LLŶR FLOATING OFFSHORE WIND PROJECT

Llŷr 1 Floating Offshore Wind Farm

Environmental Statement

Volume 1: Chapter 04 – Description of the Proposed Project

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FLOVENTIS ENERGY

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Glossary of project terms

Term	Definition
The Applicant	The developer of the Project, Llŷr Floating Wind Limited.
Array	All wind turbine generators, inter array cables, mooring lines, floating sub-structures and supporting subsea infrastructure within the Array Area, as defined, when considered collectively, excluding the offshore export cable(s).
Array Area	The area within which the wind turbine generators, inter array cables, mooring lines, floating sub-structures and supporting subsea infrastructure will be located.
Floventis Energy	A joint venture company between Cierco Ltd and SBM Offshore Ltd of which Llŷr Floating Wind Limited is a wholly owned subsidiary.
Kilometer Point (KP)	Landmark points making the relevant Kilometer along the Onshore and Offshore Cable Corridors.
Landfall	The location where the offshore export cable(s) from the Array Area, as defined, are brought onshore and connected to the onshore export cables (as defined) via the transition joint bays (TJB).
Llŷr 1	The proposed Project, for which the Applicant is applying for Section 36 and Marine Licence consents. Including all offshore and onshore infrastructure and activities, and all project phases.
Marine Licence	A licence required under the Marine and Coastal Access Act 2009 for marine works which is administered by Natural Resources Wales (NRW) Marine Licensing Team (MLT) on behalf of the Welsh Ministers.
Offshore Development Area	The footprint of the offshore infrastructure and associated temporary works, comprised of the Array Area and the Offshore Export Cable Corridor, as defined, that forms the offshore boundary for the S36 Consent and Marine Licence application.
Offshore Export Cable	The cable(s) that transmit electricity produced by the WTGs to landfall.
Offshore Export Cable Corridor (OfECC)	The area within which the offshore export cable (s) will be located, from the Array Area to the Landfall.
Onshore Development Area	The footprint of the onshore infrastructure and associated temporary works, comprised of the Onshore Export Cable Corridor and the Onshore Substation, as defined, and including new access routes, that forms the onshore boundary for the planning application.
Onshore Export Cable(s)	The cable(s) that transmit electricity from the landfall to the onshore substation.
Onshore Export Cable Corridor (OnECC)	The area within which the onshore export cable(s) will be located.
The proposed Project	All aspects of the Llŷr development.
Onshore Substation	Located within the Onshore Development Area, converts high voltage generated electricity into low voltage electricity that can be used for the grid and domestic consumption.
Section 36 consent	Consent to construct and operate an offshore generating station, under Section 36 (S.36) of the Electricity Act 1989. This includes deemed planning permission for onshore works.

Acronyms and abbreviations

Acronym	Definition	Acronym	Definition
AA	Appropriate Assessment	MHPA	Milford Haven Port Authority
AHTV	Anchor Handling Tug Vessel	MHWS	Mean High Water Spring
AIS	Autonomic Identification System	MLWS	Mean Low Water Spring
BNG	British National Grid	MoD	Ministry of Defence
BPEO	Best Practicable Environmental Option	NGET	National Grid Electricity Transmission
CAA	Civil Aviation Authority	NRW	Natural Resources Wales
CBRA	Cable Burial Risk Assessment	NRA	Navigational Risk Assessment
CJB	Cable Joint Bays	OCT	Open Cut Trenching
CTMP	Construction Traffic Management Plan	O&M	Operation and Maintenance
CTV	Crew Transfer Vessels	OfECC	Offshore Export Cable Corridor
BEIS	Department of Business, Energy and Industrial Strategy	OnECC	Onshore Export Cable Corridor
DEFRA	Department for Food and Rural Affairs’	OWF	Offshore Wind Farm
DESNZ	Department for Energy Security and Net Zero	PCNPA	Pembrokeshire Coast National Park Authority
DIO	Defence Infrastructure Organisation	PEDW	Planning and Environment Decisions Wales
DP	Dynamic Positioning	PLONOR	Pose Little or No Risk to the Environment
EIA	Environmental Impact Assessment	PPW	Planning Policy Wales
ES	Environmental Statement	PDE	Project Design Envelope
GEBCO	General Bathymetric Chart of the Oceans	ROVs	Remotely Operated Vessels
HRA	Habitats Regulations Assessment	S36	Section 36
HAT	Highest Astronomical Tide	SCADA	Supervisory Control and Data Acquisition
HDD	Horizontal Directional Drilling	SF6	Sulphur Hexafluoride
HDPE	High-density polyethylene	SOV	Service Operation Vessel
HSE	Health and Safety Executive	STATCOM	Static Synchronous Compensator
HVAC	High Voltage Alternating Current	SUDS	Sustainable Drainage Systems
IAC	Inter Array Cables	SVC	Static VAR Compensators
IMO	International Maritime Organisation	SWMP	Site Waste Management Plan
INNS	Invasive Non-Native Species	TCC	Temporary Construction Compounds
KIS-ORCA	Kingfisher Information Service – Offshore Renewable & Cable Awareness	TLP	Tension Leg Platform
Km / Km^2	Kilometres / Kilometres Squared	TP	Transition Piece
KP	Kilometer Point	TJB	Transition Joint Bay
kV	KiloVolts	UXO	Unexploded Ordnance
LAT	Lowest Astronomical Tide	VAR	Voltage and Reactive Power

Acronym	Definition	Acronym	Definition
LMP	Lighting and Marking Plan	VSC	Voltage Source Converter
m / m^2 / m^3	Metres / metres squared / metres cubed	WCS	Worst Case Scenario
mm	Millimetres	WTG	Wind Turbine Generator
MCA	Maritime and Coastguard Agency	XLPE	Cross-linked Polyethylene
MGN	Marine Guidance Note		

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4. DESCRIPTION OF THE PROPOSED PROJECT

4.1. Introduction

1. Llŷr Floating Wind Limited (hereafter referred to as the Applicant) is proposing to develop the Llŷr 1 Floating Offshore Wind Farm, (hereafter referred to as the proposed Project), located 35 kilometres (km) from the northeastern corner of the Array Area to Linney Head (the closest location on the coast of Pembrokeshire) in the Celtic Sea.
2. The proposed Project is a test and demonstration wind farm development comprising up to 10 wind turbine generators (WTGs) and associated infrastructure. The proposed Project will make landfall at Freshwater West before connecting into the National Grid network at Pembroke Dock power station.
3. The Applicant is seeking a Section 36 consent and Marine Licence for the offshore components and deemed planning permission as part of the Section 36 consent for the onshore components of the proposed Project. This chapter forms part of the Environmental Statement (ES) which is submitted in support of those consent applications.
4. This chapter describes the design details of the proposed Project and forms the project design basis (the 'Design Envelope') of the impact assessments presented within this ES. The design of the offshore and onshore project components is described in detail within this chapter, alongside the proposed methods and timing of construction, operation and maintenance and decommissioning for which consent is sought and upon which impact assessments for each technical discipline are based.

4.2. Overview of the Proposed Project

5. The proposed Project will provide a facility to demonstrate floating offshore wind technology in Welsh territorial waters. In contrast to conventional fixed bottom projects, which are restricted by water depths, the proposed Project consists of floating substructures anchored to the seabed that can exploit deeper waters such as those found offshore of the Pembrokeshire coast.
6. The proposed Project comprises both offshore and onshore components. The offshore project components are located wholly within the Offshore Development Area. The **Offshore Development Area** comprises of:
    - **The Array Area**: the area within which Wind Turbine Generators (WTGs), floating substructures, mooring and Inter Array Cable (IAC) arrangements will be located. This is an area of 45 square kilometres (km^2); and
    - **The Offshore Export Cable Corridor** (OfECC): the area within which the offshore export cables will be located. The OfECC runs from the northern boundary of the Array Area to the Mean High Water Springs (MHWS) mark. This is an area of 42.5 km^2.
7. The onshore project components are located wholly within the Onshore Development Area which comprises:
    - The **Onshore Substation Compound**: the area within which the Onshore Substation and associated infrastructure will be located. This is an area of up to 15,000 m^2 (excluding Sustainable Drainage Systems (SuDS)), located 1.5 km from the grid connection location.
    - The **Onshore Export Cable Corridor** (OnECC): the area, of circa 2 km^2, within which the onshore export cable will be located. The onshore export cables are connected to the offshore export cables via Transition Joint Bays (TJBs) at the landfall at Freshwater West. The OnECC runs from Mean Low Water Springs (MLWS) to the grid connection location at Pembroke Dock power station.

8. The Offshore and Onshore Development Areas are shown on **Volume 5: Figure 4-1** and **Volume 5: Figure 4-2** respectively and are discussed further in **Sections 4.5** and **4.6** respectively.

4.2.1. Project Design Evolution

9. Since the receipt of the Scoping Opinion from NRW's Marine Licensing Team in July 2022, further pre-application consultation has been carried out in relation to the proposed Project design. Subsequently, design refinements have been made to the proposed Project design as presented in **Chapter 3: Site Selection and Alternatives, Section 3.5**. As a result, the Offshore Development Area and the Onshore Development Area have both been reduced to address feedback from consultees and to minimise potential environmental impacts wherever possible (**Chapter 3: Site Selection and Alternatives, Section 3.3, Section 3.5 and Table 3-4).**

10. In relation to the Offshore Development Area, the southeastern corner of the Array Area has been reduced in response to feedback from shipping and navigation stakeholders relating to vessel traffic patterns to and from the Port of Milford Haven. This decreases the Array Area presented during Scoping by 11% and in turn reduces potential impacts on the marine environment and other sea users. In addition, the OfECC has been reduced in area, particularly in the nearshore and at landfall, to refine the design and align with the selected landfall location at Freshwater West. In addition, the alternative landfall location to the south of West Angle Bay was discounted following review of technical, engineering and environmental constraints and the selection of Freshwater West as the most appropriate landfall location.

11. The coordinates for the Offshore and Onshore Development Areas are provided in **Table 4-3** and **Table 4-4** and are contained within **Appendix 4E: Red Line Boundary Coordinates**, and the red line boundaries of the development areas are presented in **Volume 5: Figures 4-1 and Figure 4-2**. The coordinates for the Array Area are provided in **Table 4-1** and **Table 4-2.**

Table 4-1. Array Area Coordinates (degrees and decimal minutes)

Corner	WGS84 Latitude	WGS84 Longitude
S	51° 17' 39.786'' N	5° 27' 21.9744'' W
NE	51° 22' 59.7144'' N	5° 23' 43.3716'' W
NW	51° 23' 3.1056'' N	5° 31' 29.8272'' W

Table 4-2. Array Area Coordinates (Decimal Degrees)

Corner	WGS84 Latitude	WGS84 Longitude
S	51.29438494	- 5.45610369
NE	51.38325422	- 5.39538129
NW	51.38419582	- 5.52495187

4.3. Proposed Project Components

12. The key components of offshore and onshore infrastructure of the proposed Project are summarised below and are described in detail within the following sections of this chapter.

