbine ($275m^2$ per jack up leg x 4 legs x 6 operations per turbine x 200 turbines)	693,000	693,000	1,380,500
Anchoring footprint – wind turbine and offshore platform installation (m^2)	$116m^2$ footprint x 4 anchors per activity x 5 activities requiring the deployment of anchors x 200 turbines + 11 offshore platforms	258,423	258,423	516,846
Pre-grapnel run (all cables)	Pre-lay grapnel run (PLGR) activities will fall within the footprint of the cable trench disturbance width.			
Anchoring footprint – export cable installation (m^2)	Indicative Length of cable route installed with anchors – 10km	22,061	44,091	66,136

Activity	**Worst case scenario description**	**Footprint – DBS East**	**Footprint – DBS West**	**Footprint – DBS East and DBS West together**
Export cable installation (m^2)	Maximum footprint for export cable installation – (combined number of circuits x 18m disturbance width)	7,128,000	11,376,000	18,504,000
Array and inter-platform cable installation (m^2)	Array cable trench area (array cable and inter-platform cable length x 18m jetting disturbance width)	6,840,000	7,632,000	18,630,000
Sandwave levelling – array areas (m^2)	Maximum footprint disturbed by sandwave levelling for inter-platform cables	950,000m^2	1,060,000	2,587,500
Sandwave levelling – offshore export cable corridor (m^2)	Maximum footprint disturbed by sandwave levelling for offshore export cable corridor	2,047,002	4,094,003	6,141,005

Activity	Worst case scenario description	Footprint – DBS East	Footprint – DBS West	Footprint – DBS East and DBS West together
Total (m²)		18,006,639	25,225,671	47,958,446

** Not included in the total area calculation, due to these parameters being in m³*

5.4.1.1.2 Array Areas Lifetime Footprint

48. **Table 5-4** describes the maximum lifetime footprints in the array areas. This includes the foundations, crossings, and external cable protection for unburied cables. It should be noted the footprints detailed in this chapter differ from those estimated in The Crown Estate's Plan Level Habitats Regulations Assessment (HRA), conducted for offshore wind farms leased in the recent Offshore Wind Leasing Round 4. See section 5.4.2 for further details.

Table 5-4 Maximum Lifetime Footprints in the Array Areas (Wind Turbines, OSPs/OCPs and Array Cables)

Infrastructure	Worst case scenario description	Footprint – DBS East	Footprint – DBS West	Footprint – (combined)
Wind turbine foundations (m^2)	95 turbines x 55,572m^2 total scour protection per turbine	2,639,653	2,639,653	5,279,305
Offshore platform foundations (HVAC + HVDC) (m^2)	Offshore platforms with scour protection for HVAC + HVDC design scenario	338,460	338,460	620,510
Array and inter-platform cable protection (unburied cables) (m^2)	Total array and inter-platform cable protection for design scenario HVAC + HVDC	656,512	790,515	2,139,904
Array and inter-platform external cable protection (cable crossings) (m^2)	Total footprint of pipeline / cable crossing material (array + inter–platform cables) for design scenario HVAC + HVDC	60,160	72,320	241,920
Total (m^2)		3,723,738	3,869,970	8,284,669

5.4.1.1.3 Export Cable Corridor Lifetime Footprint

49. **Table 5-5** describes the maximum lifetime footprints for the offshore export cable corridor. This only concerns crossings and any external cable protection that may be used, including at the landfall exits. It should be noted the footprints detailed in this chapter differ from those estimated in The Crown Estate's Round 4 Plan Level HRA. See section 5.4.7 for further details.

Table 5-5 Maximum Lifetime Footprints Export Cables

Infrastructure	Worst case scenario description	Footprint – DBS East	Footprint – DBS West	Footprint – (combined)
External cable protection – unburied cables (m^2)	Total export cable protection for HVAC + HVDC design scenario	1,089,660	1,642,872	2,708,148
External cable protection – cable crossings (m^2)	Total footprint of pipeline / cable crossing material for HVAC + HVDC design scenario	122,611	294,267	441,400
Total (m^2)		1,212,271	1,937,139	3,149,548

5.4.1.1.4 Operation and Maintenance Temporary Footprint (All Areas)

50. **Table 5-6** describes the maximum temporary footprints during O&M in both the array areas and the export cable corridors. This includes the use of jack-up vessels for major component replacement, cable repair and cable reburial works.

Table 5-6 Maximum Temporary O&M Footprints in the Array Areas and Cable Corridors

Activity	Worst case scenario description	Footprint – DBS East	Footprint – DBS West	Footprint – (combined)
Jack-up vessel footprints for major maintenance activities across Projects lifespan (m^2)	Seabed disturbance - 20,460m^2 per year x 30 year lifespan	306,900	306,900	613,800
Array cable repair or replacement across Projects lifespan (m^2)	Seabed disturbance - 13 events x 6,000m^2 per event	42,000	42,000	78,000
Export cable repair or replacement across Projects lifespan (m^2)	Seabed disturbance - 6 events x 6,000m^2 per event	18,000	18,000	36,000
Total (m^2)		366,900	366,900	727,800

5.4.2 Wind Turbines

5.4.2.1 Wind Turbine Parameters

51. The project design envelope includes a range of turbines in order to accommodate the ongoing rapid development in wind turbine technology. Accounting for this range and the assumed total capacity of the Projects there could be between 48 and 100 wind turbines at each of DBS East and DBS West, equating to up to 200 turbines across the two Projects. Wind turbine parameters are summarised in **Table 5-2**. It should be noted the parameters detailed in this table differ from those estimated in The Crown Estate's Round 4 Plan Level HRA. The reduction in the maximum number of turbines from 300 (as assessed in The Crown Estate HRA) to 200 would reduce some of the impacts of the Projects associated with number of WTGs. See section 5.4.7 for further details.

5.4.2.2 Wind Turbine Layout

52. The wind turbine layout will not be finalised until much closer to the time of construction, following completion of detailed pre-construction wind resource studies, site investigations and the selection of the preferred turbines and their foundations. A layout will be selected from within the consented parameters to optimise energy output and the foundation installation process accounting for ground conditions. The wake downstream of a turbine rotor is characterised by decreased wind speed and increased turbulence compared to the flow upstream of the rotor. An optimum layout will ensure that the flow in front of a wind turbine is affected as little as possible by wake effects from other wind turbines.

53. At this time, the layout can therefore only be described in general terms with the minimum separation distance between turbines as described in Table 5-7 . Inter-row spacing is the distance between the main rows of wind turbines and in-row spacing is the distance separating turbines in the main rows, which would be orientated to face the prevailing wind, or as close to this as is practical. In-row spacing and inter-row spacing may vary across the array areas.

54. The layout will require Maritime and Coastguard Agency (MCA) approval prior to construction to minimise risk to surface vessels, including rescue boats and search and rescue aircraft, as per Marine Guidance Notice (MGN) 654 (MCA, 2021) (see **Chapter 14 Shipping and Navigation** and **Chapter 15 Aviation and Radar** for further details).

5.4.2.3 Wind Turbine Installation

55. The precise details of the installation process will be confirmed prior to construction however it will follow one of the methodologies outlined below (details of the pre-installation works are given in relation to the foundations, section 5.1.1.1):

- Turbine components will be loaded on to the installation vessel (typically a jack-up vessel or an anchored floating vessel) at the marshalling base port.
- The installation vessel will then transit to the Project site and the components will be lifted by the vessel's crane onto the foundation or transition piece (depending on the foundation type being used). For each wind turbine, the tower would be installed first, followed by the nacelle, then the blades. Technicians will then fasten components together as they are lifted into place. Each wind turbine installation is likely to take in the order of one day, assuming no weather delays.
- Alternatively, the wind turbine components may be loaded onto barges or dedicated transport vessels at the marshalling base and installed by an installation vessel that remains on site throughout the installation campaign.
- It is also possible that complete wind turbines could be pre-assembled and commissioned onshore and transported to site for installation as a single unit.

56. The total duration of the installation campaigns for the wind turbines is expected to be a maximum of 30 months if the Projects are constructed concurrently or up to 54 months if the Projects are developed sequentially.

57. Each installation vessel or barge may be assisted by a range of support vessels. These are typically smaller vessels that may be tugs, guard vessels, anchor handling vessels, or similar. These vessels will make the same general movements to, from and around the wind farm areas as the installation vessels that they are supporting. See section 5.4.8 for further details of vessel types, numbers, and movements.

5.4.2.4 Wind Turbine Oils, Fluids and Materials

58. Wind turbines and the associated equipment require a number of oils, fluids and other materials for their safe use and operation. Biodegradable oils would be selected where possible, all chemicals used will be certified to the relevant standard and all wind turbines will have provision to retain any spilt fluids within the structure where possible.

59. The required volume of oil and fluids will vary depending on the design i.e. conventional design or gearless, whether one or two or more rotor bearings are used in the design and the amount of redundancy designed into the system. Typical materials used include:

- Yaw grease;
- Yaw gear oil;
- Main bearing grease;
- Transformer (ester oil);
- Cooling fluid (water/glycol);
- Hydraulic oil;
- Pitch lubrication (grease);
- Pitch system hydraulic accumulators (nitrogen);
- Pitch gearbox oil;
- Gearbox oil; and
- Sulphur hexafluoride (SF6) gas.

5.4.3 Wind Turbine Foundations

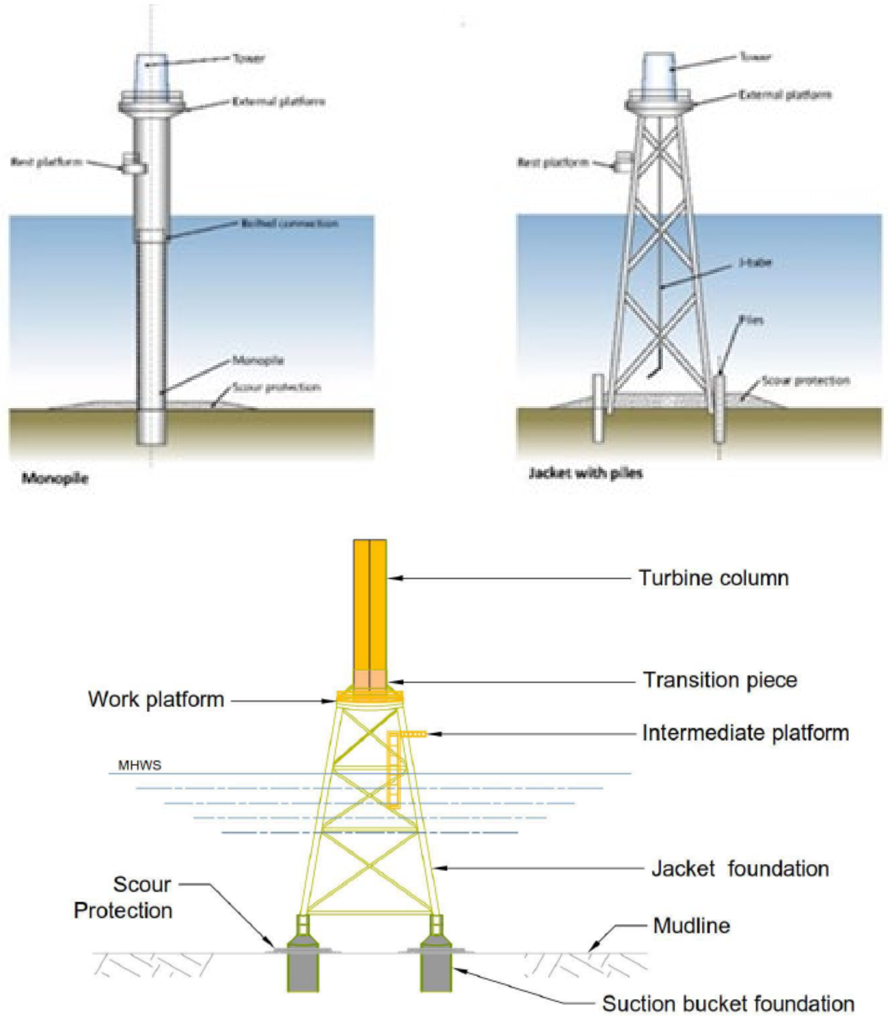
60. The following sections describe the foundation types under consideration for the wind turbines at the Projects: Monopiles, pin pile jackets and suction bucket jackets (**Plate 5-4**), as well as details of the pre-installation works.

61. It is possible that more than one type of wind turbine foundation will be installed on DBS East and DBS West, accounting for the construction programme (i.e., when the Projects are constructed and whether they are constructed at the same time), ground conditions, water depth, wind turbine model and wind resource.

62. The foundations will be manufactured at an onshore facility and most likely delivered to site as fully assembled units with all ancillary structures attached. As with many aspects of the wind farm construction process, different logistical approaches are being explored within the industry as technologies and methodologies continue to evolve.

63. Fabrication and construction methods will depend on the foundation type selected, as described in the sections below.

Plate 5-4 Examples of Wind Turbine Foundations



5.4.3.1 Pre-Installation Works

64. Pre-installation works may include:

- Pre-construction surveys to confirm that the seabed is clear of any obstructions prior to installation activities commencing (including unexploded ordnance (UXO)) and to provide information to inform any micrositing of infrastructure, clearance operations, seabed preparation and for environmental monitoring purposes.
- UXO clearance requirements will be informed by the results of the pre-constructions surveys. Micrositing will be used to avoid UXO where possible, however where this is not the case, clearance may be required to safely remove or detonate any UXO that present a hazard to the construction activities or the ongoing operation of the wind farms. An example of UXO on the Sofia OWF is shown in **Plate 5-5**. Low impact techniques will be used for clearance subject to them being a suitable method for any UXO found, noting that UXO clearance works will be the subject of separate Marine Licence application/s prior to the start of construction.

Plate 5-5 Example of UXO from the Sofia OWF

5.4.3.2 Monopiles

5.4.3.2.1 Overview and Materials

65. A monopile is a large tubular structure on which a cylindrical transition piece can be fitted. The pile and/or transition piece may be tapered or change in diameter along their length. The key parameters for monopile foundations are presented in **Table 5-7**.

66. Monopiles are fabricated from steel, with a number of secondary structures on the associated transition pieces such as handrails, ladders and working platforms that may be produced from a range of materials such as steel, concrete, aluminium, other metals and composites. The transition piece may be either steel or concrete

Table 5-7 Monopile Foundation Parameters

Parameter	Small Turbines	Large Turbines
Maximum penetration (piled solution) (m)	40	70
Maximum pile diameter (m)	11	17
Average drill arisings per foundation (m^3)	4,524	17,813
Drill arisings across both Projects combined (m^3)	45,239	84,611
Maximum footprint on the seabed per foundation (excl. scour protection) (m^2)	95	227
Maximum outer scour protection diameter at seabed (incl. foundation structure) (m)	63	93
Maximum area of scour protection per foundation (incl. structure footprint area) (m^2)	3,117	6,793
Maximum scour protection volume per foundation (m^3) (rock)	5,278	11,988

5.4.3.2.2 Seabed Preparation

67. Cable installation may require some form of seabed preparation which may include pre-lay grapnel runs and/or pre-lay plough, boulder relocation and possibly sandwave clearance. In general, the preparations will be limited to the area directly associated with the array cable or export cable corridor.

5.4.3.2.3 Scour Protection

68. Scour protection material may be required around the base of some or all foundations to protect from current and wave action, thus ensuring structural integrity. Scour protection types may include, but are not limited to, rock filter layers (typically laid before foundation installation) with a rock armour layer, rock/stone filled geotextile bags (typically laid after foundation installation), and/or anti scour mattress solutions.

69. The maximum diameter, area, and volume requirements for scour protection per foundation are provided in **Table 5-7** and **Table 5-9**.

5.4.3.2.4 Installation

70. Monopiles are installed vertically into the seabed by either driving (use of a piledriving hammer), or a combination of driving and drilling techniques where harder ground conditions are present. Other appropriate alternative methods may be used as they become available and practicable.