13. Offshore infrastructure:

- Up to 10 WTGs, each with a maximum rotor diameter of 285 m.
- Up to 10 associated floating platforms.
- Up to eight mooring lines, for each floating platform (up to 80 in total).
- Up to eight anchors or piles for each floating platform (up to 80 in total).
- Up to 11 offshore IACs, at 66 kiloVolts (kV) High Voltage Alternating Current (HVAC) (dynamic but with the potential to touch the seabed).
- Up to two offshore export cable, each up to 132 kV HVAC with landfall achieved via Horizontal Directional Drilling HDD) at Freshwater West; and
- Associated scour and cable protection (if required).

14. Onshore infrastructure:

- Temporary construction HDD compound.
- Up to two onshore export cable between the landfall and the onshore substation (each up to 132kV), and then one from the onshore substation to the grid connection (of up to 400kV). The total length of each onshore cable will be, up to 7.1 km from landfall to grid connection point.
- Up to two Transition Joint Bays (TJB) to connect the offshore cables to the onshore cables;
- Cable joint bays to connect sections of the onshore cables.
- Onshore substation 1.5 km from the grid connection point.
- Temporary construction compounds; and
- Access routes where necessary.

15. **Figure 4-1** provides an illustration of the offshore and onshore infrastructure for the proposed Project.

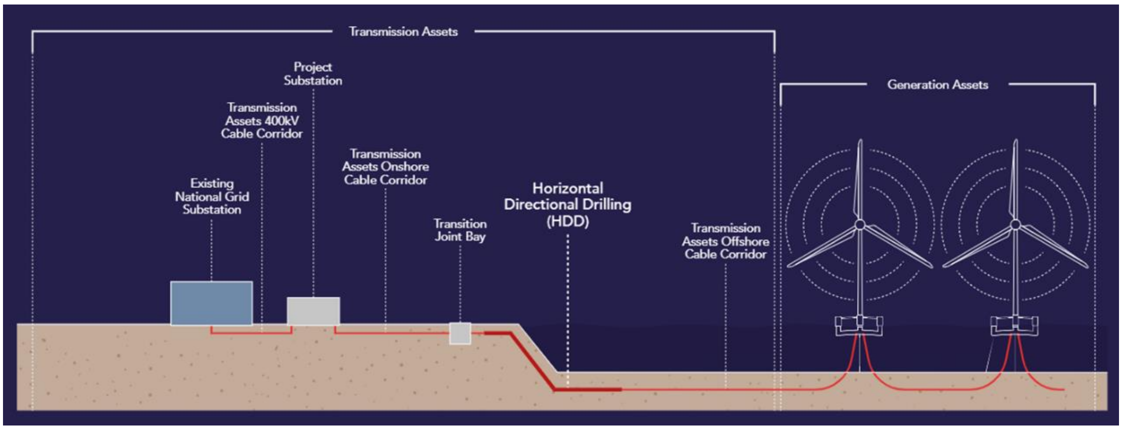

Figure 4-1. Illustration of offshore and onshore project infrastructure

16. Construction of the proposed Project is anticipated to commence in Q1 2027 and last up to 2 years, completing in Q4 2028.

17. Final commissioning of the proposed Project is anticipated to take place in Q4 2028, and the wind farm will be operational for a period of 30 years.

18. The dates provided above are indicative and the final construction programme for the proposed Project will be confirmed prior to the commencement of construction and as a condition of consent

19. Further details on the construction of the offshore and onshore project infrastructure are summarised in **Section 4.6** and **4.8.**

4.4. Project Design Envelope

20. A Project Design Envelope (PDE) (sometimes called a Rochdale Envelope) approach has been used to describe the design of the proposed Project to be used in assessments (as detailed in **Chapter 5: Methodology, Section 5.5**). This approach is taken as, at this early stage in the development process for the proposed Project, it is not possible to finalise the specifics of the project design due to procurement and supply chain considerations for emerging floating technologies and further site investigation which will inform the detailed design of the proposed Project.

21. The PDE approach sets out a series of realistic design assumptions from which worst-case parameters are identified and allows specific reasoned maximum extents for key assessment parameters to be assessed on a 'realistic worst-case' basis. The final design of the proposed Project will fall within the maximum extents of the parameters defined. Detailed design can then vary, within the PDE parameters, while maintaining the validity of the assessment of the potential impacts of the proposed Project on the environment.

22. Using this PDE approach also allows supply chain and design to maintain flexibility and to allow for technological advancements, with the final design remaining within the assessed parameters.

23. The full PDE for the proposed Project is detailed within this chapter, and the specific parameters within the PDE that are relevant to the assessment of each receptor are summarised within each impact assessment chapter of this ES (Chapters 7 to 28).

24. An indicative construction programme is included within this chapter in **Section 4.7.7** and **Section 4.8.12.** The construction timing and methodologies will be fully developed once the project design is finalised and installation contractors are appointed. Similarly, operation and maintenance (O&M) activities will be adjusted to the final, as built, project requirements whilst remaining within the PDE assessed.

4.4.1. Characteristics of the Offshore Development Area

25. As shown in **Figure 4-1**, the Offshore Development Area comprises the Array Area and the OfECC, which extends from the Array Area to the landfall at MLWS.

26. The Array Area comprises an area 45 km^2 and at its closest point, the Array Area is 35 kilometres (km) from the northeastern corner of the Array Area to Linney Head (the closest location on the coast of Pembrokeshire) in the Celtic Sea.

27. The OfECC will be up to 49 km long. The red line boundary of the OfECC extends to up to 5 km wide immediately to the north of the Array Area, and up to 1.8 km wide within the 6 km nearshore area. It is anticipated that the construction of each cable will disturb a corridor of up to 25 m wide, providing a total width of disturbance of up to 50 m.

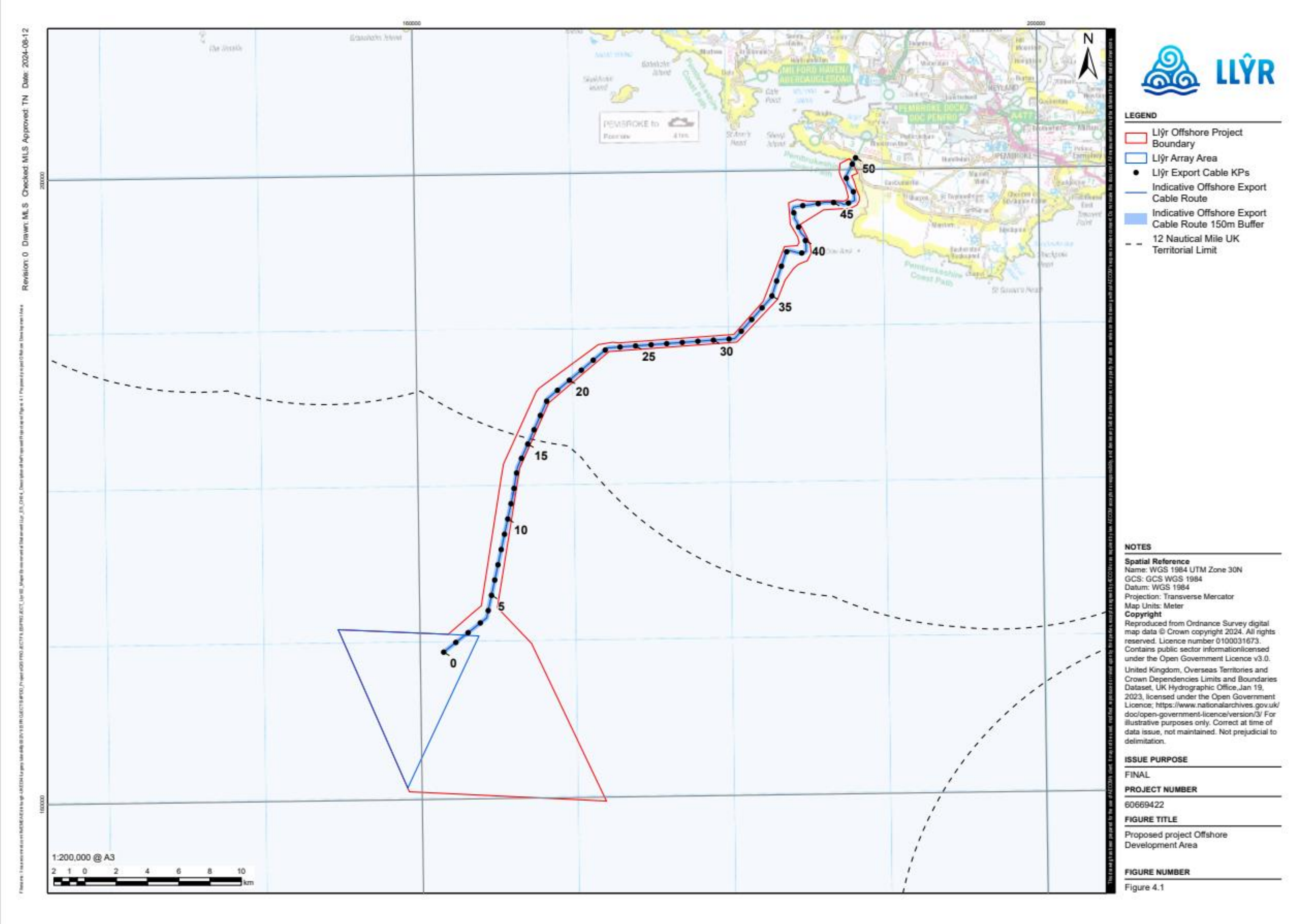

Figure 4-2. Proposed project Offshore Development Area

28. The Design Envelope for the Offshore Development Area is summarised in **Table 4-3.**

29. Water depths across the Array Area range from 65 m to 75 m below Lowest Astronomical Tide (LAT). Along the OfECC, these depths gradually decrease towards the coastline.

30. Average wind speeds in the Celtic Sea are high, typically greater than 8 m/s. The predominant wind direction for the Array Area is south-southwest, with a long term mean wind speed of 9.78 m/s. The waves are predominantly from a west-southwest to south-westerly direction with frequent heights of 1 m to 1.9 m, and an extreme significant wave height of greater than 8 m.

31. Seabed sediments off the west coast of Wales are predominantly muddy sandy gravel. The seabed sediments inshore and around the south Pembrokeshire coast are characterised by rocky reefs, shoals and sandbanks, defined as 'hard substrate'. Across the Array Area, the sediments vary from gravelly sand to sandy mud, although some boulders are present within the site boundary.

32. There are no known oil and gas extraction activities, or aggregate interests in the Offshore Development Area. Water depths and ground conditions are also suitable for several mooring and anchor types. There are up to four potential cables that cross the Offshore Development Area.

33. Further details on the marine physical characteristics of the Array Area and OfECC, as well as the coastal processes of the proposed landfall at Freshwater West are described in **Volume 3, Chapter 18: Physical Processes** and **Chapter 19: Marine Sediment and Water Quality**.

Table 4-3 Offshore Development Area Design Envelope

Offshore Development Area	Design Envelope
Array Area	45 km^2
OfECC length	Up to 49 km
OfECC disturbance width	Up to 25 m wide per cable

4.4.2. Characteristics of the Onshore Development Area

34. The Onshore Development Area comprises of the OnECC, which is a maximum width of up to 900 m and a minimum width of 70 m, and the onshore Substation Compound which comprises an area of up to 15,000 m^2. As shown in **Volume 5: Figure 4-2**, the Onshore Development Area extends eastwards from MLWS at the proposed landfall at Freshwater West, for 7.1 km, past the onshore substation location and on to the grid connection point at Pembroke Power Station.

35. The Onshore Development Area including the OnECC, and the Substation Area will be up to 2.1 km^2 (excluding SuDS).

36. The design envelope for the Onshore Development Area is summarised in **Table 4-4.**

37. The Onshore Development Area predominantly occupies land within the Pembrokeshire Coast National Park Authority (PCNPA) with the majority of the OnECC comprising agricultural land. The OnECC will also cross several roads and minor watercourses. These were considered during onshore cable routing exercises and are detailed in **Section 4.8.4**.

38. Landfall at Freshwater West will be achieved using Horizontal Directional Drilling (HDD), with the onshore TJB at the HDD compound located up to 400 m inshore from MHWS. The OnECC, as shown in **Volume 5: Figure 4-2** takes the following route:

- Travels northeast, crossing the B4319 to B4320.
- Heads east, north of the B4320 and Kilpaison Burrows/ Sir Benfro.
- Between Little Neath and Hoplass Solar Farm the OnECC curves to the north- northeast adjacent to Wallaston Green; and

- Adjacent to the northern boundary of Hoplass Solar Farm the cable corridor turns east towards the Greenlink Converter station before finally travelling north to the substation near Pembroke Power Station.

Table 4-4. Onshore Development Area Design Envelope

Onshore Development Area	Design Envelope
Maximum substation building footprint	6,000 m^2
Maximum Substation Compound Area (including external equipment)	15,000 m^2
Maximum temporary construction compound area	5,000 m^2
Maximum OnECC Length	7.1 km
OnECC area (export cable route plus 100m buffer)	0.72 km^2
Onshore Development Area footprint (excluding SuDS)	2.1 km^2

4.5. Offshore Infrastructure

39. The proposed Project will consist of up to 10 WTGs supported by floating offshore platforms, which in turn are moored to the seabed via mooring and anchoring systems. Each WTG will have an electrical cable connection to the wider wind farm via an IAC network.

40. The offshore export cables will transport the electricity from the Array Area to the proposed landfall at Freshwater West, from which the power will be transported via the onshore export cables to the onshore substation and then on to the National Grid network Point of Connection by Pembroke Power Station.

41. The following sections provide further detail on the key parameters of the proposed offshore infrastructure.

4.5.1. Wind Turbine Generators

42. The WTG design envelope needs to provide enough flexibility to accommodate innovations in emergent floating WTG technologies. As such the proposed Project is considering a range of WTG options and associated dimensions against which the environmental impacts of the WTGs can be assessed, however, all WTGs follow conventional offshore design architecture with three blades and a horizontal rotor axis.

43. Due to the fast pace of WTG technology development, it is not considered appropriate to constrain the PDE based on the capacity of individual WTGs. The receptor-specific impact assessments undertaken within this ES are not linked to, or affected by, WTG capacity. Instead, the number and physical dimensions of the WTGs are the relevant aspects and hence these parameters are defined below and used within the impact assessments. An illustrative WTG, with key design parameters, is shown in **Figure** 4-3**.**

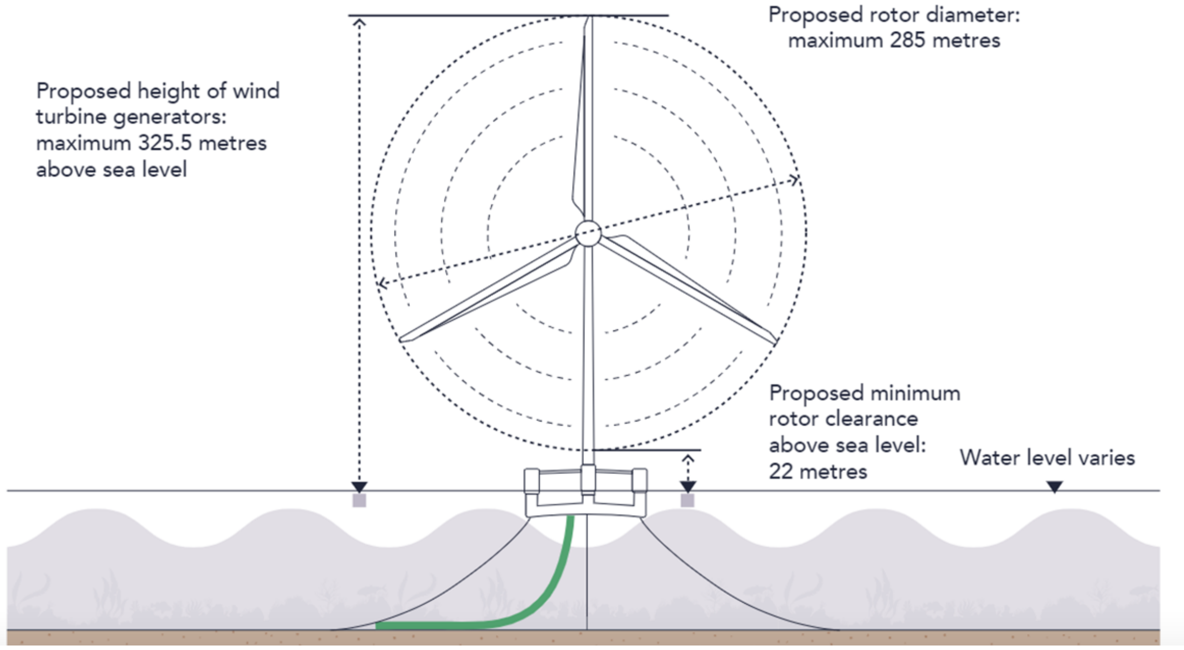

Figure 4-3. Illustration of the design parameters for a WTG

44. The WTG blades are connected to a central hub, forming a rotor that turns a generator and in some cases a gearbox. The generator and gearbox are located within a containing structure known as the nacelle, which is positioned at the top of the WTG tower structure, the base of which is affixed to the floating platform. The rotor can rotate or 'yaw' in order to face the oncoming wind direction.

45. Each WTG will have a minimum blade tip clearance of 22 m between sea level and the lowest position of the blade. The rotor diameter size will vary depending on the final design selected.

46. The WTGs operate by facing the rotor blades into the predominant wind direction, rotating to maximise power output depending on wind speed. Each WTG operates independently and will operate within a wind speed range, with a minimum cut in wind speed of 3 m/s and a maximum cut out wind speed of 28 m/s. When the maximum operational wind speed is reached, the WTG will cut-out, either fully or gradually, to limit loading. If the high wind speed cut-out is gradual, the WTG will continue to generate some power through to higher wind speeds, with the maximum dependent on the WTG design. A SCADA (Supervisory Control and Data Acquisition) computer system monitors and controls the output from each WTG, and an integrated alarm system will be triggered automatically in the event of any fault.

47. The maximum and minimum WTG parameters that inform the impact assessment are shown in **Table 4-5.** The final parameters and number of WTGs being deployed will fall within these ranges.

Table 4-5 Proposed WTG design envelope parameters

WTG Parameter	Design Envelope
Maximum number of WTGs	Up to 10
Minimum blade tip clearance (from sea level)	22 m
Maximum hub height (HAT)	177 m
Maximum tip height (HAT)	325.5 m
Maximum rotor diameter	285 m
Maximum rotor swept area	63,794 m^2
Maximum blade width (chord width)	7 m

WTG Parameter	Design Envelope
Minimum separation distance between WTGs (tower centre to tower centre)	1,000 m
Average rotation speed	6.2 -8 rpm
Tidal offset (range)	3.61m (HAT) and -3.47m LAT) 2.32m (Mean High Water (MHW)) and -2.22m (Mean Low Water (MLW))
Design life of WTG	30 years from commissioning

48. The proposed Project will be designed and constructed to satisfy the safety requirements of the Maritime and Coastguard Agency (MCA) as well as the marking, lighting, and fog-horn specifications of the Civil Aviation Authority (CAA), Trinity House, Defence Infrastructure Organisation (DIO) of the Ministry of Defence (MoD) and the MCA. The use of Autonomic Identification System (AIS) Aid to Navigation will be discussed post consent with Trinity House. In addition, after installation the final positions and height of each turbine will be provided to the United Kingdom Hydrographic Office (UKHO), the MoD, and Defence Geographic Centre (DGC).

49. It is anticipated that the WTG structure will be painted yellow (RAL 1023 traffic yellow) from sea level to 15 m above sea level and the tower, hub and blades above 15 m will be painted grey (RAL7035 light grey). When in operation, the floating platforms shall be painted yellow and marked with clearly visible unique identification characters, which will be visible from all sides and comply with applicable requirements in MCA MGN (Marine Guidance Note) 654 (MCA, 2021). Currently, these recommend that the floating platforms should be visible from at least 150 m from the structure and that lighting for this purpose is hooded or baffled to avoid unnecessary light pollution or confusion with navigation marks.

50. Additionally, for aviation purposes, the unique identification characters must be visible from the air and the WTGs shall have red blade tips and high contrast markings (dots or stripes) placed at 10 m intervals on both sides of the blades to provide helicopter pilots with a hover-reference point.

51. The final WTG lighting and marking arrangements will be discussed and agreed with relevant stakeholders (such as the MoD and MCA) prior to construction and set out within the Lighting and Marking Plan (LMP), if required as a condition of consent.

52. Although battery backup is the preferred solution, the WTGs may have diesel generators to provide power during commissioning and during maintenance. Generators are also typically used for back-up power supply on the floating offshore wind platform supporting the turbines. Additionally, each WTG contains components that will require lubricating oils, hydraulic oils and coolants for its operation. Examples of these are:

- Grease;
- Synthetic oil / hydraulic oil;
- Nitrogen;
- Transformer silicon / oil;
- Sulphur Hexafluoride (SF6); and
- Water / glycerol.

53. To minimise the impact from an unlikely leak of any of these fluids, the nacelle, tower, and rotor will be designed and constructed to contain leaks, thereby reducing the risk of spillage into the marine environment. Indicative maximum requirements for these oils and fluids for each WTG are shown in **Table 4-6** below.

Table 4-6 Indicative Maximum requirements for oil and lubricants within each turbine platform

Oil & Lubricants per WTG	Design Envelope
Lubrication oil (gearbox, yaw drive, pumps etc.)	1,500 litres
Hydraulic oil	700 litres
Cooling agent	600 litres with ~50% glycol to prevent freezing
Diesel fuel for generators	One generator per WTG

WTG indicative Layout

54. The Array Area covers an area 45 km^2 and WTGs will be spaced to a minimum separation distance of 1,000 m from turbine centre to turbine centre.

55. WTGs will be arranged in a 'string' or 'star' layout. In a string layout, each WTG connected to the next via IACs, the final WTG in the string layout will be connected to a subsea connector which in turn will connect the IAC cable to the export cable. In a star layout, the IAC's connect individually from the WTG to a subsea connector hub which is connected to the export cable. The maximum dimensions of the subsea connector (for a star layout) will be 30 m length by 12 m width by 8 m height. The subsea connector will be mounted on a concrete plinth on the seabed with a footprint of 64 m^2.

56. The design envelope of the IAC is presented in **Table** 4-9 and the design envelope for the offshore export cables is presented in **Table 4-10**. An illustration of the subsea connector is provided in **Figure** 4-4**.**

57. The final array layout will be determined with consideration of several factors, including the final number of WTGs to be deployed and WTG model choice, geophysical characteristics and metocean conditions, efficiency in WTG installation, seabed characteristics identified (including any sensitive environmental features) and operation conditions. For the purposes of assessment worst case scenario layouts have been developed where necessary for each receptor topic and these are presented in **Chapters 7 to 27** of this ES.