71. The preference is to utilise DPV installation technology to limit the seabed impacts, however, this may not be possible across the whole site due to the water depths or metocean conditions. At a smaller number of locations an anchor spread may be required during foundation installation. As a worst case, calculations on anchoring are based on anchor deployment occurring at every turbine.

72. Alternatively, or possibly in addition to a DPV, a JUV may be deployed for foundations installation.

73. The installation process typically comprises the following stages:

- Lift monopile into the pile gripper on the side of the installation vessel;
- Lift hammer onto monopile and drive monopile into seabed to required embedment depth (anticipated to be up to approximately 70m embedment, dependent upon ground conditions and water depth);
- Lift hammer from monopile and remove pile gripper;
- Lift transition piece onto monopile; and
- Secure transition piece. Transition piece bolted or grouted to the monopile (if required). The grout used is an inert cement mix that is pumped into a specially designed space between the transition piece and the monopile. It is also possible that the transition piece will be integrated with the monopile, in a 'TP-less' concept, in which case this installation stage would not be required. However, there could be separate installation of secondary and tertiary steelwork such as access systems, corrosion protection systems.

74. Where conventional piling is unable to achieve necessary pile penetration, additional methods may be used (e.g. drilling, water jetting, vibro-piling and/or electro-osmosis).

75. Drilling arisings would be disposed of adjacent to installed foundations, as has been performed on existing UK offshore wind farms, including RWE's project at Gwynt y Môr.

76. It is expected that a single monopile foundation installation will take approximately 24 hours on average from vessel arrival to vessel departure, without weather delays. If drilling is required, then the installation duration will be increased.

5.4.3.2.5 Pile Driving

77. For the piling of monopile foundations, larger hammer spreads are more efficient and are likely to reduce the overall installation time and number of blows required to install each pile. However, the actual energy output will be optimised to that required for successful installation. At the time of writing, 5,500kJ spreads are available although the expectation is that larger hammers in the region of 6,000kJ to 7,000kJ may become available prior to the start of construction of the Projects and may be needed for larger diameter piles. A drivability assessment will be carried out prior to construction when further information is available regarding the ground conditions, to determine the required piling requirements (e.g., hammer energy and blow rate).

78. At this stage, the maximum hammer energy used for monopile installation is assumed to be 7,000kJ for the largest 17m diameter monopiles. Each piling event would commence with a soft start at a lower hammer energy, followed by a gradual ramp-up for at least 20 minutes to the maximum hammer energy required. The maximum hammer energy is only likely to be required at a few of the piling installation locations.

79. As an alternative to traditional impact piling, the feasibility of alternative installation methods will also be explored pre-construction. Such methods include:

- Vibration piling
  - A method in which the pile is vibrated into the sediment rather than being hammered in. The type and classification of the sound that is generated with vibratory versus impact pile driving is different. The sound generated from vibratory pile driving is classified as more non-impulsive, continuous sound as opposed to the impulsive and sharp sounds produced from impact pile driving.
- Blue piling
  - A piling solution that uses the deceleration of a large water mass contained in a water vessel to deliver a long-lasting blow to the pile. This technology aims to reduce the noise generated at the source during installation.
- Electro-osmosis
  - A piling technique that utilises electro-osmosis (defined as the movement of water through a porous medium, such as soil, by the application of an externally applied electrical potential) while piling to reduce resistance in the underlying sediment when piling (Rose and Grubbs, 1979).
- Water jetting
  - Either used in conjunction with, or separate from, traditional impact piling, this method utilises a carefully directed and pressurized flow of water to assist in achieving pile penetration. The jetting technique liquefies the soils at the pile tip during pile placement, decreasing the bearing capacity of the soils, causing the pile to descend toward its final tip elevation with much less soil resistance and may lead to a reduced hammer energy being required.

80. It should be noted that these techniques are not yet proven for offshore wind foundations, but are included in the design envelope to allow for future technology developments. Even if feasible, it is likely that such techniques could only be used for part of the installation of each pile, with impact piling being required to complete the installation. As such, the worst case scenario for assessment purposes is reflected by the impact piling parameters.

81. The key impact piling parameters (worst case) are described in **Table 5-8**. Further information describing the detailed piling parameters used to inform the assessment, including the underwater noise modelling are provided in **Chapter 10 Fish and Shellfish Ecology** and **Chapter 11 Marine Mammals**.

Table 5-8 Monopile Piling Parameters for Wind Turbines

Parameter	Value
Maximum Diameter (m)	17
Maximum hammer energy (kJ)	7000
Indicative pile depth (m)	70
Typical piling time per foundation (mins) (includes soft-start and ramp-up, and providing allowance for issues such as low blow rate, etc.)	320
Maximum piling duration per foundation (hours)	8
Maximum simultaneous piling events	3

5.4.3.2.6 Drilling

82. Whilst pile driving is the most likely installation method, in the event that ground conditions are not suited to piling, monopiles may be drilled, or both drilled and driven, into the seabed. For this purpose, it is estimated that up to 5% of the wind turbine locations could need drilling i.e., a likely minimum of two for each of DBS East and DBS West. Potential volumes of drill arisings for the Projects are detailed in **Table 5-7**.

83. The drill arisings (spoil) would be disposed of adjacent to the foundation location, above or slightly below the sea surface, from where they would be expected to settle onto the seabed in the immediate vicinity of each foundation (see **Chapter 8 Marine Physical Environment** for further details).

5.4.3.3 Jackets

5.4.3.3.1 Piled Jackets

84. The jacket is secured to the seabed by small diameter pin piles which are driven into the seabed through pile sleeves at each leg. Alternatively, the pin piles may be pre-installed into the seabed through a template, prior to the arrival of the jacket structure. The pin piles are connected to the jacket legs via a grouted or deformed connection.

85. The installation process typically comprises the following stages:

- Piling template placed on seabed;
- Piles installed;
- Piling template recovered for re-use; and
- Jacket lowered onto piles.

Or:

- Jacket lowered onto seabed; and
- Piles installed.

86. Pin pile installation methodology is similar to that for the monopiles.

87. Depending on the approach taken it would typically take about 24 hours for the pilling operations and then about the same again for the jacket installation and the grouting.

88. The key parameters for jacket foundations (worst case) are presented in **Table 5-9**. Jackets are primarily fabricated from steel. Secondary structures such as handrails, ladders, working platforms etc. may be produced from a range of materials such as steel, concrete, aluminium, other metals and composites.

Table 5-9 Jacket Foundation Parameters (Wind Turbines)

Parameter	Small Turbines	Large Turbines
Pin Pile Jacket		
Maximum. number of legs per foundation	4	4
Number of legs across wind farm	800	380
Average drill arisings per foundation (m^3)	2,012	5,948
Maximum volume of arisings (m^3)	20,106	28,246

Parameter	Small Turbines	Large Turbines
Indicative height of platform above LAT (m)	20.5	20.5
Indicative separation of adjacent legs at seabed level (m)	20	45
Indicative separation of adjacent legs at LAT (m)	16	35
Indicative leg diameter (m)	2.5	3.5
Indicative pin pile diameter (m)	3	4.2
Hammer energy (kJ)	up to 3000	up to 3000
Maximum outer scour protection diameter at sea bed per leg (including foundation structure) (m)	23	29
Maximum scour protection area per foundation (incl. structure footprint area MP) (m^2)	1,700	2,700
Maximum scour protection volume per foundation (m^3) (rock)	2,300	3,900
Suction Bucket Jacket		
Maximum. number of legs per foundation	4	4
Maximum number of buckets across wind farm	800	380
Indicative Height of Platform above LAT (m)	20.5	20.5
Indicative separation of adjacent legs at seabed level (m)	20	45
Indicative separation of adjacent legs at LAT (m)	16	35
Indicative bucket diameter OD (m)	15	25

Parameter	Small Turbines	Large Turbines
Indicative bucket penetration depth (m)	30	40
Maximum suction bucket height above seabed (m)	10	10
Maximum outer scour protection diameter at sea bed per leg (including foundation structure) (m)	85	135
Maximum scour protection area per foundation (incl. structure footprint area MP) (m^2)	21,700	55,600
Maximum scour protection volume per foundation (m^3) (rock)	37,800	100,700

5.4.3.3.2 Suction Bucket Jackets

89. This foundation type may require more focused seabed levelling, to ensure that all of the buckets for each structure can be placed at the same level. The suction buckets need to have level ground beneath to form a sealed chamber within each bucket once the foundation has been lowered to the seabed.

90. The suction bucket is embedded into the seabed by creating a negative (suction) pressure inside the bucket. The difference in pressure across the top plate as a result further pushes the bucket into the seabed.

91. The installation process typically comprises the following stages:
    - Jacket lowered onto seabed;
    - Water pumped from bucket(s); and
    - At desired depth, the pump is turned off.

92. It is expected that a single suction bucket jacket installation will take approximately 24 hours on average from vessel arrival to vessel departure, without weather delays.

Table 5-10 Jacket Foundation Piling Parameters (Wind Turbines)

Parameter	Small Turbines	Large Turbines
Indicative pin pile diameter (m)	3	4.2
Maximum hammer energy (kJ)	Up to 3,000	
Total piling time per pin pile (mins) (includes soft-start and ramp-up, and providing allowance for issues such as low blow rate, etc.)	190	
Number of simultaneous piling events	3	

5.4.3.3.3 Drilling

93. Whilst pile driving is the most likely installation method of the jacket pin piles, in the event that ground conditions are not suited to piling, the jacket pin piles may be drilled, or both drilled and driven, into the seabed. For this purpose, it is estimated that up to 5% of the jacket pin pile locations could need drilling.

94. The drill arisings (spoil) would be disposed of adjacent to the foundation location, above or slightly below the sea surface, from where they would be expected to settle onto the seabed in the immediate vicinity of each foundation (see **Chapter 8 Marine Physical Environment** for further details).

5.4.4 Offshore Platforms

5.4.4.1 Offshore Substation / Converter / Collector Platforms

95. The cables from each string of turbines will be brought to an OSP / OCP / CP, located appropriately to optimise the array, inter-platform, and export cable lengths. At the OSPs / OCPs / CPs, the generated power will be transformed to a higher AC voltage of up to 275kV (HVAC) or 525kV (HVDC).

96. There will be up to eight OSPs / OCPs/CPs, depending on how the Projects are developed, as described in section 5.1.1. In the case that eight OSPs / OCPs / CPs are constructed there will be four located in in DBS East and four in DBS West. The location of the OSPs / OCPs / CPs will be confirmed during the detailed design process, accounting for the wind turbine layout, but will be within the order limits of each wind farm site.

97. The basic OSP / OCP/CP design will consist of a topside structure configured in a multiple deck arrangement, with the decks either open with modular equipment, or fully clad. Weather sensitive equipment would be housed accordingly. Equipment and facilities may consist of:

- Medium voltage (MV) to high voltage (HV) step-up power transformers;
- HVDC valve hall;
- HV Reactors;
- MV and/or HV switchgear;
- Other electrical power systems;
- Instrumentation, metering equipment and control systems;
- Standby generators;
- Large-scale energy storage systems (batteries etc.), plus associated systems;
- Auxiliary and uninterruptible power supply systems;
- Navigation, aviation and safety marking and lighting;
- Helicopter landing facilities;
- Systems for vessel access and/or retrieval;
- Vessel and helicopter refuelling facilities;
- Potable water;
- Black water separation;
- Storage (including stores, fuel, and spares);
- Offshore accommodation and mess facilities

- Cranes;
- Communication systems and control hub facilities;
- Offshore vessel charging point; and
- Drone landing pad.

98. Indicative parameters for a single OSP/OCP/CP topside are provided in **Table 5-11** below, with an example OSP (from the Triton Knoll offshore wind farm) being shown in **Plate 5-4**.

Table 5-11 Indicative Topside Parameters for a single OSP / OCP / CP

Parameter	Value
Indicative topside weight (tonnes)	20,000
Maximum topside length (m)	125
Maximum topside width (m)	100
Maximum topside area (m^2)	12,500
Maximum topside height (m) (excluding crane and helideck)	105
Maximum topside height (m) (including crane)	195
Height of lightning protection above topside (LAT)	10

Plate 5-6 Example OSP / OCP

5.4.4.2 Other Platforms

99. In addition to the OSPs and / or OCPs / CPs, up to three other platforms may be required for the Projects, including:

- RCP;
- ESP; and
- Accommodation Platform

100. The ESP (if required) will provide a link to a co-ordinated east coast transmission system which is planned to run from Scotland to England, as per National Grid ESO's Holistic Network Design . This platform may be located either within one of the array areas (likely alongside a converter station) or mid-way along the offshore export cable corridor (likely next to the RCP if required).

101. An RCP will be required for a HVAC solution. The RCP will host the shunt reactors required to provide reactive compensation, as necessary for HVAC transmission over long distances. The RCP will be located mid-way along the export cable corridor, at a minimum of 52km from the landfall location.

102. In addition, a single accommodation platform may be required which will be located within either DBS East or DBS West array sites.

5.4.4.3 Platform Foundations

5.4.4.3.1 Parameters and Materials

103. At the time of writing, the foundation types that may be used for the platforms are monopiles, pin-pile jackets, suction bucket jackets or gravity based foundations.

104. Scour protection may be required around the base of the foundations to protect against localised erosion of the seabed. The types of scour protection that could be used and installation methods are as described for the wind turbine foundations (section 5.4.3.2).

105. The worst case platform parameters for each foundation type, including details on scour protection, are detailed in **Table 5-12**.

Table 5-12 Worst Case Platform Foundation Parameters, Including Scour Protection

Parameters	Value
Monopile	
Maximum number	11 (Eight OSP/OCPs/CPs + Three Other Platforms)
Maximum pile diameter (m)	17
Maximum hammer energy (kJ)	7000
Maximum outer scour protection diameter at sea bed per leg (including foundation structure) (m)	93
Maximum scour protection area per foundation (including structure footprint area MP) (m^2)	6,800
Maximum scour protection area for all foundations (including structure footprint area MP) (m^2)	74,800

Parameters	Value	
Windfarm seabed area affected (km²)	0.072	
Maximum scour protection volume per foundation (m³) (rock)	12,000	
Maximum scour protection volume for project (rock) (m³)	131,900	
Pin-pile jacket		
Maximum number	11	
Number of legs per platform	8 (HVDC), 6 (HVAC)	
Separation of adjacent legs at seabed level (m)	30 (6 legged HVAC OSP/OCP)	
Separation of adjacent legs at LAT (m)	30 (6 legged HVAC OSP/OCP)	
Indicative leg diameter (m)	2.8	
Indicative pin pile diameter (m)	3.8	
Maximum hammer energy (kJ)	3000	
Maximum outer scour protection diameter at sea bed (including foundation structure) (m)	27	
Maximum scour protection area per foundation (including structure footprint area pin pile (m²)	4,600	
Maximum scour protection area for all foundations (including structure footprint area pin pile) (m²)	45,800 (HVAC + HVDC)	45,800 (HVDC Only)
Windfarm seabed area affected (km²) (excluding structure footprint area pin pile)	0.045 (HVAC + HVDC)	0.045 (HVDC Only)
Maximum scour protection volume per foundation leg (m³) (rock)	808	

Parameters	Value	
Maximum scour protection volume for project (rock) (m^3)	64,661 (HVAC + HVDC)	64,661 (HVDC Only)
Suction bucket jacket		
Maximum number	11	
Maximum number of buckets per platform	8	
Separation of adjacent legs at seabed (m)	30	
Separation of adjacent legs at sea surface (m)	30	
Maximum bucket diameter (m)	20	
Indicative bucket penetration depth (m)	40	
Suction bucket height above seabed (m)	10	
Maximum outer scour protection diameter at sea bed (including foundation structure) (m)	108	
Maximum scour protection area per foundation (including structure footprint area MP) (m^2)	73,387 (8-legged foundation)	
Maximum scour protection area for all foundations (including structure footprint area MP) (m^2)	732,871	
Windfarm seabed area affected (km^2)	0.708 (HVDC Only)	
Maximum scour protection volume per foundation leg (m^3) (rock)	16,361	
Maximum scour protection volume for project (rock) (m^3)	1,308,913	
Gravity-based structure		
Maximum number	11	

Parameters	Value
Maximum base diameter (OD) (m)	65
Seabed preparation diameter (m)	70
Scour protection width (m)	260
Maximum gravity based height above seabed (m)	10
Maximum outer scour protection diameter at sea bed (including foundation structure) (m)	268
Maximum scour protection area per foundation (including structure footprint area) (m^2)	56,410
Maximum scour protection area for all foundations (including structure footprint area (m^2)	620,510
Windfarm seabed area affected (km^2)	0.584
Maximum scour protection volume per foundation (m^3) (rock)	102,842
Maximum scour protection volume for project (rock) (m^3)	1,131,200

106. The jacket foundation will mainly be comprised of steel. However, it is possible that some secondary structures, such as handrails, gratings and ladders, could be produced using other metals, such as aluminium, or composites. Also, concrete could be used to form the working platform.