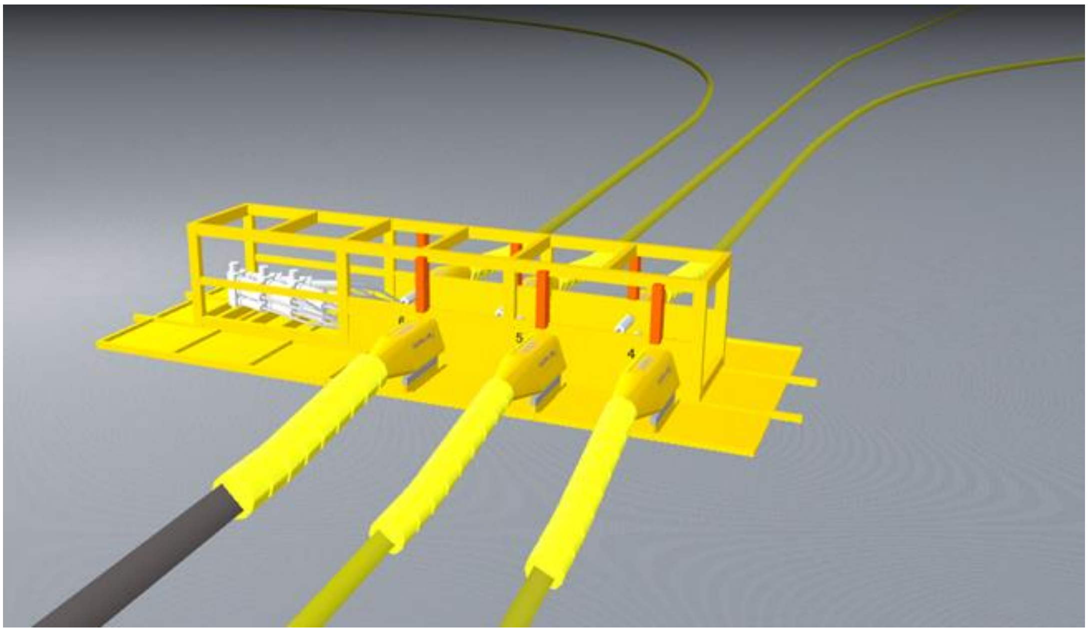

Figure 4-4. An indicative drawing of a subsea connector used for a 'star' layout (courtesy of Siemens, 2024)

4.5.2. Floating Offshore Wind Platforms and Moorings

58. Floating Offshore Wind Platforms (floating platforms) will provide a base for each WTG. The platforms will be moored and anchored in deeper offshore waters, as an alternative to the fixed bottom foundations historically used by offshore wind farms. Each WTG will be mounted to a floating platform, which in turn comprises three key components:

- A **floating platform substructure** – a floating substructure made from concrete and/or steel that supports the WTG.
- A **transition piece** – that provides the connection between the substructure and WTG tower; and
- A **mooring** system comprising mooring lines, anchors and ancillary components – which anchors the structure to the seabed.

59. These key components are described further in the following sections.

Floating Platform Substructure

60. The floating platform technology selected for the proposed Project will be either a floating barge, semi-submersible or tension-leg platform (TLP) and therefore, the platform shape can vary between circular, rectangular, and triangular depending on which technology is selected. An overview of the different floating platforms under consideration for the proposed Project are illustrated in **Figure** 4-5.

61. Both barges and semi-submersible floating platforms achieve necessary stability through their buoyancy and their semi-submersible nature, which ensures the wind loadings on the structure and WTG are countered / dampened by the equivalent buoyancy force on the opposite side of the structure. These buoyant stable platforms have a relatively large footprint area compared to the TLP solution and are typically larger and heavier in nature. Both floating barges and semi-submersibles are anchored to the seabed using catenary mooring lines.

62. The TLP is a semi-submerged buoyant structure that achieves its stability through line tension on mooring lines. This system stability, as opposed to the stability coming from the floating structure itself, generally allows for structures that are smaller in footprint area and lighter than barge or semi-submersible platforms.

63. Each floating substructure technology will have varying dimensions because of the different WTG sizes, and project-specific requirements. Maximum parameters for the floating platforms are based upon the maximum WTG scenario presented in **Table 4-5** and these parameters will not be exceeded in the final project design.

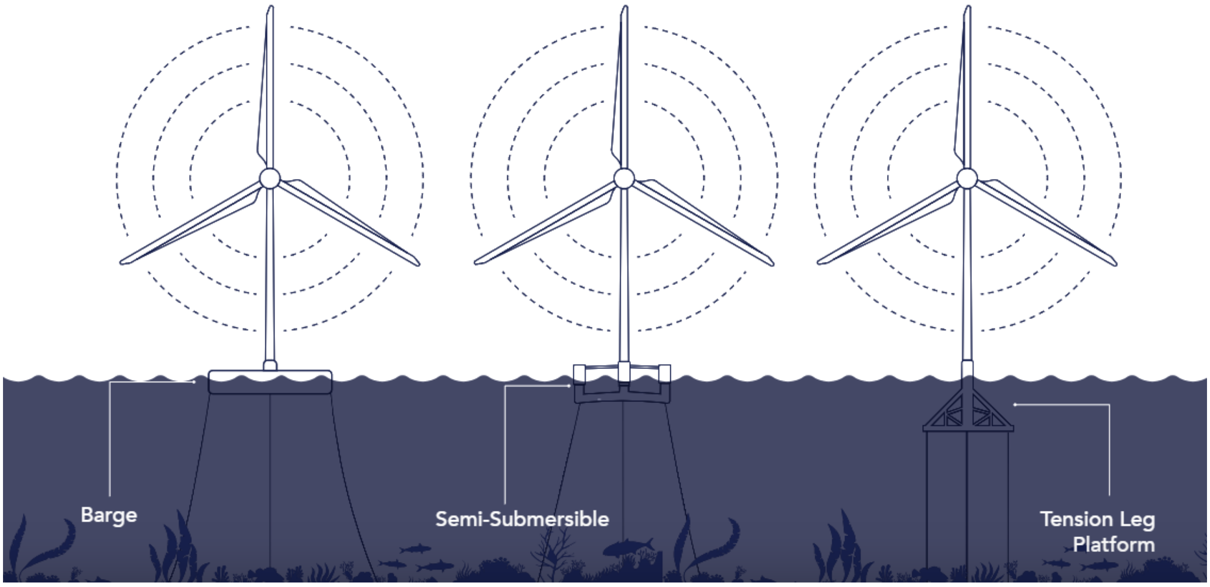

Figure 4-5 Illustration of the different floating platform designs under consideration

64. Floating platforms for WTGs, irrespective of design, are not stationary like traditional fixed bottom offshore WTGs. The platforms move with the water conditions, although the mooring systems restrain the platform excursions and motion within certain allowable limits.

65. Minimum and maximum parameters for the floating platforms under consideration are set out in **Table 4-7.**

Table 4-7 Proposed floating platform design envelope parameters

Floating Platform Parameter	Design Envelope
Maximum dimensions of substructure (triangle)	115 m per side
Maximum dimensions of substructure (rectangle)	60 m width x 120 m length
Maximum dimensions of substructure (square)	80 m width x 80 m length
Maximum visible footprint area above the water line per platform	155 m2 to 6500 m^2
Maximum column diameter	12 m to 20 m
Maximum column distance (centre to centre)	55 m to 100 m
Maximum column height above sea level	16 m to 32 m
Operating draught (distance from keel to sea level)	12 m to 45 m
Maximum excursion of hull from slack line position / neutral position	Up to 50 m

Transition Piece

66. The transition piece (TP) for a floating structure forms the connection between the floating foundation and the WTG tower. The TP is an integrated part of the floating structure and has a circular flange for the bolted tower connection. The TP typically holds essential components including cable connections, maintenance equipment landing platform, davit crane, platforms ladders and boat landing systems, which enable technicians and engineers to enter the turbine

tower to undertake repair and maintenance work. TP's areas vary considerably depending on the type and nature of the floating foundation.

Mooring System

67. Floating platforms will be attached to the seabed using anchored mooring lines. Floating offshore WTGs need to maintain their position even during the most extreme weather events and the mooring system will be designed to address station-keeping issues and to enable efficient installation and connection-disconnection procedures to be performed by widely available anchor handling vessels.

68. The proposed Project needs to maintain flexibility in mooring system design to accommodate innovation and development of the final design. The final mooring configuration will be informed by the selection of the floating platform design, site conditions and ground conditions.

69. Two types of mooring systems are under consideration for the proposed Project, these include, tensioned (or TLP) and catenary spread mooring. The different mooring systems under consideration are illustrated in **Figure** 4-5**.**

70. Mooring lines will be installed on each floating platform, the precise number and location will vary depending on the type of mooring system and anchorage selected. All mooring systems and anchors will be installed using Dynamic Positioning (DP) vessels and specialist Remotely Operated Vessels (ROVs).

71. The mooring lines themselves will be up to 1,250 m in length, depending on the location of their installation and mooring type. These mooring lines will be formed from a combination of chain, steel and synthetic ropes; all of which will be offshore grade material. Various ancillary infrastructure will also be utilised to improve the mooring performance of the WTGs, and these include, buoys mooring clump weights and load reduction devices. The following text provides a more detailed description of the mooring configurations considered for the proposed Project and **Table 4-8** summarises the design envelope parameters for the proposed mooring systems.

Tensioned Moorings

72. Tensioned moorings are specific to TLP structures which are buoyant structures, vertically moored to the seabed by vertical tendons (also called tethers), each of which are anchored to the seabed under significant tension. The pretensioned tethers provide the righting stability and allow for horizontal movement with wave disturbances, but do not permit vertical or heave movement. Tensioned moorings have a smaller mooring footprint compared to other systems and require certain anchor types to withstand the uplift force. This provides for a more stable structure but increases the complexity in the anchor design required. Different anchor types are further detailed below.

73. TLP moorings will consist of a bundle of up to four pairs of tensioned moorings lines, providing a maximum of eight mooring lines per platform. The plan length of the mooring line beyond the edge of the foundation will be up to excursion (offset) of 35 m.

74. The point of connection of the mooring lines to the substructures will be dependent on the mooring system and the type of substructure ultimately selected. This could be some meters below the sea surface, at the bottom of the floating platform, or closer to the sea surface near the top or at the top of the floating platform and this has implications on the level of interactions with vessels (termed under-keel clearance). For the TLP mooring system there will be a minimum under-keel clearance to the seabed of 35 m.

Catenary Spread Moorings

75. Catenary spread mooring (including plain catenary and semi-taut) configurations are typically used for semi-submersible platforms and the weight and curved shape of the mooring line holds the floating platform in place. The mooring lines can be made from chain, steel or synthetic rope (or a hybrid of these options). The lower section of the mooring system rests on the seabed, supporting the anchor and acting as a counterweight in stormy conditions which allows conventional and more cost-effective anchor types (drag anchors) to be used, although other anchor types can also be employed. **Figure** 4-6 illustrates the various station keeping elements that can be utilised). Buoyancy elements also form part of the mooring system, to prevent the mooring line from touching the seabed. More information on anchor types is provided below.

76. In a catenary mooring arrangement, each mooring line grouping is attached to each extremity of the floating platform. Clump weights are likely to be required to add mass to the mooring line and reduce the lateral movement of the floating structure. These weights are attached to each mooring line and will be in the form of a casing around the mooring line where it meets the seabed (the touch-down point), spread out along the grounded portion of the mooring chain and in some configurations extended into the water column. The maximum number clump weights will be 25 per mooring line spread evenly along the casing, with each clump weight being up to 2m x 2m x 1m. Each clump weight will weigh up to 20 tonnes; it is possible clump weights which are smaller than those described here could be used and positioned closer together along the mooring line, but the feasibility of this will only be determined during detailed design.

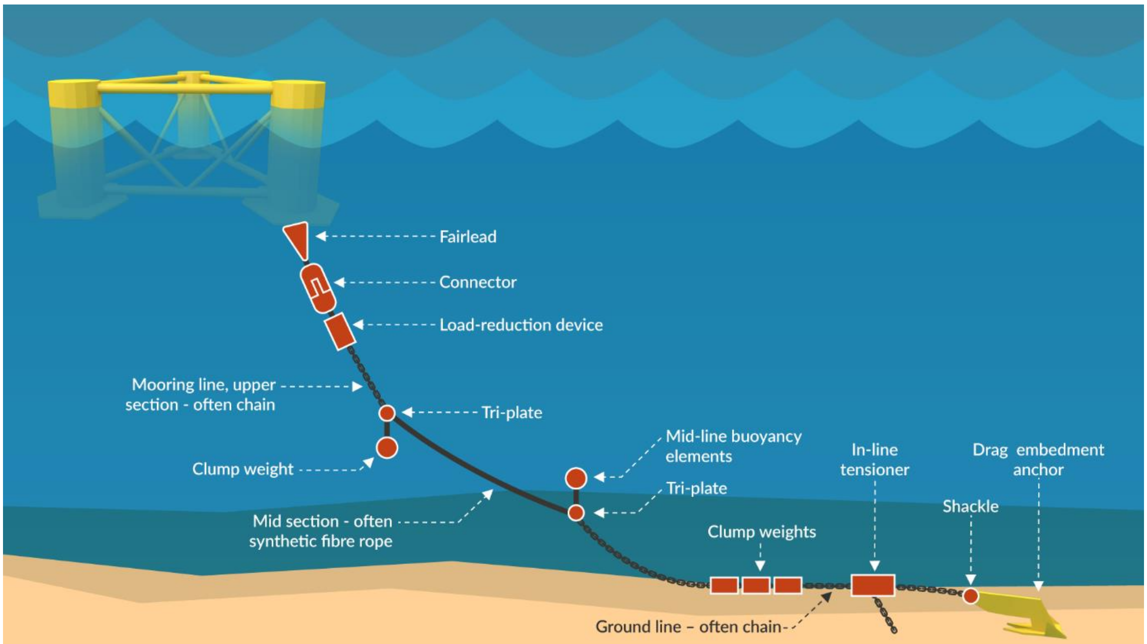

Figure 4-6 Illustration of a catenary mooring system with chain – rope – chain set up

77. The catenary spread mooring arrangement has a maximum of eight mooring lines per platform, with each linking to an individual anchor. The maximum length of mooring line will be up to 1,250 m with a maximum expected horizontal excursion (offset) of 54 m. The radius of mooring (from the platform hull to anchor) will be up to 1,350 m. As a worst case scenario, the maximum mooring line disturbance would be 770 m^2 per WTG, equalling a total seabed footprint area of up to 5,600 m^2 across the Array Area. There will be a minimum under keel clearance to the seabed of 40 m.

78. The exact dimensions and configuration of the mooring system to be used for the proposed Project cannot be finalised at this stage due to procurement and supply chain considerations of

emerging technology. However, **Table 4-8** provides the design envelope parameters of the different mooring systems considered.

Table 4-8 Proposed Mooring Systems design envelope parameters

Mooring System Parameters	Design Envelope	
	TLP	Catenary Spread
Maximum number of mooring lines per WTG	8	8
Maximum mooring line length (based on maximum water depths)	60 m	1,250 m
Maximum proportion of mooring line that may come into contact with the seabed	0 m	150 m
Maximum spread (radius) of mooring lines (based on maximum water depths)	130 m sided triangle/square	1,350 m
Maximum horizontal excursion extent	35 m	54 m
Minimum under-keel clearance	35 m	40 m
Maximum number of clump weights per mooring line	0	25
Maximum seabed footprint of clump weights (per mooring line)	-	100 m^2
Maximum total seabed footprint of clump weights	-	8,000 m^2
Total seabed footprint of anchors and chains per WTG	100 m^2	700 m^2

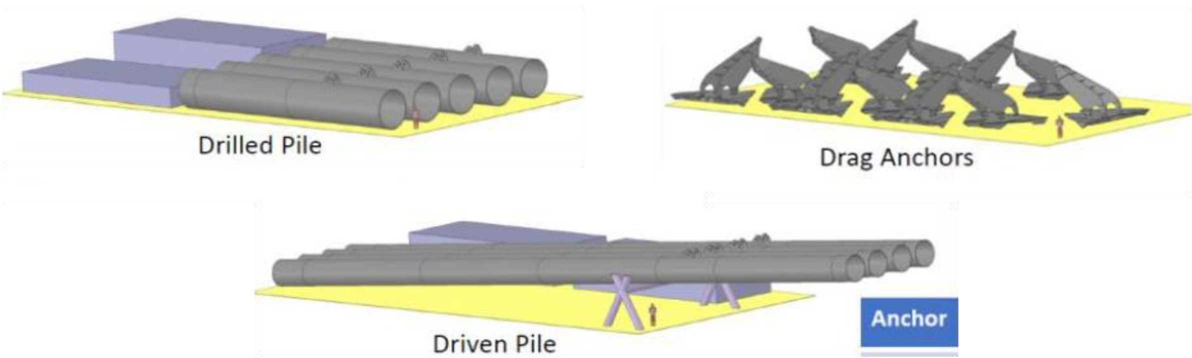

Figure 4-7 Overview of different anchor types

Anchorage

79. Anchorage will be required to fix the mooring systems to the seabed. Different anchor options are currently under consideration for the proposed Project and the final anchor solution will depend on the technology selected, mooring configuration, seabed conditions and the required holding capacity, but will be either drag embedment anchors, driven or drilled piles (**Figure 4-7**). The different anchor types are described below, and design envelope parameters are summarised in **Table** 4-9.

80. The number of required anchors will vary according to the selected mooring system, with a maximum of eight anchors per WTG.

Drag Embedment Anchors

81. Drag embedment anchors use a drag and penetration arrangement, where the anchor is installed by being dragged along the seabed until it reaches the required depth and holding capacity. The anchor is then held in place by seabed sediment resistance. Drag embedment anchors are typically associated with catenary mooring systems where the mooring line is horizontal to the seabed and are not suited for any vertical loading. Drag embedment anchors are best suited to cohesive sediments and function best when they are fully submerged into the seabed. An example of a drag embedment anchor is shown in **Figure 4-8**.

82. For the proposed Project, drag embedment anchors will have maximum dimensions of 8.5 m length x 9 m width x 5 m height, with a maximum weight of up to 40 tonnes. The associated seabed penetration depth of any drag embedment anchor utilised for the proposed Project will be up to 25 m. Up to 80 drag embedment anchors will be utilised across the Array Area with a total anchor footprint area of up to 6,120 m^2.

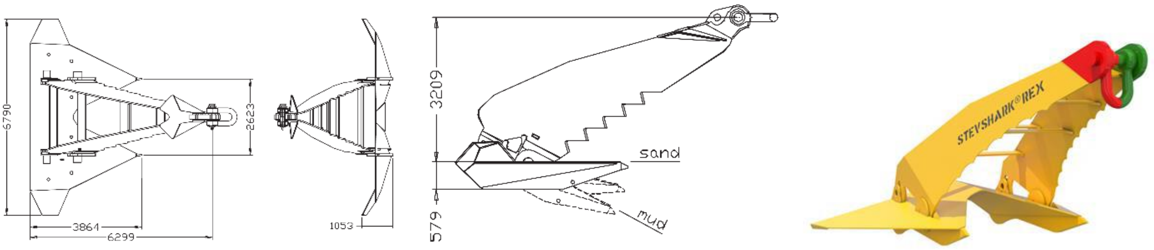

Figure 4-8 Example of Drag Embedment Anchor (a Vryhof StevShark Mrk–5 - Courtesy of Vryhof)

Drilled / Driven Pile Anchors

83. Drilled piles involve installation of anchors with external force applied from a specialist installation vessel. For the proposed Project, a maximum of 8 drilled piles will be used per WTG with a maximum pile diameter of 3.5m and a maximum penetration of depth of 55 m. For drilled piles the maximum drill arisings across the array area (i.e. 80 piles) will be up to 42,300m^3 total.

84. Impact / driven piles are typically steel tube or H sections, which are driven mechanically by a percussive pile driving hammer or vibrated into the seabed. These are typically utilised with taut mooring systems but can be used with catenary moorings if required. Various types of hammers are available with different impact energy, frequency, noise and vibration profiles. The hammer type and size, size of the pile and seabed sediment properties each of these factors affects the number of blows and time required to achieve the target penetration depth.

85. It is estimated that the maximum number of days when piling may occur during construction would be 45 days with a minimum of 20 piling days over the construction period. This assumes up to six piles can be installed in one day. No more than 1 pile will be installed concurrently. The anticipated piling duration per day would range between 90 minutes and 180 minutes and piles of this nature would require a maximum hammer energy of 800 kJ. Up to three driven piles will be used per WTG for the proposed Project, with a diameter of up to 3 m and penetration depth of up to 55 m.

86. The type of anchors or piles that will be used for the proposed Project cannot be finalised at this stage due to ongoing engineering design studies, to determine the suitability of each option for the mooring technology to be used and seabed sediment conditions for each WTG location. However, **Table** 4-9 provides the design envelope parameters for both drag embedment and impact / driven pile options. Further information on noise propagation into the marine environment is provided in **Appendix 21B: Marine mammals noise modelling**.