107. Some of the equipment at the OSP / OCP / CP would contain fluids. The key types of fluids that may be used include:

- Diesel fuel for the emergency generators (in diesel storage tanks);
- Oil for the transformers (oil will be monitored and filtered, top-up may be required);
- Engine oil;
- Glycol;
- Sewage and grey water;
- Lead acid contained within batteries; and
- SF6.

108. The OSP / OCP / CP design will include bunds to collect oil spills which would be disposed of according to industry best practice procedures. Transfer of oil/fuel between the OSP / OCP / CP and service vessels will also follow best practice procedures, with additional procedures in place should there be a spill to the marine environment.

109. Any significant oil spillage would be collected in a separate oil waste tank. Both oil waste and other wastes (waste water etc.) would be disposed of according to industry best practice procedures.

110. All other waste streams would be processed on the OSP / OCP / CP or transferred to shore as required.

5.4.4.3.2 Platform Installation

111. The general installation process for offshore platforms would be as follows:

- Offshore platforms are generally installed in two stages, firstly the foundation will be installed, secondly the topside will be lifted from a transport vessel/barge, onto the foundation.
- The foundation installation method will, depending upon the design, be similar to the wind turbine foundation installation methods described in section 5.4.2, with the addition of gravity base jacket typology (included below).
- The foundation and topside may be transported on the same transport vessel/barge, or separately.
- The foundation may also be transported by the installation vessel.
- The foundation, particularly if it is a gravity based concept, may also be towed and floated into position with the support of a number of tug and anchor handling vessels. The final ballasting and installation activities will be supported from an installation vessel or a construction support vessel.
    - The gravity based foundation may be ballasted to the seabed utilising either water or other dry ballast materials. This is dependent on the final design requirements of the structure.

112. For the electrical equipment platforms, a jack-up vessel may be stationed alongside the structure to facilitate commissioning activities. It is likely that a Service Operation Vessel will also remain in the field.

113. Drill arisings would be disposed of adjacent to the foundation location, above or slightly below the sea surface, from where they would be expected to settle onto the seabed in the immediate vicinity of each foundation (see **Chapter 8 Marine Physical Environment** for further details). The key parameters (worst case) for platforms piling are described in **Table 5-13**.

Table 5-13 Platform Piling Parameters

Parameter	Value
Maximum pile diameter (m)	17
Maximum hammer energy (kJ)	7000
Indicative pile depth (m)	60
Total piling time per pin pile (hr) (includes soft-start and ramp-up, and providing allowance for issues such as low blow rate, etc.)	3.2

5.4.5 Underwater Noise

114. A number of activities during the construction, operation and decommissioning of the Projects will result in underwater noise. The most significant noise sources are likely to be piling of the foundations and clearance of UXO. An underwater noise modelling study has been undertaken in support of the assessment and is provided in **Appendix 11-1**.

5.4.6 Navigation Lighting Requirements and Colour Scheme

115. With respect to lighting and marking, the wind turbines and platform topsides will be designed and constructed to satisfy the requirements of the Civil Aviation Authority (CAA), MCA and Trinity House Lighthouse Service (THLS).

116. Further details including reference to the relevant guidance and regulations is presented in **Chapter 14 Shipping and Navigation** and **Chapter 15 Aviation and Radar.**

5.4.7 Further Electrical Infrastructure – Cables

117. The wind farm electrical array cables connecting the wind turbines to the OSP / OCP / CP will collect the power produced at the wind turbines. This is exported to the UK electricity transmission network via the export cables. The electrical transmission system, made up of the OSP / OCP / CP and export cables will be constructed by the Applicant and the ownership will be transferred to an Offshore Transmission Owner (OFTO) in accordance with applicable rules and regulations in a transaction managed by the Office of Gas and Electricity Markets (Ofgem).

118. The electrical cables that make up the offshore electrical infrastructure include:

- Offshore export cables (linking the OSPs / OCPs / CPs to the landfall);
- Inter-platform cables (linking platforms); and
- Array cables (linking the wind turbines to the OSPs / OCPs / CPs).

119. These are described in the following sections.

5.4.7.1 Offshore Export Cables

120. Depending on the design scenario used, there will be up to four HVAC 3-core export cables and two single core HVDC offshore export cables. The HVAC cables will include an integrated fibre optic cable, whilst for HVDC the fibre optic cable will be bound externally to the cable. The power cable voltage will be up to 275kV for HVAC, and up to 525kV for HVDC, with an indicative external cable diameter of 155mm to 275mm.

121. The length of the export cables depends on the development scenario in question (**Table 5-14**). In the event of an HVAC and an HVDC Project being developed, the maximum offshore cable length will be up to 1,028km (198km for DBS East and 158km for DBS West per cable, with six power cables required i.e. 4 x 3 core AC cables and 2 x 1 core DC cables).

122. For DBS East in isolation using HVDC only, the maximum length per offshore export cable is 198km, giving a total of 396km as two cables are required.

123. For DBS West in isolation using HVAC only, the maximum length per offshore export cable is 158km giving a total of 632km as four cables are required.

124. DBS West in isolation may also use two HVDC cables only, if this Project is taken forward as a HVDC project rather than HVAC. In this scenario, given the maximum length per export cable is 158km, two cables measuring 396km are required.

125. The offshore export cables make landfall near Skipsea, where they will be connected to the onshore cables in transition joint bays, having been installed by HDD, or similar trenchless technique.

126. Each offshore export cable will be installed in a separate trench with a spacing of up to 50m between the cables, where two export cables are installed in parallel. For the purpose of the DCO application and environmental assessment, an offshore export cable corridor has been defined in order to encompass all required cables and the adjacent area of seabed that may be subject for temporary works, such as anchoring, lay-down or the use of jack-up vessels.

127. The offshore export cable corridor provides space for the installation works and any foreseeable operation and maintenance activities such as cable reburial or repairs. The offshore export cable corridor is 1km wide (with a 500m temporary working area buffer either side) but funnels out to up to 4km on approach to the landfall. The greater width of the corridor on the approach to landfall is designed to accommodate the two potential landfalls remaining under consideration for the Projects, in addition to providing greater flexibility in the detailed routeing of the export cable/s at the pre-construction stage.

128. Due to the length of the cable corridor, and the limitations upon cable carousel size/weight on the installation vessel, it is very likely that the export cables will be installed in sections with pre-planned cable joints along the export corridor. At the pre-planned cable jointing locations, the two ends of the cables are laid on the seabed with sufficient slack to allow them to be lifted onto a suitable vessel. The cable jointing is then completed in an environmentally benign environment onboard the vessel before the cable is lowered back down to the seabed. The cable is then buried, if possible, or protected using measures as described in section 5.4.7.7. A similar procedure is deployed for cable repairs.

Table 5-14 Offshore Export Cable Parameters

Parameter	DBS East (HVDC only)	DBS West (HVAC only)	Both Projects (worst case HVAC + HVDC)
Maximum length of export cable measured from OSPs / OCPs / CPs to landfall (per cable) (km)	198	158	198
Maximum length of export cable measured from OSPs / OCPs / CPs to landfall (all cables) (km)	396	632	1,028
Export cable corridor width (km)	Approximately 1km plus a 500m temporary construction area buffer on both sides		
Export cable corridor width at landfall (km)	Approximately 4km		
Maximum number of export power cables	2	4	6
Maximum number of trenches	2	4	6
Minimum spacing between cables in trenches (m)	50m		
Offshore export cable corridor temporary disturbance width during installation (per cable) (m)	18m		
Export cable operating voltage (kV)	Up 275kV HVAC, up to +/-525kV HVDC		

5.4.7.2 Inter-Platform Cables

129. Inter-platform cables will be required to connect the OSPs /OCPs / CPs between the Projects, and the OSPs OCPs / CPs to the accommodation platform, switching platforms etc.

130. The inter-platform cable voltage will be up to 275kV, with an indicative external cable diameter of up to 275mm. They will be integrated with fibre optic cables.

131. Inter-platform cable parameters are set out in **Table 5-15**.

Table 5-15 Inter-Platform Cable Parameters

Parameter	**Details**
Maximum length of inter-platform cable for HVAC + HVDC design scenario (km)	385
Maximum length of inter-platform cable for HVDC in isolation design scenario (km)	55
Maximum length of inter-platform cable for HVAC in isolation design scenario (km)	100
Inter-platform cable temporary disturbance width during installation (per cable) (m)	18
Indicative external cable diameter (mm)	275

5.4.7.3 Array Cables

132. Array cables link the wind turbines to the OSPs / OCPs / CPs. The cable system design will be based on radial strings from the OSPs / OCPs / CPs connecting multiple turbines per string

133. The array cables will be up to 132kV, with an indicative external cable diameter of up to 220mm. Cable circuits (strings) will be optimised according to the electrical load they are required to carry, with up to three different cable dimensions being used. They will be integrated with fibre optic cables.

134. Each array cable will be installed in its own trench, with the maximum length of array cables being 650km. Array cable parameters are set out in **Table 5-16**.

Table 5-16 Inter Array Cable Parameters

Parameter	DBS East	DBS West	Combined
Maximum length of array cables (km)	325	325	650
Array cable temporary disturbance width during installation (per cable) (m)	18		
Maximum array cable voltage (kV)	Up to 132		

5.4.7.4 Cable Installation Methods

5.4.7.4.1 Removal of Existing Out of Service Cables

135. Where the cable routes cross out-of-service cables, depending on the length of cable and burial depth, these will either be recovered from the seabed by grapple hook or similar method prior to the start of installation, or cut at an appropriate distance either side of the cable and the free ends secured to the seabed by clump weights.

5.4.7.4.2 Boulder clearance

136. Boulders that present an obstacle to the construction activities will be confirmed by the pre-construction surveys. In the instance that a boulder cannot be avoided, it will be relocated to an adjacent area of sea bed within the offshore development area where they do not present an obstacle to the works, and where possible to an area of seabed with similar sediment type and avoiding any known sensitive habitats. If required, boulder clearance will be undertaken by subsea grab.

5.4.7.4.3 UXO Clearance

137. Specific surveys to identify potential locations of UXO will not be undertaken until the DCO is granted. This is to allow more detailed engineering work to be carried out on the cable routes and locations of turbines to allow a targeted survey for potential UXO to be undertaken.

138. However, data from the geophysical surveys already undertaken will be used to determine the potential for UXO within the offshore development area. As such, the ES will include an assessment of the worst case number of potential UXO within the offshore development area and how any identified UXO will be disposed of.

139. A marine licence application would be applied for post-consent to allow for the investigation and clearance of any UXO to ensure appropriate mitigation is put in place.

5.4.7.4.4 Pre-Lay Grapnel Run

140. Before cable-laying operations commence, it must be ensured that the route is free from obstructions such as discarded fishing gear, anchors or abandoned cables, wires and ropes that may be identified as part of the pre-construction surveys. A survey vessel would be used to undertake a pre-lay grapnel run (PLGR) to clear all such identified debris.

141. The width of seabed disturbance along the PLGR is estimated to be up to 6m, which would be encompassed by the maximum footprint of cable installation works – see **Table 5-14** for further details.

5.4.7.4.5 Sandwave levelling

142. Areas of mobile seabed (typically either in sandwaves or megaripples) may present a risk to the cable burial process either by preventing the cable burial tools from operating efficiently or by resulting in exposure and scouring of the cable once installed. In some cases, this could result over time in the cable being left 'free-spanning' over the seabed. Free spanning cables present a risk to other marine users and result in a large amount of strain being placed on the cables, significantly increasing the chance of their failure and the subsequent need for repair works.

143. In order to prevent this, cables can be placed where possible in the troughs of sandwaves to the reference seabed level, which would minimise the potential for cables becoming exposed. However, where this is not possible, the alternative is to dredge the top of the sandwaves prior to installation down to the seabed reference level. This process is termed sandwave levelling. If this was required, it would be completed before the cable is laid on the seabed.

144. Current worst case sandwave levelling scenarios are detailed in **Table 5-17**.

Table 5-17 Worst Case Sandwave Levelling Scenarios

Parameter	DBS East in isolation (HVDC only)	DBS West in isolation (HVAC only)	DBS West and DBS East concurrently and / or in sequence (HVAC + HVDC)
Maximum seabed footprint disturbed by sandwave levelling within array areas (m^2)	950,000	1,060,000	2,587,500
Maximum sandwave material to be dredged/relocated within array areas (m^3)	384,750	429,300	1,047,938
Maximum seabed footprint disturbed by sandwave levelling within offshore export cable corridor (m^2)	2,047,002	4,094,004	6,141,005
Maximum sandwave material to be dredged/relocated within offshore export cable corridor (m^3)	33,121,800	66,243,600	99,365,402

5.4.7.5 Cable Burial

145. The purpose of cable burial is to ensure that the cables are protected from damage, either from other activities such as fishing and shipping, or from naturally occurring physical processes acting on the seabed.

146. Burial of the offshore cables will be through any combination of ploughing, jetting, or mechanical cutting. The dimensions of the cable trenches and the overall seabed footprint affected by the burial process will depend on the installation method. Information on the different techniques is provided below.

5.4.7.5.1 Ploughing

147. A plough uses a forward blade to cut through the seabed, while burying the cable behind it. Ploughs can be used as a pre-trench tool (i.e. the cables are laid into a trench for later backfilling), a post-lay burial tool (i.e. the cable is first laid in position on the seabed before being ploughed in) or, more commonly, as a simultaneous lay and burial tool. Ploughing tools can be pulled directly by a surface vessel or can be mounted onto self-propelled caterpillar tracked vehicles which run along the seabed taking power from a surface vessel. The plough inserts the cable into the seabed as it moves. The indicative width of disturbance from ploughing is 15m.

148. There are two types of plough: displacement and non-displacement. The difference is important in terms of understanding the effect on the seabed. Displacement ploughs are typically used to pre-cut a trench in hard ground conditions, creating a trench that remains open for subsequent cable installation. A second backfilling pass of the plough is then undertaken to bury the cable.

149. By contrast, a non-displacement plough is designed to trench and bury the cable in a single pass, consequently causing less disturbance on the seabed as part of either a simultaneous or post lay and burial process. The plough may be fitted with additional equipment to help improve performance in certain soils, for example water jets for burying in sand.

5.4.7.5.2 Jetting

150. Jetting uses high powered jets of water to fluidise the seabed sediments and lower the cable to the required depth. Jetting may be undertaken either as a separate operation on a cable that has been pre-laid on the seabed, or by simultaneously laying and jetting. As with a plough, the jetting tool can either be pulled directly by a surface vessel or mounted onto self-propelled caterpillar tracked vehicles. The indicative width of disturbance from jetting is 18m.

5.4.7.5.3 Mechanical Cutting

151. This method involves the excavation of a trench (either by pre-trenching or simultaneously with cable laying), with the excavated material placed alongside. The cable is then laid in the trench and the sediment returned to the trench to complete the burial of the cable, either mechanically or by natural processes. An example mechanical cutting tool that could be used is the Global Marine Q1400 Trenching System (Global Marine, 2019).