87. An example of an impact/driven pile is shown in **Figure** 4-9.

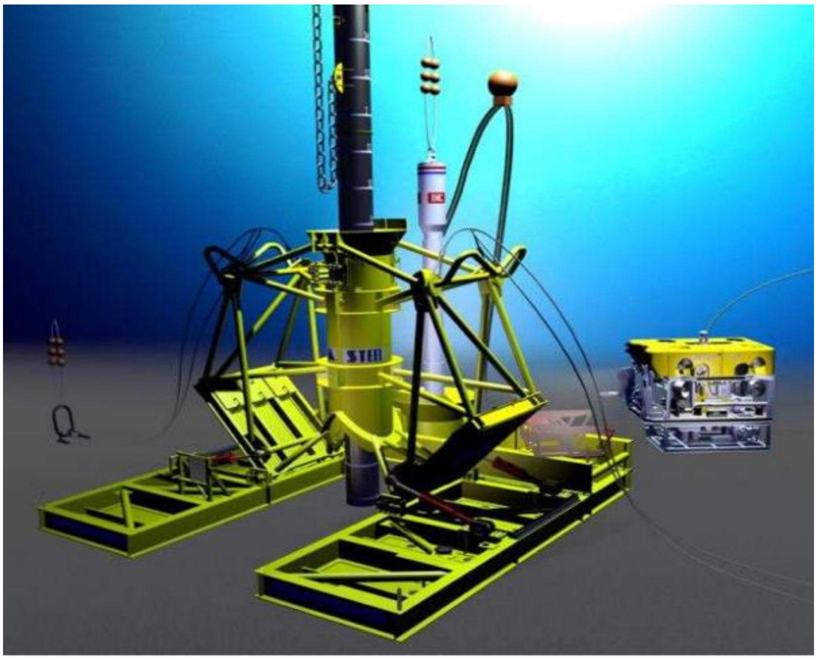

Figure 4-9. Example of driven pile anchor (using a drilling guide tool)

Table 4-9. Proposed anchor design envelope parameters

Anchor Design Parameters	Design Envelope		
	Drag embedment anchor	Drilled piles	Driven piles
Maximum number of anchors per WTG	8	8	8
Maximum anchor/pile width	6 m	3.5 m	3 m
Maximum anchor height	4 m	n/a	n/a
Maximum anchor/pile penetration depth	25 m	55 m	55 m
Anchor/pile height above seabed	-20 m	4 m	4 m
Seabed footprint per anchor/pile	76.5 m^2	15 m^2	15 m^2
Total anchor/pile footprint	6120 m^2	1200 m^2	1200 m^2
Maximum anchor/pile weight	40 tonnes	300 tonnes	400 tonnes
Maximum distance of anchor drag during installation	75 m	n/a	n/a
Maximum pile hammer energy	n/a	n/a	800 kJ
Maximum number of piles installed per day	n/a	4	6
Minimum number of piles installed per day	n/a	1	2
Maximum piling duration per day	n/a	n/a	180 minutes
Minimum piling duration per day	n/a	n/a	90 minutes
Number of concurrent piling events	n/a	n/a	1
Maximum number of days when piling may take place	n/a	n/a	45
Minimum number of days when piling may take place	n/a	n/a	20

Anchor Design Parameters	Design Envelope		
	Drag embedment anchor	Drilled piles	Driven piles
Maximum volume of drill arising per pile	n/a	529 m^3	n/a
Maximum volume of drill arising across the Array Area	n/a	42,300 m^3	n/a

Offshore Inter-array Cables and Subsea Connection Point

88. Inter Array Cables (IAC) transmit electricity between the WTGs, with each WTG delivering electricity at up to 66 kilovolts (kV) HVAC.

89. The proposed Project will require up to 11 IACs each with an average length of up to 1.6 km per IAC and a total length of approximately 17.6 km. IACs will be installed to form a 'string' or 'star' configuration between each WTG. If a string layout is used, the final WTG in the string will connect to a subsea connector, as described in **Section 4.5.1.**

90. Each IAC will consist of a three-phase conductor (typically aluminium or copper) and will be surrounded by XLPE insulation, lead casing, an inner sheath, armour wire (multiple layers depending on design) and an outer corrosion protective jacket. Each cable will have a maximum diameter of 200 mm. A fibreoptic communications cable will run alongside the IACs to link each WTG to the remote computer system. An illustration of example IAC composition is provided in **Figure** 4-10**.**

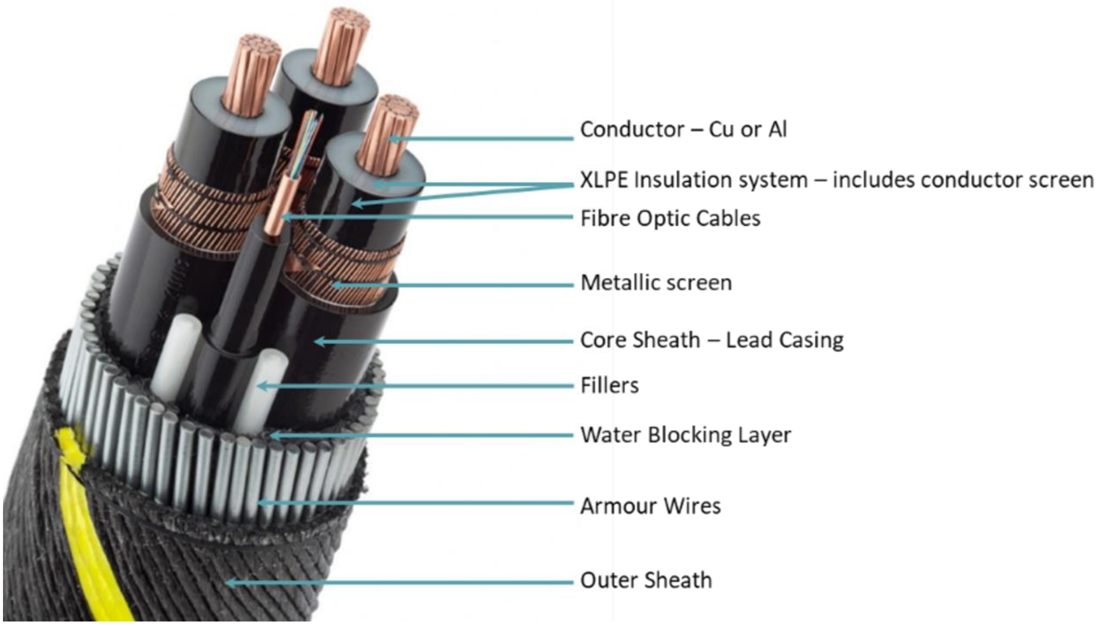

Figure 4-10 Illustration of composition of IAC (courtesy of Qifancable.com)

91. A key design difference between IACs for a fixed-bottom wind farm development and those for floating WTGs is the dynamic nature of the cables within the water column, to accommodate the movement of the floating substructure. As a consequence, the IACs will require a form of load/stress reduction support, such as distributed buoyancy modules attached to a portion (Mid-point) of the cable to obtain a 'Lazy Wave' shape as per **Figure 4-11**, which provides higher flexibility to avoid over-stressing.

92. Buoyancy modules are typically clamped to the cable during installation and the number of buoyancy modules required will be driven by various factors including, water depth, the desired cable configuration and surrounding metocean conditions.

93. IAC cables are secured to the seabed at a ‘touchdown point’, up to 150 m from the hull of the WTG and the touchdown point will be provided with cable protection where necessary. It is assumed as a worst case scenario that:

- 100% of the IACs may need to touch the seabed from the location of the touchdown point (i.e. the IACs will be dynamic in the water column from the hull of the WTG to the touchdown point), and;
- up to 20% of the IACs on the seabed may require cable protection (i.e. up to 3,420 m), with a maximum width of 5 m.

94. The touchdown point and the IAC protection will therefore occupy a maximum footprint area of 17,100 m^2 for all IACs across the Array Area (3,420 m x 5 m).

95. **Figure 4-11** below illustrates an IAC in the water column with a lazy wave and a single touch down point.

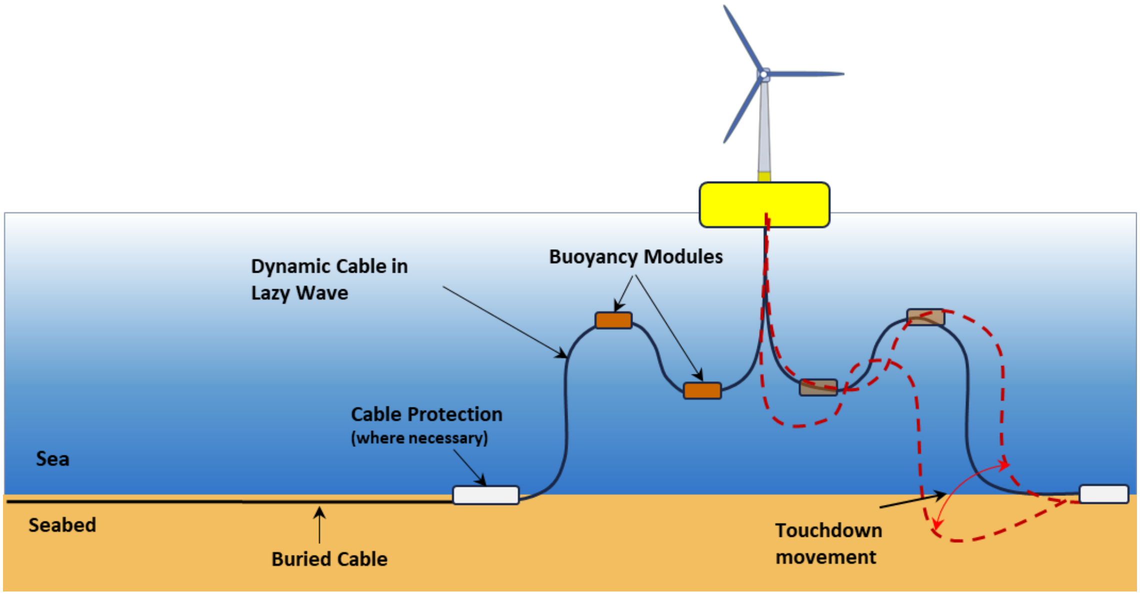

Figure 4-11 Illustration of the Lazy Wave Dynamic IAC cable configuration, mooring point and touch down point

96. From the touch down point on the seabed, no movement in the cable is expected and the static portion of the IAC will either be laid on the seabed or buried. The target burial depth for IACs is 1.2 m below the seabed (the minimum burial depth being 0.8 m) and the maximum trench width for IAC cable installation will be up to 25 m. Cables will be buried where possible, however, where burial is not possible additional cable protection measures will be used. Cable protection measures are described further in **Section 4.7.5.**

97. **Table 4-10** provides the design envelope parameters for IACs for the proposed Project.

Table 4-10 Proposed design envelope parameters for IACs

IAC Parameters	Design Envelope
Maximum number of IACs	11
Maximum IAC voltage	132 kV
Average length of each IAC	1.6 km
Maximum length of each IAC on seabed	Up to 1.55 km
Maximum cumulative length of IACs in contact with seabed	17.10 km
Maximum external cable diameter	200 mm

IAC Parameters	Design Envelope
Maximum length of touchdown movement for each IAC	150 m
Maximum footprint of touchdown movement for each IAC	4,000 m^2
Maximum footprint of touchdown movement for all IACs	44,000 m^2
Maximum trench width for cable installation	25 m
Target burial depth (where technically possible)*	1.2 m
Maximum length of IAC cable protection	3,420 m (total length)
Maximum width of cable protection	5 m
Maximum area of IAC cable protection	17,100 m^2

**The exact target burial depth will be based on the cable burial risk assessment (CBRA) and may vary throughout the Array Area. The Applicant will seek to maximise cable protection by burial wherever possible.*

4.5.3. *Offshore Export Cables*

98. Up to two offshore export cables will be installed for the proposed Project within the OfECC and these will transmit electricity from the IAC and subsea connector to the proposed landfall at Freshwater West. Each offshore export cable will deliver electricity at up to 132 kV HVAC. Each offshore export cable will have a maximum length of up to 49 km, providing a total length of up to 98 km. The composition of the offshore export cables will be the same as the IACs (Paragraph 90). Each cable will have a maximum diameter of 200 mm and a fibreoptic communications cable will run alongside the export cables to link each WTG to the remote computer system.

99. **Figure 4-12** provides an illustration of the key elements of an offshore export cable for a floating wind farm.

100. The offshore export cables will be laid in separate trenches providing two trenches in total, with a target separation of 50 m between cables as per '*Export transmission cables for offshore renewable installations – Guideline for leasing of export cable routes/corridors*' (Crown Estate, 2012). The target separation distance may decrease in the nearshore area from where the cables approach Turbot Bank (Kilometre Point (KP) 38) to the HDD exit point (KP 48). The separation distance between the two proposed Project offshore export cables will vary along the indicative offshore export cable route; however, a minimum separation distance of 150 m will be established between the offshore export cables of project Erebus and of the proposed Project.

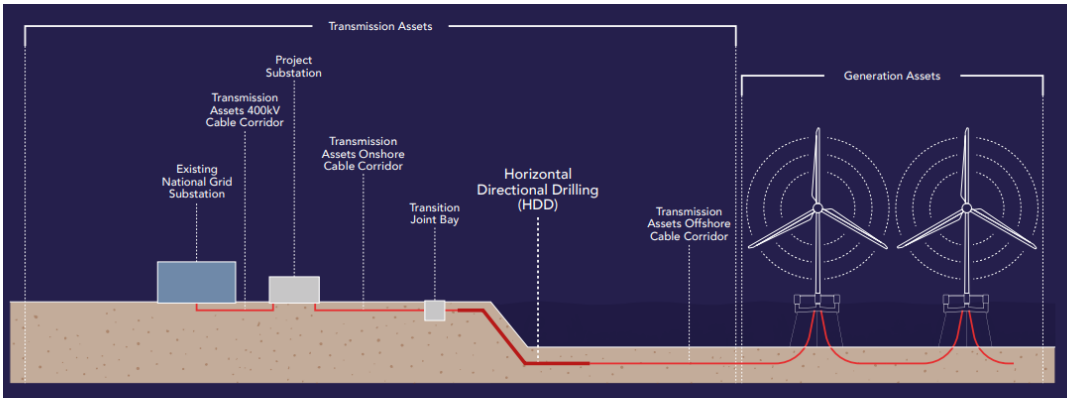

Figure 4-12 Illustration of key elements of floating wind farm offshore export cable

101. The target burial depth for the offshore export cable is 1.2 m below the seabed for the majority of the OfECC. The exception to this is in the nearshore where the cable runs north-south parallel to the coast from the HDD exit point where target burial depth is 1.5 m for up to 1.7 km, and for the 4.5 km along the eastern edge of Turbot Bank where target burial depth is 2 m (see **Table 4-11** for approximate locations for burial depths).

102. The maximum disturbance corridor width for cable installation will be up to 25 m per cable, therefore up to 50 m in total for two cables. The cable will be buried where possible, however, where minimum burial depth is not achievable, cable protection measures will be used.

103. In the nearshore area it is assumed the cable between KP 38 and KP 48 will be 100% protected using iron articulated pipe protection, (11,000 m for each cable)or up to 22.4% of the total export cable length . Within this nearshore area, no other cable protection measures are proposed.

104. Up to five potential cable crossings have been identified, which will be confirmed upon the final Array layout design. At the point of cable crossings additional cable protection may be required and cable protection measures are described further below. However, no protection measures are required for one of the five identified cable crossings, the Greenlink cable crossing, as the cables will be installed by HDD (and therefore underground and not on the seabed) in this area. It is assumed that up to 4.9% of the 49 km total length of each export cable (or 2,400 m of each cable) will require additional cable protection measures, including 200 m of protection at each of the four remaining cable crossings.

105. **Table 4-11** provides the design envelope parameters for offshore export cables for the proposed Project.

Table 4-11. Proposed design envelope parameters for the offshore export cables

Offshore Export Cable Parameters	Design Envelope
Maximum number of export cables	2
Maximum offshore export cable voltage	132 kV
Maximum length of each offshore export cable	49 km
Maximum external cable diameter	200 mm
Maximum trench width for export cable installation	25 m
Target burial depth KP 0 to KP 38	1.2 m
Target burial depth KP 38 – KP 42 (to the east of Turbot Bank)	2 m
Target burial depth KP 46.5 – KP 48 (parallel to beach)	1.5 m
Minimum burial depth (where technically possible)*	0.8 m
Maximum length of each export cable requiring cable protection (including at crossings but not including nearshore articulated pipe protection measures)	2,400 m (4.9% of 49 km)
Maximum length of each export cable requiring iron articulated pipe protection	Up to 11,000 m (22.4% of 49 km) (KP48 – KP38 + 10% contingency)
Maximum number of cable crossings	Up to five potential cable crossings per proposed Project cable (10 total) at the following indicative locations:

Offshore Export Cable Parameters	Design Envelope
	• KP 2-3 • KP 3-4 • KP 7-8 • KP 30-31 • KP 48-49 Greenlink Interconnector - *to note cable protection will not be required as the export cables will pass below the Greenlink cable underground via the HDD installation (i.e. there will be no seabed surface crossing of Greenlink cables).*

**The exact target burial depth will be based on the cable burial risk assessment (CBRA) and may vary throughout the OfECC. The Applicant will seek to maximise cable protection by burial wherever possible.*

Nearshore Offshore Export Cable Corridor

106. The HDD exit point, within the OfECC red line boundary, emerges to the south of the northern promontory of potential Annex 1 reef (as defined by MBES data (**Appendix 17B: 2024 MBES Survey Report)),** exiting at KP48, approximately 1,500 m from the onshore HDD compound and approximately 600 m offshore in depths of between 5 m to 8 m.

107. From the offshore HDD exit point, the offshore export cables will be installed from a shallow draft cable lay barge with high manoeuvrability. Up to four supporting work boats will also be present. The offshore export cables will be installed in a southerly direction from the HDD exit point to KP46, parallel to the coastline and avoiding encroachment to the potential Annex 1 reef to the west (**Volume 5: Figure 4.3**), to a point where the 'gap' has been identified within the potential Annex 1 reef. The intention is to bury the cable, but where not possible a low-profile cable protection system (such as an iron articulated pipe) will be used. Up to 2 km of iron articulated pipe protection in this area (KP48 – KP46), per cable, has been included as a worst-case scenario. No other cable protection measures are proposed within this area.

108. The cables will then be surface laid, using iron articulated pipe protection, in a westerly direction for up to 4 km per cable, placing the cable in the bottom of gullies where the rock is highly scoured and there is limited epibiota; avoiding encroachment onto potential Annex 1 reef between KP46 and KP42. No other cable protection measures are proposed within this area.

109. At the point where the export cables approach the northeastern side of Turbot Bank designated sandbank area at KP42, the offshore export cables will travel in a southerly direction within the OfECC, maintaining a position outside of the Turbot Bank Sandbank designated area and avoiding encroachment onto potential Annex 1 reef. Burial will be the preferred option of protection, however where this is not possible, the export cables will continue to be surface laid within iron articulated pipe protection alongside Turbot Bank to KP38, up to 4 km of articulated pipe protection may be required in this section of the OfECC, per cable. Once the offshore export cables have cleared the Annex 1 reef and Turbot Bank at KP38, they will travel in a south-westerly direction for approximately 13 km, avoiding environmental protected areas, to where the OfECC then turns south south-west until it reaches the array area.

110. It is acknowledged that there may be more advantageous routes within the OfECC, therefore the final offshore export cable routes will be refined following further geophysical and geotechnical surveys that will be conducted post consent determination. As part of these pre-construction surveys (the scope of which will be agreed with NRW), data will be analysed to ascertain the

locations of the offshore export cable routes along with the potential for micro-siting of the proposed Project infrastructure within the OfECC. The target burial depths and any areas requiring potential cable protection will also be identified and reported as part of the Cable Burial Risk Assessment (CBRA). It is anticipated that the CBRA will be produced to discharge an appropriately worded consent condition and will be provided to NRW for acceptance prior to construction commencing.

111. The final proposed Project layout, including the locations of the export cables will be presented within the Design Project Array Layout Plan, which is anticipated to form conditions of the Section 36 consent and Marine Licence, subject to NRW approval prior to installation operations commencing.

Cable and Scour Protection

112. The intention will be to maximise the burial of IACs and offshore export cables wherever possible across the Array Area and within the OfECC. However, burial requires a minimum sediment depth which may not be present for the full length of the cable routes. The estimated cable burial for the proposed Project is 73% with up to 27% potentially requiring cable protection. Where the minimum cable burial depth cannot be achieved, cable protection measures will be used to protect the cables.

113. Additional cable protection measures may be considered for specific localised areas, as appropriate, including but not limited to IAC touch down locations and cable crossing locations for offshore export cables. The final choice of cable protection solution will be made post-consent and reported in the CBRA, considering geotechnical and geophysical data, meteorological and oceanographic conditions and maintenance strategy. The CBRA will be produced post-consent which will detail the minimum burial depths of the offshore export cables throughout the offshore export cable route, and indicative proposed locations where the target depth of burial may not be achievable and external protection is expected to be required. The CBRA will detail which type of cable protection measure would be utilised at which locations within the OfECC. The CBRA will also confirm the assumptions used within the EIA regarding cable protection to confirm that the impact assessment remains valid.

114. There may also be a requirement to install scour protection post installation for some anchor solutions to prevent the structure from being undermined by sediment processes and seabed erosion. The amount of scour protection required for anchorage will vary depending on the foundation type selected, however, for the purposes of assessment it is assumed that up to 310 m^2 scour protection will be required at each anchor location. There will be a total of up to 80 anchors, and therefore up to 24,800 m^2 of scour protection across all anchors is assessed as a worst case.

115. Typical cable and scour protection solutions include:

- **Iron encased articulated pipe protection solution** – cable protection systems such as “Protectorshell” will be used to protect the cables in areas of constrained routeing options within the OfECC, such as, but not limited to, the 11,000 m of offshore export cables nearest to shore (between KP48 and KP38. Details to be defined in the CBRA produced post determination. The articulated pipe will be up to 500 mm diameter once installed per cable, and up to 11,000 m length per cable of this form of protection may be required as a worst case scenario. No other cable protection measures are proposed in this area;
- **Rock placement** – industry standard graded rock is used with grain size tailored to achieve the necessary protection around cables or anchors. Likely to be at a slope ratio of 1:3, however details are to be defined in the CBRA produced post determination;

- **Sand / Grout bags** - bags of hardened gravel, sand/ cement grout or concrete placed over the cable or onto the seabed; or
- **Concrete mattress** - pre-formed mattresses comprising a mesh of small concrete blocks that are placed across the cables or on the seabed and which confirm to seabed morphology.