5.4.7.5.4 Trench Sizes

152. The maximum temporary disturbance width for export, inter-platform and array cable installation would be up to 18m, encompassing the pre-grapnel run and trenching works. The respective indicative trench widths are as follows:

- Pre-lay ploughing 6m;
- Post-lay ploughing 0.5m;
- Jet trenching 1m; and
- Mechanical trenching 0.6m.

5.4.7.6 Array Cable Installation

153. Each section of cable will be laid from the cable lay vessel either from a static coil or a revolving carousel, turntable, or drum. The cable will be pulled into the turbine foundation via a J-tube (or alternative cable entry system) and hung-off inside the foundation structure before being connected to the turbine electrical system.

154. A typical methodology for installing the cable into a J-tube is:

- Mobilisation of a specialist cable installation vessel to site.
- A vessel will take up station adjacent to a wind turbine foundation. The cable end will be connected to a pre-installed messenger wire at the wind turbine foundation. The messenger wire will be recovered by a Remotely Operated Vehicle (ROV). The messenger wire would then allow the cable to be pulled into the wind turbine foundation from a temporary pre-installed winch arrangement at the wind turbine foundation. An ROV will be used to monitor the cable entering the J-tube or cable entry system.
- When the first cable end is pulled in with required overlength, the cable is secured with a temporary hang-off arrangement and cable installation continue towards the wind turbine foundation for second end pull-in and hang-off. Separate teams will be mobilized for installing permanent

hang-off of the cable and terminate the cable cores and fibre optic cables.

- Second end cable pull-in, hang-off and termination will in principle be similar to the first end, except for overboarding of the last end of the cable from the installation vessel that will be by means of a quadrant.
- The same principle for cable installation is applicable for wind turbine foundations without a J-tube. The main differences are the interface between the cable protection system and the foundation entry; without a J-tube the cable is free hanging inside the foundation structure.

5.4.7.7 External Cable Protection

5.4.7.7.1 Need for External Cable Protection

155. There are certain situations where the use of external cable protection may be required. These are:

    - Where an adequate degree of protection has not been achieved from the burial process. This may be as a result of challenging ground conditions, or unforeseen circumstances with the burial process, such as break down of the burial tool/s;
    - Where the array cables approach the wind turbines and OSPs/OCPs, as described above in section 5.4.7.6;
    - At cable and / or pipeline crossings (section 5.4.7.7.3);
    - At the HDD exit pit (section 5.5); and
    - In the event that cables become unburied as a result of seabed mobility during the operation of the wind farms or (where necessary) in the event of making a cable repair (discussed in section 5.4.7.5.7).

156. In all cases, the amount of external cable protection will be minimised as far as is possible.

157. Since it is not possible to bury the array cables in close proximity to the wind turbines and platforms due to the scour protection that will be installed, the cables would be surface laid with cable protection on the approach to each foundation. An allowance of up to 170km of cable protection (total across both Projects) is included for this purpose, although it would be partly within the footprint of the foundation scour protection.

5.4.7.7.2 Types of External Cable Protection

158. A range of external cable protection systems are available and include:

- Rock placement – the laying of loose rock on top of the cable. Use of rock is often preferred as it is well proven to offer excellent protection in the marine environment, is suitable for application over large areas and is relatively simple and cost effective to deploy;
- Concrete mattresses – prefabricated flexible concrete coverings laid on top of the cable. Deployment is slow and therefore mattresses only tend to be used for short sections of cable;
- Frond mattresses – similar to concrete mattresses but the addition of fronds is used to encourage the settlement of sediment over the mattress and the cable underneath. Only suitable in certain hydrodynamic and sedimentary conditions;
- Protective aprons or coverings – solid structures of varying shapes, typically prefabricated in concrete or similar;
- Bagged solutions – including geotextile sand containers, rock-filled gabion bags or nets, and grout bags, filled with material sourced from the site or elsewhere); and
- Uraduct shell, Tekmar or similar cable protection system – a protective shell fixed around the cable. Generally used for short spans at crossings or near offshore structures where there is a high risk from falling objects. Such systems alone do not typically provide protection from damage due to fishing trawls or anchor drags.

159. Protection systems may be placed alone or in combination with other types and may be secured to the seabed where necessary.

5.4.7.7.3 Unburied Cables

160. An allowance is made for external cable protection where an adequate degree of protection has not been achieved from the burial process. The cable protection is assumed to have a width on the seabed of up to 15.2m for the offshore export cables and inter-platform cables, and 6m for the array cables. A total allowance of up to 177.7km is assumed for the export cables, 76.52km for the inter-platform cables (for both Projects) and 162.8km for the array cables.

5.4.7.7.4 Cable and Pipeline Crossings

161. A number of cable and pipeline crossings will be required for the Projects. Potential crossings include:

- Shearwater to Bacton gas pipeline (DBS West only);
- Esmond to Bacton gas pipeline (DBS West only);
- Esmond to Forbes gas pipeline (DBS West only);
- Esmond to Gordon gas pipeline (DBS East and DBS West);
- Cygnus to ETS gas pipeline (DBS East only);
- Cavendish gas pipeline (DBS East only);
- Cavendish methanol pipeline (DBS East only);
- Langeled pipeline (offshore export cable corridor only);
- Northern Endurance CCS pipeline (offshore export cable corridor only);
- Hornsea 4 export cable corridor (Up to six cables, offshore export cable corridor only);
- Third Eastern Link HVDC cable (referred to as TGDC, offshore export cable corridor only); and
- Fourth Eastern Link HVDC cable (referred to as E4L5, offshore export cable corridor only).
- National Grid HND Bootstrap (route not yet finalised, potentially within the array areas).

162. Additional new 3rd party infrastructure may be installed ahead of DBS, requiring further crossings.

163. The maximum width and length of cable protection for crossings is 15.24m and 400m, respectively. The maximum height of cable crossings will be 1.4m and all crossings will be designed to be over-trawlable.

164. Crossings are designed to protect the obstacle being crossed, as well as the Projects cables once they have been installed. Detailed methodologies for the crossing of cables and pipelines will be determined in consultation with the owners of the infrastructure to be crossed. However, a number of techniques may be utilised, including:

- Pre-lay and post lay concrete mattresses;
- Pre-lay and post lay rock placement; or
- Pre-lay cable with Uraduct (or similar) shell structure protection and post-lay rock placement / rock bags.

5.4.7.7.5 Summary of Potential Cable Protection Requirements

165. A summary of all potential cable protection requirements is provided in **Table 5-18**. As noted previously, these figures differ from The Crown Estate's Round 4 Plan Level HRA. Site specific survey data analysis is ongoing to inform the cable burial risk assessment, with refinements to these figures likely to occur prior to ES.

Table 5-18 Cable Protection Summary

Cables	Maximum estimated number of crossings (cable + pipeline)	Crossing protection	Cable protection of unburied cables	Protection of unburied cable notes
Offshore export cable corridor (m²)	72	441,400	2,701,040	Based on a maximum 180km cable for protection, up to 15.2m wide
Inter-platform (m²)	24	146,800	1,163,104	Based on a maximum of 80km cable for protection, up to 15m wide.
Array (m²)	40	98,200	976,800	Based on a maximum of 170km cable for protection, up to 6m wide
Total (m²)	136	686,400	4,840,944	

5.4.8 Construction Vessels

166. A variety of vessels will be used during the construction phase, although the exact number and specification will not be known until much closer to the time of construction. Similarly, whilst it is likely that both DBS East and DBS West will be operated from the RWE O&M port at Grimsby, the construction ports will not be confirmed until nearer the start of construction.

167. In order to inform the environmental assessment, **Table 5-19** below gives an indication of the maximum construction vessel quantities and related movements to and from port that can be expected on site at any one time. Due to construction sequencing not all types of vessels will be on site at the same time.

168. A total of 11,489 vessel movements (round-trips) is estimated during construction of both Projects on a worst case basis (assuming the Projects are constructed sequentially).

Table 5-19 Construction Vessel Peak Numbers

Construction Element	Detailed Activity (Where Applicable)	Number of Spreads	Vessel Type	Peak Number On-Site Simultaneously Per Spread	Maximum Return Trips
Foundation installation	Site preparation	N/A	Site preparation vessels	4	78
	Wind turbine foundation installation	3	Noise mitigation vessels	2	267
			Installation vessels	1	
			Pre-piling vessels	1	
			Anchor handling vessels	2	
			Feeder vessels	1	
			Other vessels	1	
	Offshore platform	1	Noise mitigation vessels	2	64
			Installation vessels	1	

Construction Element	Detailed Activity (Where Applicable)	Number of Spreads	Vessel Type	Peak Number On-Site Simultaneously Per Spread	Maximum Return Trips
			Pre-piling vessels	1	
			Anchor handling vessels	2	
			Feeder vessels	1	
			Other vessels	1	
	Wind turbine transition piece installation	3	Installation vessels	1	16
			Anchor handling vessels	2	
	Scour protection	N/A	Installation vessels	2	1,676
	Gravity base ballast	N/A	Installation vessels	2	1,261
Subtotal				**49**	**3,260**

Construction Element	Detailed Activity (Where Applicable)	Number of Spreads	Vessel Type	Peak Number On-Site Simultaneously Per Spread	Maximum Return Trips
Wind turbine installation	N/A	4	Installation vessels	1	148
			Anchor handling vessels	2	
			Barges	1	
			Tugs	1	
Subtotal				**20**	**148**
Array cable installation	N/A	4	Cable lay vessels	1	506
			Cable support vessels	1	
			Seabed preparation vessels	1	
			Rock dumping vessels	1	
			Tugs	2	

Construction Element	Detailed Activity (Where Applicable)	Number of Spreads	Vessel Type	Peak Number On-Site Simultaneously Per Spread	Maximum Return Trips
Subtotal				**24**	**506**
Export cable installation	N/A	2	Cable lay vessels	1	3,085
			Cable support vessels	1	
			Seabed preparation vessels	1	
			Rock dumping vessels	1	
			Tugs	2	
Subtotal				**12**	**3,085**
Other installation vessels	N/A	N/A	Commissioning vessels	3	78
			Offshore platform topside installation vessels	4	32

Construction Element	Detailed Activity (Where Applicable)	Number of Spreads	Vessel Type	Peak Number On-Site Simultaneously Per Spread	Maximum Return Trips
			Other vessels	20	4,380
Subtotal				**27**	**4,490**
Overall Total				**132**	**11,489**

169. Where they are used, jack-up barges and anchored vessels will have a seabed footprint (**Table 5-20**) (these footprints are also incorporated in section 5.4.1.1). For this purpose, it is assumed that there would be one operation for each foundation installation (most likely using anchors) and a further operation for each wind turbine installation (most likely using a jack-up). Jack-up vessels may have four or six legs/spudcans, generally with a smaller footprint if there are six legs. Where the jack up vessel has four legs it is assumed each will have a footprint of up to 275m^2. The footprint for deployment & recovery of one anchor will be approximately 116m^2.

Table 5-20 Construction Vessel Footprints (Foundation, Wind Turbine and OSP/OCP/CP Installation)

Parameter	DBS East in isolation (HVDC only, 100 small turbines)	DBS West in isolation (HVAC only, 100 small turbines)	DBS West and DBS East concurrently and / or in sequence (HVAC + HVDC, 200 small turbines)
Jack-up vessels			
Area per jack-up leg (m^2)	275	275	275
No. of legs per jack-up vessel	4	4	4
Total area per jack-up vessel (m^2)	1,100	1,100	1,100
No. of jack-up operations per turbine	6	6	6
Total jack-up area per turbine (m^2)	6,600	6,600	6,600
Total jack-up area for turbine installation (m^2)	660,000	660,000	1,320,000
Vessel jack-up footprint for all offshore platforms (m^2)	33,000	33,000	60,500

Parameter	DBS East in isolation (HVDC only, 100 small turbines)	DBS West in isolation (HVAC only, 100 small turbines)	DBS West and DBS East concurrently and / or in sequence (HVAC + HVDC, 200 small turbines)
Anchoring			
Anchoring footprint (m^2)	116	116	116
Anchor placements per activity	4	4	4
Anchoring footprint per activity (m^2)	464	464	464
Number of activities requiring anchoring per turbine	5	5	5
Worst case turbine number for anchoring (m^2)	232,000	232,000	464,000

170. Anchoring may also be used during offshore export cable installation where a simultaneous lay and plough methodology is used. **Table 5-21** below details the indicative anchoring footprint during offshore export cable installation.

Table 5-21 Indicative Anchoring Footprint for Export Cable Installation

Parameter	DBS East in isolation (HVDC only)	DBS West in isolation (HVAC only)	DBS West and DBS East concurrently and / or in sequence (HVAC + HVDC)
Indicative length of cable route installed with anchors (km)	10	10	10
Indicative impacted footprint for deployment of all anchors used during installation activity (m^2)	485	485	485
Indicative impacted volume for one deployment (m^3)	728	728	728
Maximum number of offshore export cable circuits	2	4	6
Indicative skid length for installation (km)	0.44	0.44	0.44
Indicative maximum total number of vessel moves	45	91	136
Maximum total impacted area for anchoring (m^2)	22,045	44,091	66,136

5.4.9 Helicopters

171. Additionally, a maximum of 1,460 return trips per year may be made by helicopters during the construction phase.

5.4.10 Safety Zones

172. Safety zones may be used to help ensure safe working during all phases of the development, namely, to ensure a safe distance is maintained between the wind farm structures and vessels. The implementation of all safety zones will be subject to application and approval prior to the start of construction. The safety zones that may be applied for are summarised in **Table 5-22**.

173. Further information on safety zones is provided in **Chapter 14 Shipping and Navigation**.

Table 5-22 Safety Zones That May be Applied For

Potential Safety Zone	Details
Construction	Up to 500m around each wind turbine foundation or platforms whilst under construction.
Commissioning	Up to 50m around each wind turbine foundation or platforms where construction has finished but where some work may be ongoing e.g., a wind turbine that is incomplete or in the process of being tested before commissioning.
Major Maintenance	Up to 500m when major maintenance is in progress (use of jack-up vessel or similar).
Decommissioning	Up to 500m at the end of the working life of a wind turbine foundation or platform when it is being decommissioned.

5.4.11 Offshore Operation and Maintenance

174. The ongoing operation of the wind farms over the Projects design life of 30 years will require a number of operation and maintenance activities.

175. An outline Operations and Maintenance Plan will be provided with the DCO application and will provide further details of the anticipated activities and how they will be controlled by the DCO.

5.4.11.1 General Maintenance Activities

176. A programme of monitoring and scheduled maintenance will be undertaken through the lifetime of the wind farms to ensure that all offshore infrastructure is maintained in safe working order and to maximise operational efficiency. Operational control of the wind farms will be through a Supervisory Control and Data Acquisition (SCADA) system, which will connect each turbine to the onshore control room. This system will enable the remote control of individual turbines, as well as remote interrogation, information transfer and data storage.

177. Surveys, including geophysical survey (most typically multibeam echosounder and/or side scan sonar) and through the use of remotely operated vehicles, will be performed at regular intervals throughout the operational lifetime of the wind farms. A typical geophysical survey programme for asset integrity purposes would be exempt from the need for a Marine Licence. The work programme would generally focus on areas of greater interest, for example areas of greatest seabed mobility.

178. Typical general maintenance activities include, but are not limited to:

- Wind turbine inspections and service;
- Oil sampling and/or change;
- Uninterruptible power supply (UPS) battery change;
- Service and inspections of wind turbine safety equipment, nacelle crane, service lift, high voltage system, blades;
- Offshore platform inspection/repair;
- Foundation inspection and repair;
- Cable repair and replacement;
- Cable remedial reburial;
- Cable crossing inspection and repair; and
- Unplanned and planned corrective work.

179. Subsea cables are designed for the lifetime of the Projects, however reactive repairs, replacements or remedial cable reburial work may be required, which are addressed in sections 5.1.1.1 and 0 below. Major replacements of components such as gearboxes may be required during the lifespan of the Projects. Other large components (e.g., wind turbine blades or OSP / OCP / CP transformers) are not expected to need replacement frequently during the operational phase, although failure of these components is possible. In the event of major component replacement, a jack-up vessel may be required to operate continuously for significant periods to carry out major maintenance activities of this type. For this purpose, it is assumed that there could be up to 558 jack-up movements over the operational lifespan of DBS East and DBS West combined.

5.4.11.2 Vessel Operations

180. Vessel visits to the wind farms will be required each year to allow for scheduled and unscheduled maintenance activities. **Table 5-23** provides a breakdown of the maximum number of vessels that may be required at any one time per year during normal operation (i.e. excluding unforeseeable serial defects) and the anticipated maximum number of vessel movements per year during operation.

Table 5-23 Anticipated Trips to the Wind Farms During Operations – Peak Vessel Quantities and Annual Vessel Round-Trips

Vessel Type	Indicative maximum number of vessels required at any one time (one project – DBS East or DBS West)	Indicative maximum number of vessels required at any one time (both projects)	Indicative maximum number of vessel movements (one project – DBS East or DBS West)	Indicative maximum number of vessel movements (both projects)
Jack-Up vessels	1	3	8	16
Service Operations Vessels (SOVs)	1	2	52	104
Accommodation O&M vessels	1	2	52	104

Vessel Type	Indicative maximum number of vessels required at any one time (one project – DBS East or DBS West)	Indicative maximum number of vessels required at any one time (both projects)	Indicative maximum number of vessel movements (one project – DBS East or DBS West)	Indicative maximum number of vessel movements (both projects)
Small O&M vessel (CTV)	1	2	52	104
Lift vessels	1	2	8	16
Cable maintenance vessels	1	2	1	1
Auxiliary vessels	4	8	64	128
Helicopter	1	1	1/mth	1/mth

5.4.11.3 Cable Repair or Replacement

181. The basic methodology for carrying out a cable repair will involve removal of the damaged or faulty section of the cable, cutting of that section (unless replacing the whole cable), followed by the insertion of a new cable section to be joined to the existing cable. The seabed footprint of cable repair and replacement works is summarised in **Table 5-24** below.

182. The section of cable to be repaired will be exposed using techniques such as jetting or mass flow excavation (if buried) and/or removal of any external cable protection. Once the repair is completed, jetting or other suitable methods of trenching would be used to rebury the cable and/or the external cable protection reinstalled. In addition, cable protection may require inspection and maintenance during the operational phase of the Projects. For the longer inter-platform and export cables, an extended cable loop would typically be surface laid onto the seabed close to and to one side of the original cable, prior to the cable being protected as described above. As the original cable would be recovered from the trench prior to cutting, it's possible that the length of cable to be re-buried, and any external cable protection (if required), would be greater than the length of cable repaired.

183. For array cables, the entire length of a cable (between 0.8km and 6km subject to turbine spacing) could require replacement and therefore 6km has been assumed as the worst case. The methodology for cable replacement will be identical to cable installation, with the addition of the removal of the cable from the turbine/platform structure.

5.4.11.4 Cable Reburial

184. In the event that cables become exposed due to the natural movement of the seabed over the lifetime of the Projects, it may be necessary to undertake remedial reburial work to ensure that the cables are adequately protected, without the need to resort to the use of external cable protection measures. The need for reburial work will be informed by an ongoing programme of geophysical surveys.

185. The seabed footprint of cable reburial works is summarised in **Table 5-24** below.

186. An In-Principle Monitoring Plan will be submitted with the DCO application which will outline the proposed monitoring, the details of which would be agreed post consent with the relevant Regulators and SNCBs. Post-construction surveys are likely to be a requirement of the DCO/DMLs.

Table 5-24 Footprint of Potential Cable Re-Burial and Cable Protection Replacement

Parameter	Small Turbine Scenario	Large Turbine Scenario
Array cable repairs/replacement - lifetime quantity	13	9
Array cable repairs/replacement - seabed disturbance per event (m^2)	6,000	6,000
Total area of array area disturbance over Projects operational lifespan	78,000	54,000
Offshore export cable repairs/replacement - lifetime quantity	6	6
Offshore export cable repairs/replacement - seabed disturbance per event (m^2)	6,000	6,000
Total area of offshore export cable disturbance over Projects operational lifespan (m^2)	36,000	36,000

Parameter	Small Turbine Scenario	Large Turbine Scenario
Export cable protection requiring replacement over the Projects lifespan	5km (dependent on survey results)	5km (dependent on survey results)

5.4.11.5 O&M Port

187. The maintenance port and facilities will be located on the East coast of the UK, and it is assumed that all direct labour will be resident within the area. It is likely that the existing facilities at the Grimsby Port will be utilised (and expanded where necessary) as the base for operations management of Dogger Bank South, as this will yield synergies and enable effective coordination with the existing operations team at the RWE Grimsby Hub.

5.4.12 Repowering

188. Once any potential life extension opportunities have been exhausted (through those maintenance activities described above and as provided for within the DCO), repowering may be considered at or near the end of the 30-year design life of the Projects. Repowering could involve the replacement of turbines and/or foundations with those of a different specification or design, for example to enable the installation of more efficient wind turbines.

189. In this event, if the specifications and designs of the new turbines and/or foundations were outside the existing maximum design scenario, or the impacts of constructing, operating, and decommissioning them were to fall outside those considered in this EIA, repowering would require further consent (and EIA) and is therefore outside of the scope of this document. At this time, it is not expected that repowering would require removal of existing or installation of new offshore (or onshore) cables.

5.4.13 Offshore Decommissioning

190. At the end of the operational lifetime of the Projects, it is anticipated that all structures above the seabed or ground level will be completely removed. The decommissioning sequence will generally be the reverse of the construction sequence and involve similar types and numbers of vessels and equipment. The decommissioning duration of the offshore infrastructure may take the same amount of time as construction of the Projects, up to five years per Project, although this indicative timing may reduce.

191. The Energy Act 2004 requires that a decommissioning plan must be submitted to and approved by the Secretary of State, a draft of which will be submitted prior to the construction of the Projects. The decommissioning plan and programme will be updated during the Projects' lifespan in accordance with requirements.

192. To take account of changing best practice and new technologies, the approach and methodologies employed at decommissioning will be cognisant of the legislation and policy requirements at the time of decommissioning.

5.4.13.1 Turbines and Platforms

193. Wind turbines will be removed by reversing the methods used to install them. Piled foundations will likely be cut approximately 1m below the seabed, with due consideration made of likely changes in seabed level and removed. This could be achieved by inserting a pile cutting device. Once the piles are cut, the foundations could be lifted and removed from the site.

194. At this point in time, it is not thought to be reasonably practicable or environmentally prudent to remove entire piles from the seabed, however, the Applicant will track the development of technology to enable this and will consider such decommissioning methodologies at the time of decommissioning.

195. The offshore platforms will most likely be a reverse installation where the decommissioning will be in two phases, in the first phase the topside will be lifted from the foundation to a transport vessel/barge and sailed to a suitable harbour for decommissioning. In the second phase the foundation will be decommissioned; piled foundations will be decommissioned as described above.

5.4.13.2 Offshore Cables

196. It is expected that most array and export cables (and any associated cable protection) will be left in situ. Exposed sections of cable are more likely to be cut and removed to ensure they don't become hazards to other users of the seabed. At this point in time, it cannot be accurately determined whether and which cables will be exposed at the time of decommissioning.

197. In the event that cables are removed, it is likely that equipment similar to that which is used to install the cables could be used to reverse the burial process and expose them. Therefore, the area of seabed impacted during the removal of the cables could be the same as the area impacted during the installation of the cables. Divers and/or ROVs may be used to support the cable removal vessels.

198. Once the cables are exposed, a grapnel will be used to pull the cables onto the decks of cable removal vessels. The cables will be cut into manageable lengths and returned to shore. Once onshore, it is likely that the cables will be deconstructed to recover and recycle the copper and/or aluminium and steel within them.

5.5 Landfall

5.5.1 Background

199. The offshore export cables make landfall near Skipsea. The offshore export cables will be connected to the onshore export cables in the TJBs, which will be constructed prior to the installation of the offshore export cables. There are two landfall locations identified for the PEIR, and these are shown in **Figure 5-4.**

200. The landfall area extends inland to allow the TJBs to be located beyond any areas at risk of natural coastal erosion, and to provide space for temporary construction logistics and access requirements.

201. The possible landfall locations near Skipsea were chosen as the result of a site selection process, considering environmental and technical constraints. The site selection process is described in **Chapter 4 Site Selection and Assessment of Alternatives.**

202. Installation of up to seven ducts which would be installed using a trenchless technique such as HDD. This consists of three ducts per HVDC project (two power cable ducts plus a smaller duct for a fibre optic communications cable) and four ducts for four HVAC cables. In a HVDC-only design scenario six ducts would be required, with four ducts for the power cables and two ducts for the fibre optic cables. Space is also allocated for an additional two HDD for contingency purposes in the unlikely event of HDD failure in a concurrent/sequential design scenario, with one spare HDD for contingency for a Project in isolation.

5.5.2 Landfall Works

203. A trenchless solution (likely to be an HDD) is to be used to install ducts that will house the cables under the beach. The ducts will run from the TJBs, located landward of landfall, to an exit location which could either be located in the intertidal or below mean low water springs. TJBs are permanent infrastructure where the offshore and onshore export cables are joined. The offshore export cables will be pulled ashore through these pre-installed HDD ducts and will interface with the onshore cables at the TJBs.

204. Landfall works are likely to include:

- Construction of a temporary access to the landfall compound;
- Construction of the landfall compound;
- HDD works (likely to require 24 hour working);
- Construction of TJBs;
- Pull-in of duct from barge (alternatively, they may be pushed from landfall side);
- Pull-in of offshore high voltage cables from vessel;
- Transition jointing offshore / onshore cables;
- Backfilling of joint bays; and
- Reinstatement works.

205. A temporary onshore compound will be required to accommodate the drilling rigs, ducting (if installed from onshore) and welfare facilities. Each drill would start from the landfall compound, travel beneath the beach, and will exit either in the intertidal or subtidal zone at a suitable water depth. The drill will be of sufficient depth below the coastal shore platform to have no effect on coastal erosion. A temporary access route will be constructed to allow for transport to/from the temporary onshore compound.

206. Offshore works, or those in the intertidal, depending on the location of the exit pits, include:

- Excavation of HDD exit area (and sheet piling, if required) and trench (if required);
- Assembly of duct whilst being pulled through the HDD to the landfall (may occur in the opposite direction);
- Laying of additional length of ducting in trench (if required);
- Capping and burial of HDD duct end.

207. As part of the HDD activities, offshore activities include the excavation of offshore HDD exit pits. A multicat vessel will typically be used for various offshore construction activities, such as excavation and dive support. A shallow draft barge may be located at the exit point for a period of approximately 10 to 14 days while each HDD is completed, and each duct is installed.

208. Prior to any construction, survey works, and site clearance will be undertaken, including geotechnical, topographical, UXO, and environmental surveys. The compound site will be cleared (topsoil removal etc.) in line with environmental requirements and the temporary access haul road will be prepared.

209. The HDD works should not require any prolonged periods of restrictions or closures to the beach for public access, although it is possible that some work activities will be required to be performed on the beach that may require short periods of restricted access. For example, use of a temporary seawater pipe and pump to supply seawater to the onshore HDD temporary works compound for use with the drilling fluid, as well as the use of vehicles to transport the ducting across the beach. Any areas subject to short-term restricted access would be agreed in advance with East Riding of Yorkshire Council and the Environment Agency prior to construction.

210. Duct extensions may be required to enable the landfall HDD ducts to be extended further offshore to facilitate cable installation from an installation vessel situated offshore. These duct extensions will be of a similar diameter to the HDD ducts and installed in their own trench at a similar depth of cover to the export cables. The duct extensions will be backfilled before the arrival of the cable installation vessel.

211. The offshore export cables will then be installed at a suitable time, as part of the main export cable installation campaign, taking into account weather, tide and the wider offshore works schedule, by positioning the cables at the offshore exit point and pulling through the ducts to the TJBs.

212. In shallow water sections of the cable route, where the ground conditions are not suitable to ground-out the export cable installation vessel on the seabed, the construction of temporary flotation pits may be required. Up to four floatation pits per export cable may be required, allowing the installation vessel to remain floating at low tide whilst pulling and installing the cable. Once the export cables are installed under the seabed, the floatation pits will be backfilled.

5.5.2.1 Transition Joint Bays

213. TJBs are required to connect the offshore export cables to the onshore export cables, and these are generally constructed at the landfall location. The TJB provides a clean, dry environment where the onshore and offshore cables are jointed, and to protect the joints once completed. The TJB pits will be dug into the ground and lined with concrete. Once the joint is completed, the TJBs are covered and the land above reinstated. Access will be required during operation to link boxes (associated with each TJB);

214. The TJB generally comprises of a reinforced concrete slab and may either have reinforced concrete walls with a reinforced concrete cover or comprise of the slab only with cement bound sand and other sand used as backfill to protect the cable joints. The TJBs are generally buried at a depth to allow the majority of land to return to normal uses such as agricultural land, with $100m^2$ of land per TJB being required permanently. However, each TJB is usually accompanied by a link box to allow testing and monitoring of cable joints. The link boxes are generally much smaller in footprint than the TJBs, however, these are generally at a much shallower depth with a manhole inspection cover at the surface.

215. Following successful testing of the cables at the TJBs the landfall compound and access route will be removed. The site will be reinstated to the original condition; this work will include the removal of all equipment and facilities, temporary fencing, haul road and reinstatement of topsoil.

5.5.2.2 Landfall Parameters

216. **Table 5-25** shows the main construction parameters for the landfall site.

Table 5-25 Landfall Construction Onshore Parameters

Landfall	DBS East and DBS West together (HVDC + HVAC)	DBS East and DBS West together (HVDC + HVDC)	DBS East or DBS West in isolation (HVDC only)	DBS East or DBS West in isolation (HVAC only)
Number of HDD drills	9 (2 spare)	9 (2 spare)	4 (1 spare)	5 (1 spare)
Number of transition joint bays	6	4	2	4
Transition joint bay(s) dimensions (m) – each	5 x 20	5 x 20	5 x 20	5 x 20
Permanent land take for total number of TJBs (m^2)	600	400	200	400
Landfall compound size	310m x 75m	190m x 75m	150m x 75m	230 x 75m
Estimated Length of HDD	1400m	1400m	1400m	1400m

5.6 Onshore

5.6.1 Onshore Export Cable Corridor

217. The onshore export cable works includes all the infrastructure necessary to connect the offshore export cables via TJBs to the onshore substations and connection to the National Grid. The type and arrangement of cables is dependent upon the electrical transmission system adopted by the Projects. It is anticipated cables will be buried along the full route where possible.

218. The onshore cable works include:

- Initial site investigation works;
- Site survey and ecological clearance required in preparation for construction;
- Construction of access to the cable corridor infrastructure;
- Temporary strip and storage of topsoil for agricultural areas;
- Construction of Main and Temporary Construction compounds (TCC);
- Construction of cable joint bays;
- Construction of temporary haul roads to facilitate the onshore export cable installation;
- Excavation of trenches and installation of cable ducts (where used);
- Installation of below ground chamber at the joint/link box locations, required to provide maintenance and inspection access to the cable system;
- Laying or pull-in of high voltage cables within duct or direct lay in trench;
- Backfilling of joint bays and cable trenches with suitable material for electrical performance and protection of cables;
- Reinstatement works;
- Design and construction of crossings or protective measure required due to close proximity or crossing of export cable to existing infrastructure and natural features. This includes roads, railways, rivers and streams. This may be achieved by construction of culverts/cable structures of trenchless methods including HDD or other appropriate methodologies; and
- Installation of ducts and cable in hard ground or road carriageways where required including temporary traffic management and reinstatement of the surfacing surface.

5.6.1.1 Location

219. A 200m wide onshore cable corridor is being considered for the purposes of the PEIR assessment, with an indicative 100m wide preferred onshore cable corridor presented in **Figure 5-4.**

220. From the landfall at Skipsea, the onshore cable corridor travels west, crossing Hornsea Road (B1242), and continuing to Dunnington Lane before turning and heading south past Dunnington, Nunkeeling, Catfoss, and across West Road (A1035) at Sigglesthorne.

221. The onshore export cable corridor then turns southwest and continues passing the village of Riston Grange, crossing Whitecross Road (A165) and again crossing Hornsea Road (A1035) as it heads west north of Tickton. The route then crosses Driffield Road (A164) to the north of Beverley before turning south crossing Constitution Hill (A1035) to the west of Beverley, down across York Road, Newbald Road, and Broadgate (B1230), before reaching the onshore substation site options located at Beverley Road along the A1079 and A164.

5.6.1.2 Onshore Export Cable Corridor Parameters

222. **Table 5-26** shows the main construction parameters for the onshore cable corridor.

Table 5-26 Onshore Export Cable Corridor Construction Parameters

Onshore Export Cable Corridor	DBS East and DBS West together (HVAC + HVDC)	DBS East and DBS West together (HVDC + HVDC)	DBS East or DBS West in isolation
Onshore export cable corridor length	39km	39km	39km
Number of cable circuits	Five (Four HVAC + One HVDC)	Two	Four (HVAC scenario) One (HVDC scenario)
Indicative no. of construction compounds	176	176	88
Size of main compound(s)	100x100m	100x100m	100x100m

Onshore Export Cable Corridor	DBS East and DBS West together (HVAC + HVDC)	DBS East and DBS West together (HVDC + HVDC)	DBS East or DBS West in isolation
Size of secondary compounds	75x75m	75x75m	75x75m
Cable corridor width	100m	70m	50m
Cable corridor width at trenchless crossings	250m	150m	125m
Maximum No. trenches	7	7	5
Approximate depth of trenches	1.3 – 1.7m	1.3 – 1.7m	1.3 – 1.7m
Indicative cable burial depth (minimum depth of soil to the top of the cable duct)	1.6m	1.6m	1.6m
Cable duct trench dimensions (assuming each cable has individual trench)	0.75-2.2m each	0.75-2.2m each	0.75-2.2m each
Typical jointing bay frequency	Every 0.75 – 1.5km	Every 0.75 – 1.5km	Every 0.75 – 1.5km
Indicative no. jointing bays	336	224	224
Jointing bay construction dimensions	10 x 25m	10 x 25m	10 x 25m
Jointing bay infrastructure dimensions	3 x 8m	3 x 8m	3 x 8m

5.6.1.3 Onshore Construction Activities

223. Initial works will include a series of site investigation activities including boreholes, geophysics surveys to establish ground conditions, and key properties of soil materials to inform the design. This will be carried out using specialist ground investigation equipment, temporary welfare, storage, and mobile plant such as excavators and dumpers.

224. The majority of the work in soil storage areas as per **Plate 5-6** will be executed using mechanical plant for earthmoving and excavation activities. This will typically include bulldozers, various excavators and dumper trucks and lorries for material handling. Highways works may be required including improvements as part of the traffic management plan; new junctions and cuttings and embankments to ensure road stability.

225. Work areas will be cleared, and the topsoil stripped and stored in stockpiles in line with soil management requirements.

226. Imported material (gravels/stones/geotextiles/road surfacing where required) will then be imported via road to the designated access point and used to form stable surfaced areas for construction activities including access points, compounds for temporary offices units, storage and parking and formation or permanent area platforms to the required level and falls.

227. A drainage scheme will be designed to manage water formation on temporary surfaces areas and control discharge from construction areas. Cable ducting and other below ground structures will be installed. This will include excavation of subsoil to the required depth, duct installation and backfill with suitable materials to ensure cable electrical/thermal performance and protection. These items will be delivered to site. The number, installation and arrangement of cables is dependent upon the final scheme electrical requirements.

228. Concrete and other imported construction materials will be used to form structures/foundations/slabs where required (including but not limited to transition joint bays, road accesses and haul road crossings of major utilities), along with any required formwork and reinforcement.

229. Excess soil arising will be used on site where possible for earthworks and landscaping with unsuitable material being removed from site for suitable re-cycling or disposal. Additional imported material for landscaping may be required.

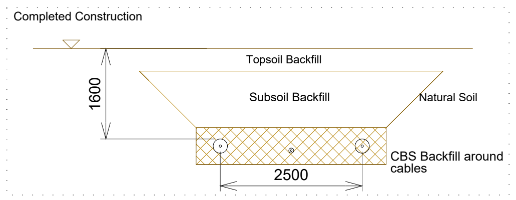
230. Cutting and breaking equipment will be used to open up hard surfaces as required during the works. Appropriate materials will be used to reinstate these areas in line with their future use requirements such as pavements, highways or hard standing areas.

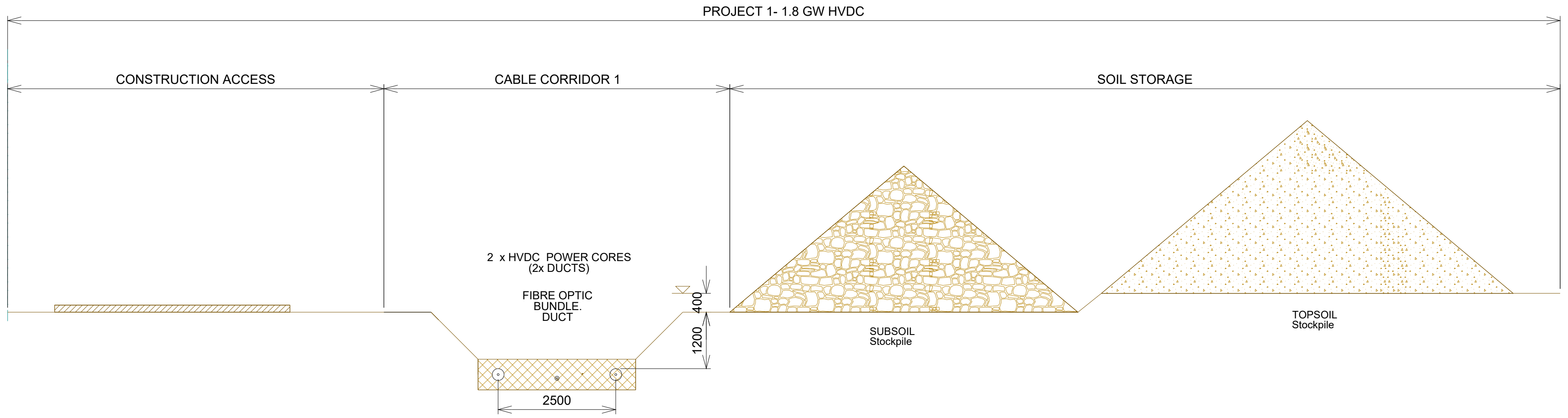
231. Where the corridor width is restricted additional soil storage land areas will be required with additional vehicles used to transport from the excavation location to the storage areas and back.

232. Hoarding, fencing, signage route diversions etc. will be used to separate the work areas from the general public.

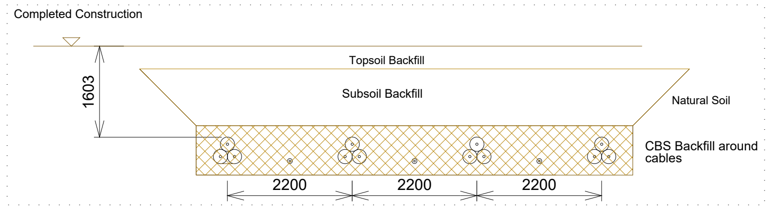
233. A typical example of onshore export cable works for an HVAC project built in isolation is shown in . A typical example of onshore export cable works for a HVDC project plus an HVAC project, constructed concurrently, is show in **Plate 5-8**. A typical example of onshore export cable works for two HVDC project, constructed concurrently, is show in in **Plate 5-9**.

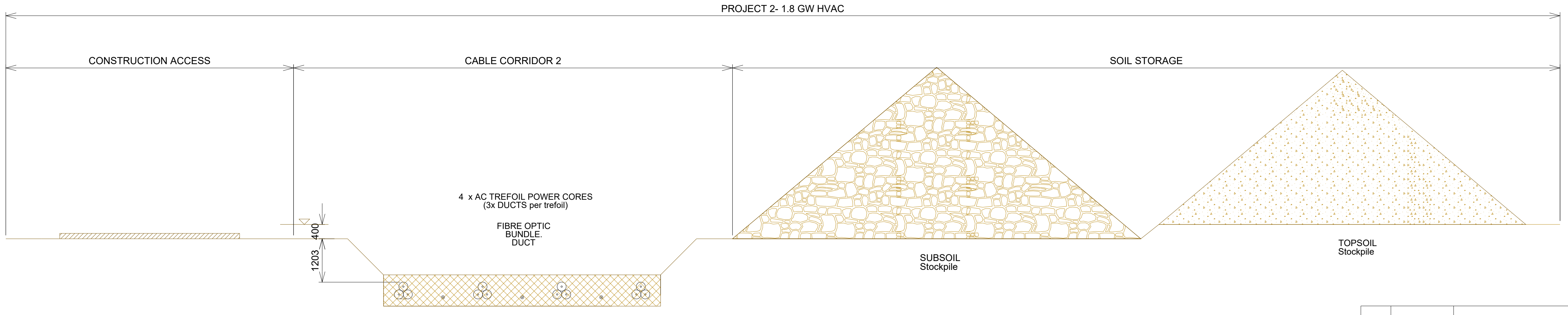
SECTION 1: 1.8GW HVDC Standalone Project





SECTION 2: 1.8GW HVAC Standalone Project





Notes

1. ALL DIMENSIONS ARE IN MILLIMETRES

2. DRAWING IS INDICATIVE ONLY AS PRECISE LOCATION AND DIMENSIONS OF CABLES WITHIN CONSTRUCTION CORRIDOR MAY VARY FROM THAT SHOWN TO SUIT LOCALISED GROUND FEATURES, ACCOMMODATE EXISTING SERVICES AND ENSURE OPTIMISATION OF CABLE DESIGN.

Rev	Date	Description of Revision	Drn	Chk	App'd
	24/3/23	PRELIMINARY DESIGN	AJP		

RWE

RWE Renewables UK Ltd,
Windmill Hill Business Park
WhitehilWay, Swindon,Wiltshire
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Project
OFFSHORE WIND FARM DEVLOPMENT UK

Contractor

Title
Onshore Cable Package
1.8GW Standalone
General Corridors for PEIR

EcoDoc Drawing No.
004754788-01

Subcon. Drawing No.

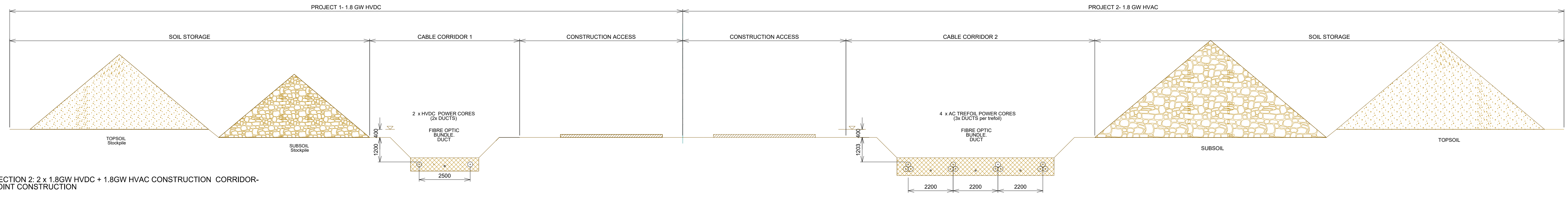
Contractor Drawing No.
REN/CIV/020/AP2-Standalone

IR Contract Nr.	Designed	Drawn	Checked	Approved	Revision
		AJP			01

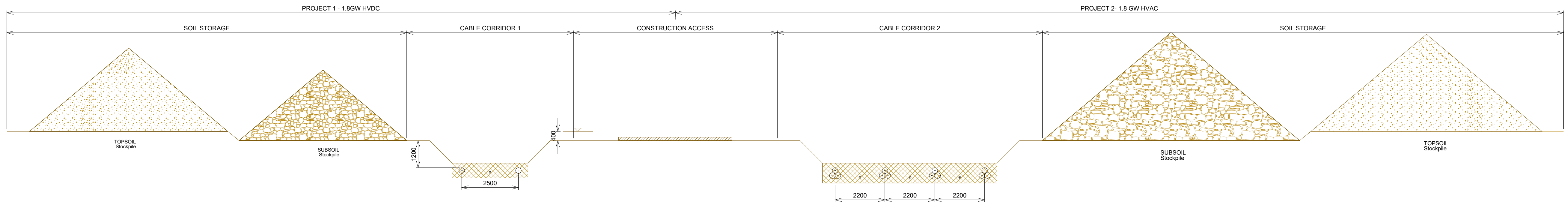
Scale	Size	Status
Not to Scale	A3	DRAFT

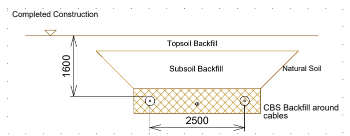
A3 420 X 297 MM : Drawing Template Documentation Reference No. TBC

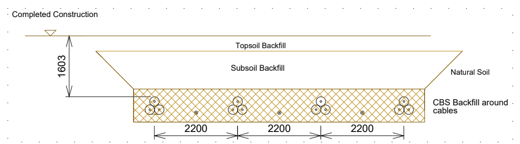
SECTION 1: 1.8GW HVDC + 1.8GW HVAC CONSTRUCTION CORRIDOR-
INDEPENDENT PROJECTS



SECTION 2: 2 x 1.8GW HVDC + 1.8GW HVAC CONSTRUCTION CORRIDOR-
JOINT CONSTRUCTION







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RWE

RWE Renewables UK Ltd,
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Project
OFFSHORE WIND FARM DEVLOPMENT UK

Contractor

Title
Onshore Cable Package
1.8GW HVDC + 1.8GW HVAC
General Corridor Arrangement for PEIR

EcoDoc Drawing No.
004754781-01

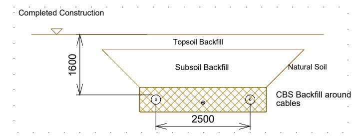
Subcon. Drawing No.

Contractor Drawing No.

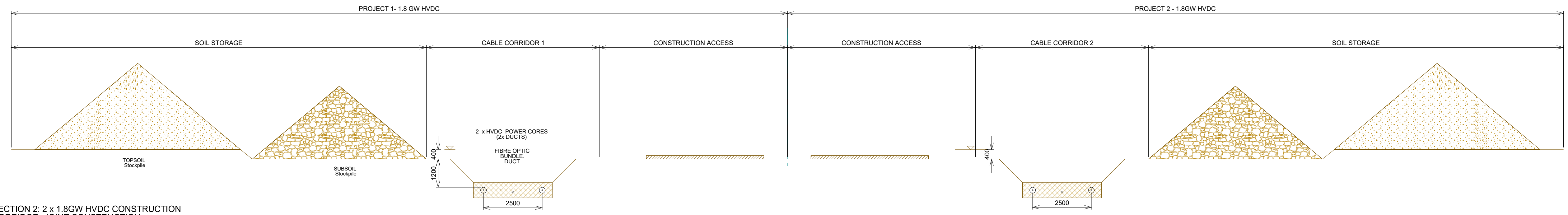
IR Contract Nr.	Designed	Drawn	Checked	Approved	Revision
		AJP			01

Scale	Size	Status
Not to Scale	A3	DRAFT

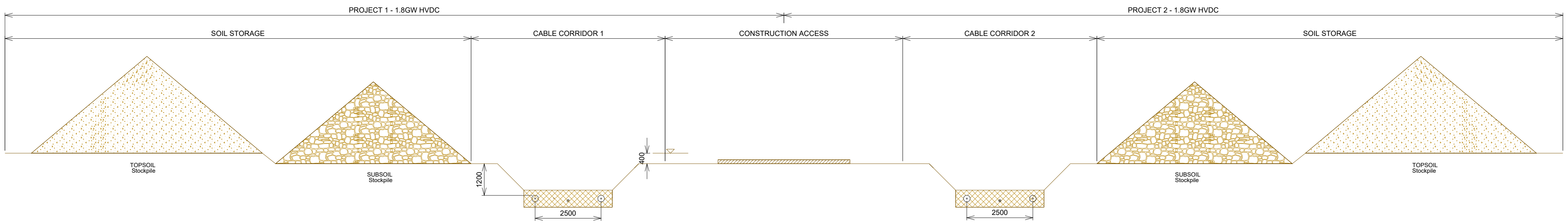
A3 420 X 297 MM : Drawing Template Documentation Reference No. TBC



SECTION 1: 2 x 1.8GW HVDC CONSTRUCTION
CORRIDOR- INDEPENDENT PROJECTS



SECTION 2: 2 x 1.8GW HVDC CONSTRUCTION
CORRIDOR- JOINT CONSTRUCTION



Rev	Date	Description of Revision	Drn	Chk	App'd
	24/3/23	PRELIMINARY DESIGN	AJP		

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RWE Renewables UK Ltd,
Windmill Hill Business Park
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SN5 6PB

Project: OFFSHORE WIND FARM DEVLOPMENT UK

Contractor

Title: Onshore Cable Package
2x 1.8GW HVDC
General Corridor Arrangement for PEIR

EcoDoc Drawing No.: 004754779-01

Subcon. Drawing No.

Contractor Drawing No.: REN/CIV/020/AP2-HVDC

IR Contract Nr.	Designed	Drawn	Checked	Approved	Revision
		AJP			01

Scale: Not to Scale | Size: A3 | Status: DRAFT

5.6.1.4 Other Onshore Construction Activities

234. Where the route requires protective measures due to close proximity or crossing of the export cable to existing infrastructure and natural features, additional specialist construction activity may be required such as:

- Temporary works to monitor, support, or protect sensitive infrastructure.
- Construction of works compounds and additional deep excavations and shafts with earthworks where required for cable crossings or for trenchless activities.
- Construction cable jointing and pulling locations to enable the sequenced installation of cables and to meet electrical performance requirements.
- Construction of trenchless cable crossings through HDD or other trenchless methods. This requires drilling/boring compounds and the supply of specialist equipment such as drills, tunnel boring machines and associated consumables.

5.6.1.4.1 Cable Installation in Cable Ducts

235. The onshore export cables will be either laid directly in trenches or pulled through pre-installed ducts. Cable ducts are generally laid in trenches and installed in HDD bores and then the cables are pulled through. The cables installed onshore for the Projects generally include the onshore transmission cables, fibre optic communications cables, Distributed Temperature Sensing (DTS), Distributed Acoustic Sensing (DAS) systems cables, and Earthing Continuity Cables.

236. Where ducts are used, the cables will require pulling through the cable ducts. Jointing bays will be constructed at intervals along the onshore cable route at the jointing locations to allow pulling and / or joining of the cables.

237. The final number of cable duct trenches required is dependent on the final electrical solution for the Projects and actual dimension of trenches would not be confirmed until the detailed design stage for the Projects.

238. Trenches will only be excavated following stripping and stockpiling of topsoil Subsoil from trenching activities will be stored in separate stockpiles to topsoil. Cement Bound Sand (CBS) is generally used as bedding material for the cable ducts in trenches, other suitable materials such as concrete, sand or natural soils may also be used.

5.6.1.4.2 Haul Road

239. Temporary haul roads are proposed running along the onshore export cable corridor to allow access to the onshore export cable corridor, cable corridor construction compounds and the substation zones.

240. Construction of the temporary haul roads will include placement of suitable graded imported material onto a prepared sub-soil, potentially with a reinforcing geogrid(s) and / or a geotextile separator.

241. The haul road and access roads will likely cross over watercourses and drainage ditches and therefore crossings will be required. The methodology of the temporary haul road crossings should be determined during the post-consent detailed design stage and may include installation of flume culverts or temporary bridges. These crossings would need to be constructed with the relevant permission from the Environment Agency and Local Authority.

242. Passing places may be constructed along the length of the haul road at set intervals to allow passing of construction vehicles.

5.6.1.4.3 Joint Bays

243. The number of jointing bays (JB) required will be dependent on the lengths of cable sections being used, the location of obstacle crossings requiring HDD, and a number of factors including topography, bends within the cable route, and the maximum pulling tension of the cable. Additional pulling pits may also be required to assist in pulling of cables where constraints are present. The location of the pulling pits would be identified by way of cable pulling assessment during the detailed design of the project.

244. JBs generally comprise a cast in situ concrete slab base and backfilled with CBS and/or sand and natural soil arisings. The JBs may also have concrete blockwork walls and pre-cast concrete roof sections and, if required, the walls and roof will generally only be added after pulling and jointing of the cables. The JBs are generally buried at a depth to allow land to return back to normal uses such as agricultural land.

245. However, each JB is usually accompanied by a link box to allow testing and monitoring of cable joints. The link boxes are generally much smaller in footprint than the JBs however these are generally at a much shallower depth with a manhole inspection cover at the surface.

5.6.1.4.4 Construction and Temporary Drainage

246. During the onshore construction works, drainage ditches and watercourses are expected to be encountered along the onshore cable corridor and these will be assessed and included within the Flood Risk and Hydrology assessment presented in the Environmental Statement. The assessment will include details on how watercourses and drainage routes are to be managed or diverted where interactions with the works are recognised. Watercourses and drainage ditches will be identified, and their positions recorded during topographical surveys of the onshore cable route.

247. Land drains are likely to be encountered in the excavation of trenches, transition bays and jointing bays. Land drains generally consist of small diameter (100-150mm) vitrified clay or plastic pipes to drain specific parts of a plot of land. Often no records are available for land drainage layout locations, or where they are available, they are not fully accurate.

248. Prior to construction commencing, a pre-condition drainage survey will be undertaken to identify specific land drainage along the cable route, to identify any areas of problem drainage and identify the existing land drainage, outfalls and other drainage features. This survey would feed into the pre-construction drainage design.

249. Generally, during installation of land drains, trenches are backfilled with the material that had been excavated to allow placement of the drain, and therefore during excavation it is difficult to identify the presence of an existing land drain before excavating through it. If a land drain is severed during construction, it should be temporarily reconnected to maintain hydrological conditions in the surrounding fields.

250. All drains will be cross connected immediately; temporary cross connections can be removed for short periods to allow access. Severed land drains will be reinstated following export cable installation and prior to backfilling for reinstatement.

251. Onsite drainage will be designed to make best use of existing land drainage. The Code of Construction Practice (CoCP) will consider the requirement to divert surface water away from the location of excavations and the construction footprint of cable trenches and joining bay and transition bay construction. The diversion of existing surface water drains will also be accounted for within the CoCP.

5.6.1.4.5 Soil Management

252. Stripped topsoil and excavated subsoil will be stored separately within the onshore cable corridor. The area to be used for storing the topsoil would be cleared of vegetation and any waste arising from the development (e.g., building rubble and fill materials). Topsoil would also be stripped from any land to be used for storing subsoil.

253. Effective stockpiles would be created by:

- Removing vegetation and waste materials from the area before forming stockpiles;
- Storing topsoil and subsoil layers separately;
- Locating stockpiles away from trees, hedgerows, drains, watercourses or excavations;
- Managing the site so that soil storage periods are kept as short as possible;
- Stockpiling soils in the driest condition possible;
- Using tracked equipment wherever possible to reduce compaction; and
- Protecting stockpiles from erosion by seeding or covering them.

254. A Soil Management Plan outlining the best practice techniques, which contractors will be obliged to comply with will also be produced which will also set out procedures for the appropriate handling of soils during the construction works.

5.6.1.5 Cable Pull

255. Cables would either be pulled through the pre-installed ducts or directly laid. Trenches would not need to be reopened, and the cable pull would take place from jointing bays located along the cable corridor.

256. Typically, this would be achieved by accessing the onshore cable corridor directly from the existing accesses (i.e., the existing road network where it crosses the onshore export cable corridor or from other accesses such as existing farm tracks) where possible. Sections of the haul road would need to be retained following the duct installation works or be reinstated to allow access to more remote joint locations. On this basis, it may be possible to reinstate sections of the haul road immediately following duct installation where access to the joint locations is possible from the existing road network.

257. However, at this stage it is unknown exactly what proportion of the haul road would need to be retained and as a worst case it is assumed that 100% of the haul road would remain in place and fenced off throughout the cable pulling works.

258. During the cable pull and jointing works cable drums would be delivered by HGV low loader to the open joint bay locations and a winch attached to the cable. The cable would then be winched off the drum from one joint pit to another, through the buried ducts. Cable jointing would be conducted once both lengths of cable have been installed within each joint bay.

5.6.1.6 Crossing Methods

259. All crossings are listed within a crossing schedule provided as **Appendix 5-1** to this chapter.

5.6.1.6.1 Trenchless Crossings

260. Trenchless technique can be used to avoid physical obstacles and environmental constraints by drilling underneath them for cable installation.

261. There are a number of potential trenchless techniques which may be used such as horizontal direction drill (HDD), microtunneling, auger boring and others. The type of trenchless crossing will be determined during detailed design, however HDD technique is likely to be a conservative case in terms of area required and likely impacts associated with the construction activities.

262. As an example of a trenchless crossing technique, HDD initially involves the construction of a shallow, inclined, narrow diameter directionally drilled open hole beneath the obstacle/constraint. The initial hole may be enlarged by one or more reaming passes until it has reached the diameter required to pull the duct through. The method does not normally require the construction of deep temporary supported pits or shafts either side of the obstacle, however, relatively small 'entry' and 'exit' pits are generally required.

263. HDD construction compounds (indicative dimensions 50m x 50m but may vary due to site specifics) are required to be established either side of the obstacle at the locations of the entry and exit pit.

5.6.1.6.2 Minor Road Crossings

264. Where the onshore export cable corridor crosses minor roads, tracks and public rights of way, open cut trenching methods may be used in combination with traffic management. Where appropriate, single lane traffic management would be utilised during installation with signal controls to manage traffic movement. Where the width of the road does not permit single lane traffic management, alternative methods such as temporary road closure or diversion could be required. Where standard traffic management techniques are not deemed to be suitable it may be necessary to revert to a trenchless crossing solution. The proposed crossing method for each road crossing is provided in the crossing schedule (**Appendix 5-1**).

265. The approach for each crossing would be agreed with the relevant authority prior to works beginning. Temporary closures or diversions would only be required for the duration of time that duct installation takes place in that location. Temporary crossings of the onshore cable corridor could then be installed to allow public access to continue where the haul road is required to remain in service. The crossings would be managed to allow safe operation. Re-instatement of the trench would broadly follow the same process described for the cable duct installation in section 5.6.1.1.4; however, the road surface would be reinstated to a specification agreed with the local highway authority.

5.6.1.6.3 Minor Watercourse Crossings

266. Where minor watercourses such as field drains are to be crossed, the approach will be open cut combined with temporary damming and diverting of the watercourse, or trenchless crossing methods are also being considered. The suitability of the methods would be agreed at detailed design.

267. The watercourse would be dammed at either side of the cable crossing point, typically using sandbags and ditching clay, and the water within the watercourse would be pumped or piped across the dammed section to effectively maintain flow across the dammed section, diversion of drains may also be considered. The cable trenches would then be excavated within the dammed section but ensuring that watercourse bed materials are stored separately to subsoils. Ducts would typically be installed below the channel bed to avoid impacts to the active channel bed. Reinstatement of the trench would be conducted to the pre-construction depth of the watercourse, taking care to reinstate the channel bed material and subsoils in the correct order. The dams would then be removed. Temporary dam and divert would only be required for the duration of time that duct installation takes place in that location.

268. The haul road could also require culverting or temporary bridging in these locations to allow continued access up and down the working corridor. These would remain in place for the duration that the haul road is required and would be removed once cable duct installation is complete.

5.6.1.7 Construction Compounds

269. Temporary construction compounds are required to support the onshore cable installation. This will include several secondary compounds and up to two main compounds per project. In addition, the landfall, trenchless crossings, and substation works would have their own dedicated construction compounds.

270. Up to two main compounds will be required for each Project to support the cable duct installation and cable pulling works. These would operate as hubs for the onshore construction works and would house the central offices, welfare facilities, and stores, as well as acting as staging posts and secure storage for equipment and component deliveries.

271. The site selection process for the main compound(s) is currently ongoing. Investigations of areas of existing surface water infrastructure are underway to reduce the need for initial site establishment works. The size of the main compound(s) will be up to 100m x 100m, however it may be preferable to use two smaller sites. In order to minimise disruption to the local road network the Applicant will identify the most suitable accesses to and from the compounds.

272. The construction works will also require a series of secondary construction compounds that will operate as support bases for the onshore construction works as the cable work fronts pass through an area. They may house portable offices, welfare facilities, localised stores, as well as acting as staging posts for localised secure storage for equipment and component deliveries.

273. Each secondary compound (up to approximately 30 in total) would be approximately 75m x 75m in size with direct access into the construction easement.

274. Other works compounds include the substation construction compound, the landfall compound, and each trenchless crossing will require its own compound.

5.6.1.8 Operation and Maintenance

275. Maintenance of the onshore cable is expected to be minimal. During operation, periodic testing of the cable is likely to be required (every two to five years). This will require access to the link boxes at defined inspection points along the onshore export cable route. This will involve attendance by up to three light vehicles, such as vans, in a day at any one location. The vehicles will gain access using existing field accesses and side accesses as agreed with landowners to reach the relevant sections of the cable.

5.6.1.9 Decommissioning

276. No decision has been made regarding the final decommissioning policy for the onshore cables, as it is recognised that industry best practice, rules and legislation change over time. It is likely the cables would be removed from the ducts and recycled, with the transition pits, jointing bays, and ducts capped and sealed then left in situ.

5.6.2 Onshore Substation

277. A HVAC onshore substation will either be an air insulated (AIS) or gas insulated (GIS) switchgear design. If an AIS design is used, then typically it shall incorporate circuit breakers of AIS design with other high voltage equipment, bus bars, isolators and disconnectors etc of AIS design. This is all installed outdoors with open air terminations. Air is acting as dielectric medium between the phase conductors. GIS uses a dielectric gas at moderate pressure for phase-to-phase and phase-to-ground insulation. A HVDC onshore substation will be a GIS switchgear design.

278. Each onshore substation zone is of sufficient size to accommodate the maximum footprint required for both DBS East and DBS West (as per the four development scenarios outlined in section 5.1.1 and shown in **Figure 5-2**). The decision on the preferred option will be informed by stakeholder feedback on the information provided in this PEIR, as well as further technical studies and ongoing environmental survey and assessment work.

279. The onshore substations will be constructed to accommodate the connection of both DBS East and DBS West to the transmission grid. The permanent footprint of a HVDC substation will be up to 64,416m^2 and the permanent footprint of a HVAC substation will be up to 135,000m^2.

280. Each substation may include:

- Control building;
- GIS/AIS building;
- External fire barriers;
- Static var compensator (SVC) building (if required);
- Valve hall (if required) (HVDC only);
- Transformers;
- Lightning protection masts
- Palisade fencing
- Switchgear;
- Shunt reactors;
- Emergency diesel generators;
- Service buildings;
- Cooling systems;
- Earth mat
- Harmonic filters if required; and
- Access roads – for operation and maintenance access to equipment.

281. Depending on the design scenario used, the largest structures within the onshore substation listed above will be the valve hall with an approximate height of 24m. The main electrical equipment (transformers etc.) will not exceed a height of 15m. The tallest features within the onshore substation site will be the lightning protection masts and gantries at a maximum height of 27m above ground level.

5.6.2.1 Onshore Substation Parameters

282. **Table 5-27** shows the main construction parameters for the onshore substation.

Table 5-27 Onshore Substation Construction Parameters

Onshore Substation	DBS East and DBS West together – HVAC + HVDC	DBS East and DBS West together – HVDC + HVDC	DBS East or DBS West in isolation – HVDC only
Operational compounds for AIS substation and station (m)	300 x 450 (HVAC) + 244 x 264 (HVDC)	244 x 264 + 244 x 264	244 x 264
Operational compounds for GIS substation (m)	320 x 300 or, Option 2, 390 x 230 (HVDC) + 244 x 264 (HVDC)	N/A	N/A
Maximum building height (m)	24	24	24
Lightning protection masts (m)	27	27	27
Construction compound (m^2)	45,000 (HVAC) + 30,000 (HVDC)	30,000 + 30,000	30,000

5.6.2.2 Onshore Substation Construction Method

283. Prior to the substation construction commencing, establishment will largely comprise the set-up of temporary construction compound and mobilisation of plant for the site preparation work. The construction compound would generally include offices for the management of construction, messing and washroom facilities, car parking, and storage. Site preparation works includes the following:

- Setting out survey;
- Installation of temporary security fencing;
- Topsoil stripping and stockpiling;
- Land forming and earthworks to form level platform as required;
- Installation of the temporary and permanent accesses;
- Installation of utilities and services; and
- Installation of drainage.

5.6.2.2.1 Foundations

284. The foundation requirements would be based on the electrical, mechanical and structural requirements for the proposed onshore substations as well as ground conditions at the proposed substation locations.

285. Foundations in favourable ground conditions would generally be conventional shallow foundations (pads and strips). Where unfavourable ground conditions are present ground improvement, or a piled solution may be required.

286. Where groundwater levels are high some dewatering of excavations for foundations may be required.

287. Ground investigation would be needed at the (up to) two new onshore substations sites prior to detailed design to confirm the ground conditions prior to foundation design based on the anticipated loads.

5.6.2.2.2 Installation Works

288. The techniques used for the installation of the mechanical and electrical plant and equipment related to the onshore substation / convertor stations is anticipated as follows:

- Within the substation buildings – a combination of mobile plant and lifting apparatus and / or temporary or permanent gantry cranes within the building.
- External transformers – the transformers are anticipated to require specialist lifting equipment to transfer them from road transport into their installed position. This is likely to comprise a temporary gantry crane.
- Other external plant and equipment – installation using mobile plant and lifting apparatus.

5.6.2.3 Drainage

289. A surface water drainage system would be required for the operational substation and would be designed to meet the technical requirements set out in the National Planning Policy Framework (NPPF) through the use of infiltration techniques which can be accommodated within the area of development and surface water discharge rates controlled to prevent any increase in flood risk to surrounding land from present day levels.

290. Some form of surface water attenuation would be required with sufficient capacity to retain a peak rainfall event (100-year event + climate change) with controls to ensure that water discharge back to the surrounding area matches the existing greenfield runoff rates, discharging into the closest watercourse or sewer connection. The full specification for the water attenuation and drainage system would be addressed as part of detailed design post-consent.

291. Foul drainage would be collected through a mains connection to an existing local authority sewer system if available or septic tank located within the development boundary. The specific approach would be determined during the detailed design phase with consideration for the availability of mains connection and the number of visiting hours for site attendees during operation.

5.6.2.4 Screening

292. A detailed landscape mitigation plan will be developed for each of the onshore substations, reflecting the form and scale of the proposals, and the assessed landscape and visual effects. Further information is provided in **Chapter 23 Landscape and Visual Impact Assessment**. It is anticipated that this will include woodland and hedgerow planting to screen key views, and to help to integrate the new development into the landscape. Species selected will be appropriate to the local environment and of local provenance. Species will be planted in an organic layout which seeks to mimic the canopy layers found in the wider countryside. However, it is expected that additional planting to further screen the substation will be identified as part of the final application.

5.6.2.5 Operations and Maintenance

293. The onshore substations would not be manned; however, access would be required periodically for routine maintenance activities, estimated at an average of one visit per week. Monitoring of the onshore substation will be done remotely using CCTV technology and other remote monitoring equipment. The security fencing installed during construction will remain in place. Certain areas of the substation will have permanent light fittings, however, these lights will only be used when required for unscheduled maintenance or emergency repair purposes. Lighting during onshore operation and maintenance activities is expected to be minimal. External lighting will be directional and limited to essential security and safety requirements. External works will usually be scheduled during daylight hours. If night working is required then portable directional task lighting will be deployed. Unscheduled maintenance or emergency repair visits will typically involve a very small number of vehicles, typically light vans. Infrequently, equipment may be required to be replaced, then the use of an occasional HGV may be utilised, depending on the nature of the repair. Inspection and minor servicing may be required for the electrical plant, but it is anticipated that the onshore substations will require minimal scheduled maintenance and operation activities.

5.6.2.6 Decommissioning

294. No decision has been made regarding the final decommissioning plan for the onshore project substation, as it is recognised that industry best practice, rules and legislation change over time.

295. It is anticipated that a full EIA will be carried out ahead of any decommissioning works being undertaken if required by regulations at the time. The programme for decommissioning is expected to be similar in duration to the construction phase of five years. The detailed activities and methodology for decommissioning will be determined later within the project lifetime, in line with relevant policies at that time, but would be expected to include:

- Dismantling and removal of electrical equipment;
- Removal of cabling from site;
- Removal of any building services equipment;
- Demolition of the buildings and removal of fences; and
- Landscaping and reinstatement of the site.

5.7 Construction Programme

5.7.1 Offshore Construction

296. A high-level indicative construction programme including the offshore works is presented in **Plate 5-10 - 13**. The earliest any construction works would start is assumed to be 2026. Offshore construction works would require up to five years per Project (excluding pre-construction activities such as surveys), assuming DBS East and DBS West were built at different times. If built at the same time, offshore construction could be completed in five years. Accounting for the development scenarios described in section 5.1.1, there could be a gap of up to two years between the start of offshore construction works on the first Project and the start of offshore construction works on the second Project.

297. It should be noted that the construction programme is dependent on numerous factors including consent timeframes and funding mechanisms. The final design of the Projects (including for example the number and type of turbines, onshore substations, offshore platforms, cables, etc.) will also affect the construction programme, as well as weather conditions once construction starts. As such, details of the construction programme are indicative at this stage in order to provide a reasonable and realistic basis for undertaking the environmental assessments.

298. Offshore (seaward of mean low water) working hours during construction are assumed to be twenty-four hours a day and seven days a week.

5.7.2 Onshore Construction Programme

5.7.2.1 Pre-Construction Works

299. Pre-construction works are expected to take place from 2026. The main pre-construction activities are noted below and would be applicable to the onshore substation and works to install the onshore export cables:

- Ground investigations and pre-construction surveys;
- Road/junction modifications and any new junctions off existing highways;
- Pre-construction drainage – installation of buried drainage along the cable corridor and at the substation, which requires an understanding of the existing agricultural drainage environment;
- Pre-construction utilities diversions (temporary and permanent);
- Hedge and tree removal – hedge and tree removal is seasonal and can be influenced by ecological factors. Removing these ahead of the main works mitigates against potential programme delays;
- Ecological mitigation – any advanced pre-construction mitigation activities, for example installation of great crested newt fencing; and
- Archaeological mitigation – pre-construction activities agreed with Historic England and Humber Historic Environment Services.

5.7.2.2 Main Works

300. A high-level indicative construction programme including the onshore works is presented below. The programme illustrates the likely duration of the major installation elements, and how they may relate to one another in the three potential construction scenarios, i.e. either DBS East or DBS West in isolation, DBS East or DBS West built concurrently, and DBS East or DBS West build sequentially.

301. Normal onshore construction (landward of mean low water) would usually only take place between:

- 0700 hours and 1900 hours Monday to Saturday, with no activity on Sundays or bank holidays. Noisy construction works will primarily occur during these hours.

302. Outside of these hours some onshore construction work may be required for essential activities including but not limited to:

- Continuous periods of operation, such as concrete pouring, drilling, and pulling cables through ducts;
- For internal fitting out works associated with the onshore substation;
- For the delivery of abnormal loads to the connection works, which may cause congestion on the local road network;
- The testing or commissioning of any electrical plant installed as part of the onshore infrastructure;
- Security monitoring; and
- Activity necessary in the instance of an emergency where there is a risk to persons, the environment, delivery of electricity or property.

Plate 5-10 Construction Programme – DBS East or DBS West Built in Isolation

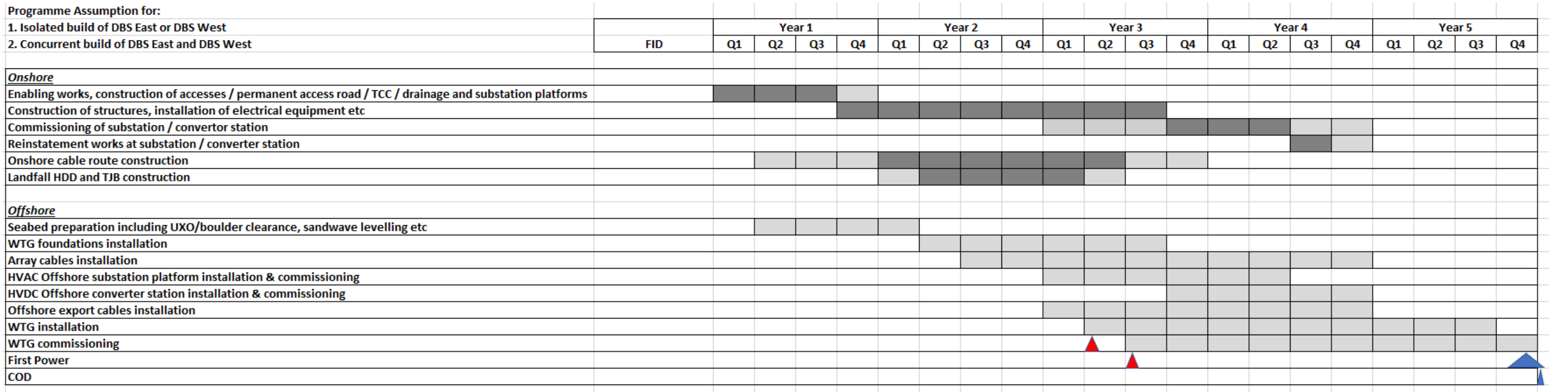


Plate 5-11 Construction Programme – DBS East or DBS West Built Concurrently

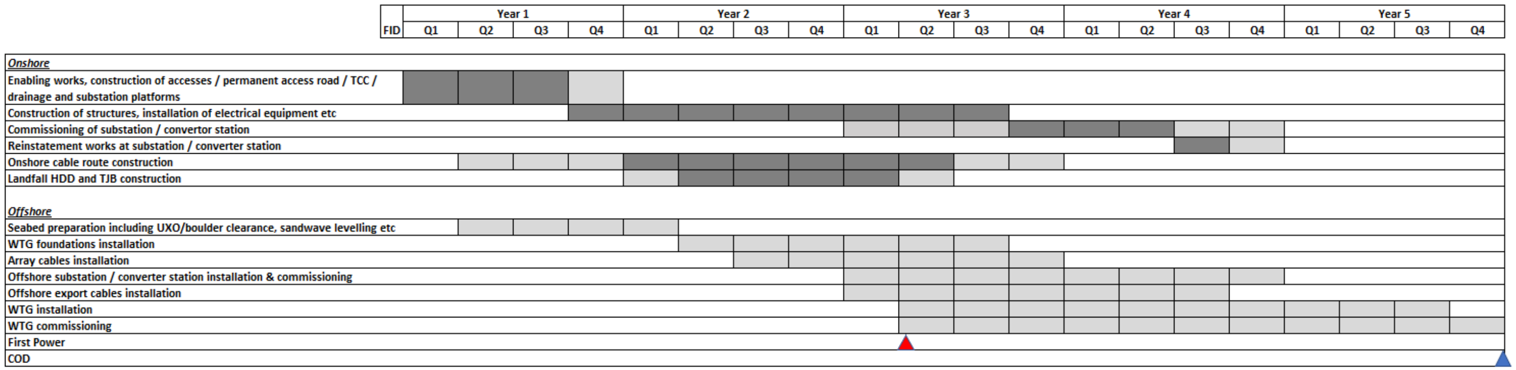


Plate 5-12 Construction Programme – DBS East and DBS West Built Concurrently (Phased Approach)

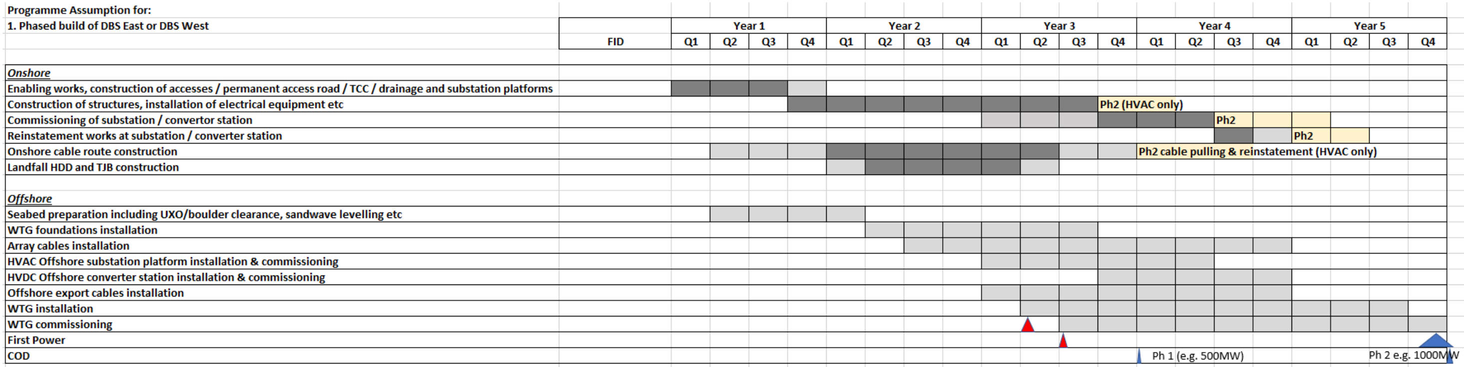
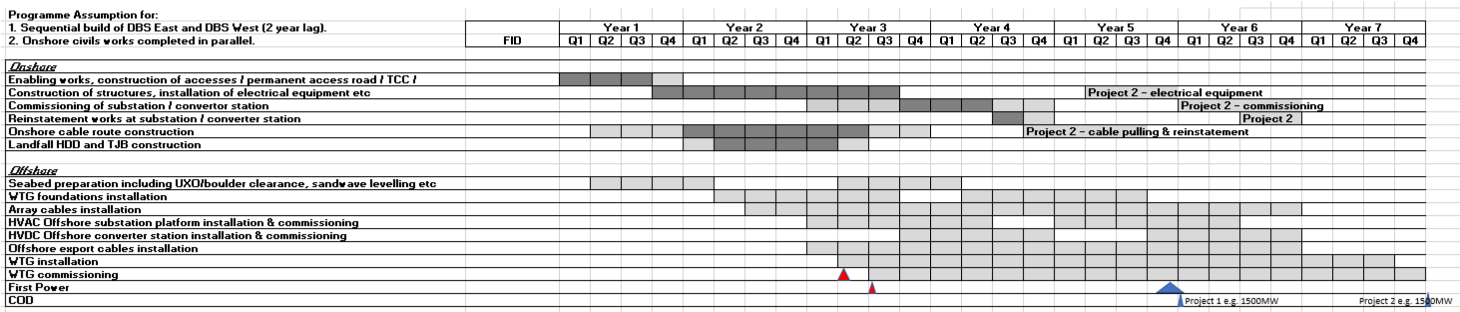


Plate 5-13 Construction Programme – DBS East and DBS West Built Sequentially



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