116. **Figure 4-13** and **Figure 4-14** below provide an illustration of scour and cable protection measures. Design parameters relating to cable and scour protection are detailed in **Table 4-12.**

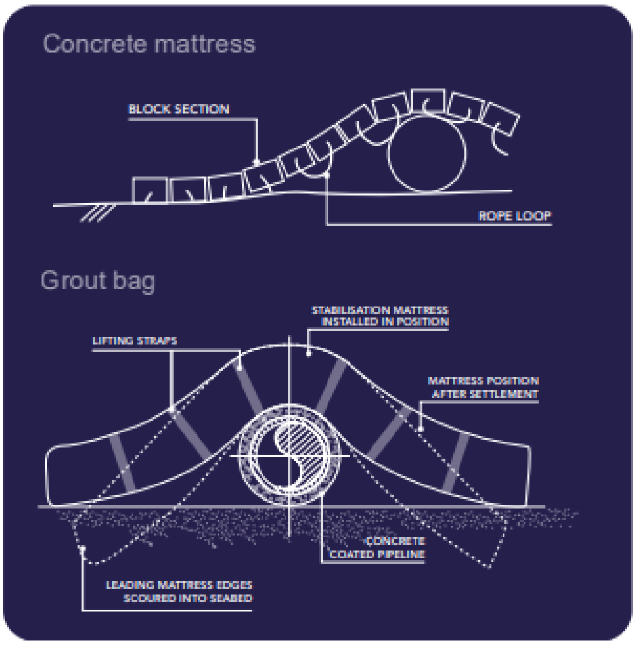

Figure 4-13 Illustration of cable and scour protection measures

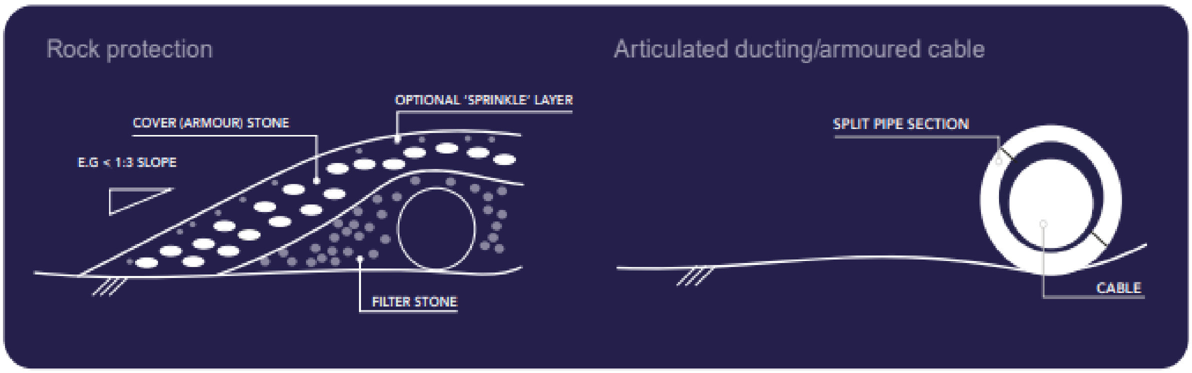

Figure 4-14 Illustration of cable and scour protection measures

Figure 4-15 - Articulated Pipe Cable Protection System (courtesy of protectorshell.com)

Table 4-12. Proposed design envelope for cable and scour protection

Cable and Scour Protection Parameters	Design envelope
Cable Protection	
Maximum cable protection width	5 m
Maximum cable protection height	1.5 m
Maximum seabed footprint of static IACs requiring cable protection (per cable)	17,100 m^2
Maximum seabed footprint of offshore export cables requiring cable protection, including at crossings (per cable)	12,000 m^2 (length of 2,400 m x max. berm width of 5m)
Maximum length of cable protection using articulated pipe, per cable	11,000 m
Maximum diameter of installed cable protection using articulated pipe	500 mm
Maximum volume of cable protection (IAC and 2 x offshore export cables)	61,650 m^3
Scour Protection	
Maximum scour protection footprint per anchor	up to 310 m^2
Maximum scour protection height per anchor	1 m
Maximum volume of scour protection per anchor	310 m^3
Maximum seabed footprint of scour protection across the Array Area	24,800 m^2
Maximum volume of scour protection across the Array Area	24,800 m^3

4.5.4. Other Associated Infrastructure

117. The Array Area will be marked with appropriate navigation safety buoys to indicate the presence of the proposed Project once operational.

118. The type, number and location of navigational buoys will be informed by engagement with relevant stakeholders, including the MCA and Trinity House, and the results of the Navigational Risk Assessment (NRA) which has been undertaken as part of this ES and reported in **Appendix 25A: Shipping and Navigation Technical Assessment.**

119. Each floating platform structure will also be marked with navigation lights, signage, fog signals and other markings, as described in **Section 4.5.1**.

120. The Array Area and OfECC will also be marked on UK hydrographic charts and notification provided to local fisheries through the Kingfisher Information Service – Offshore Renewable & Cable Awareness (KIS-ORCA).

4.6. Onshore Infrastructure

121. All infrastructure landward of MLWS is considered to be onshore. The offshore export cables come onshore at the landfall and a connection is made between the offshore export cable and the onshore export cable at the TJB. The onshore export cable continues to the onshore substation and then to the grid connection point. The Onshore Development will comprise the following key elements, which are discussed further in the following sections:

- **Cable landfall** (the Landfall), located at Freshwater West where up to two Offshore Export Cable(s) from the Array Area will be brought ashore via HDD and into the TJB;
- **TJB** where up to two offshore and up to two onshore cables will be spliced together (each cable is made up of three individual cables in a trefoil or flat arrangement);
- **Onshore cables** (up to two), buried to a target depth of 1.8 m and laid in a maximum of two trenches each up to 1.2 m wide, subject to ground conditions and landowner requirements;
- **Cable Joint Bays** (CJBs) may be required if the onshore cable(s) are installed in sections, to join the sections together;
- **Onshore Substation** covering an area of 95 m wide, 63 m length and 15 m in height, which is required to transfer the electricity from the proposed Project prior to connection into the grid at Pembroke Power Station; and
- **Onshore cable from** the substation to the grid connection point Pembroke Power Station, laid in trenches and/or ducts.

4.6.1. Landfall

122. The proposed landfall location at Freshwater West was selected based on engagement with stakeholders, discussions with National Grid and feedback from the Scoping Opinion and known environmental and technical constraints. For further details on how the landfall location was selected see **Chapter 03: Site Selection and Alternatives, Section 3.4.4.**

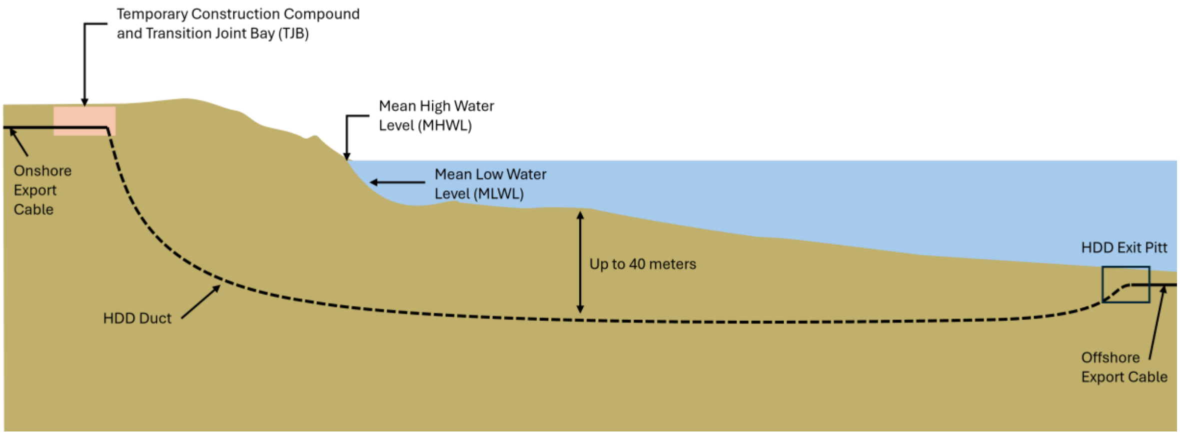

Figure 4-16 HDD landfall arrangement

123. At the landfall the export cable(s) will be installed via HDD ducts to traverse the intertidal zone at Freshwater West. There will be up to two ducts drilled and the maximum HDD distance of each

duct will be up to 1,300 m. Each HDD duct will have a diameter of up to 660 mm with each of the two onshore HDD drilling entry locations being spaced up to 20 m apart. Landfall HDD drilling will require one 100 m x 75 m temporary compound as part of the HDD temporary works area.

Table 4-13. Design Parameters for Landfall

Feature	Parameter
Number of drilled holes	2 successful drilled holes
Maximum HDD length	Up to 1,300 m
HDD drill cuttings volume (total)	1,700 m^3
Distance between HDD (onshore) entry points (approximate)	20 m
Distance between HDD (offshore) exit points (approximate)	50 m
Compound area	100 m x 75 m

4.6.2. Transition Joint Bay

124. At the landfall site each offshore cable will be connected to the onshore cable in an underground transition joint bay (TJB). There will be up to two TJBs and each will be up to 12 m long, 6 m wide and 2.25 m deep.

125. Once constructed, the only infrastructure remaining above-ground will be the link pillar above each TJB. Link pillars are required for TJB inspection and maintenance and will be of a size up to 1 m x 1 m x 0.6 m.

126. The target depth of burial of each TJB will be 1 m (dependent on ground conditions) and minimum depth of cover will be 0.9 m, however if this is not possible, mechanical protection will be used to achieve a depth of cover. Two buried earth link boxes of up to 0.8 m x 0.8 m x 0.6 m will be provided adjacent to each joint bay, therefore accommodating one export cable per TJB. Access will be required throughout the Project's operational phase for maintenance.

127. A 100 m x 50 m temporary works area along with a 40 m x 50 m construction compound will be required at each TJB during installation. The key parameters associated with the TJB are provided below in **Table 4-14**.

Table 4-14. Design parameters for TJBs

Feature	Parameter
Maximum number of TJBs	2
Minimum depth of cover for TJB	0.9 m
Target burial depth	1 m
Maximum depth of TJB trench	2.25 m
TJB footprint (per TJB)	72 m^2
Maximum number of cable per TJB	1
Link box volume	0.38 m^3
TJB temporary works area footprint	5,000 m^2
TJB construction compound footprint	2,000 m^2

4.6.3. Onshore Cables

128. There will be one onshore export cable from each TJB, at either 66 kV or 132 kV. Each onshore cable comprises of three power cables and a fibre optic cable for monitoring purposes. Each cable

will utilise a stacked "trefoil" formation. In certain locations a flat cable formation will be used, such as across bridges and culverts.

129. Each power and fibre optic cable with the export cable will comprise of a copper or aluminium single core cable with a cross-linked polyethylene (XLPE) insulated layer and an outer protective layer with a final layer of steel armouring.

130. The cables will be laid in separate trenches created by Open Cut Trenching (OCT). At certain locations along the OnECC, for example at water and road crossings, where OCT is not feasible the cables will be installed by HDD.

131. The cables will run from the TJB to the onshore substation and from the substation to the point of connection at Pembroke Power Station. This route was developed in conjunction with the preferred landfall location, the outcomes of stakeholder engagement activities, avoidance of known technical and environmental constraints, and in line with the intention to minimise construction disruption and cumulative environmental impacts with Project Erebus (refer to **Chapter 03: Site Selection and Alternatives, Section 3.4.3**)

132. The OnECC length is 7.1 km and up to 900 m wide. The precise cable route within the OnECC will be refined in the run-up to construction to a working width within the OnECC of up to 35 m wide with the exception of passing through hedgerows where this width would reduce to 10m. Micrositing within the cable corridor will take place to make minor adjustments to accommodate constraints and any unexpected on-site conditions identified ahead of installation.

133. The minimum burial depth is 0.9 m, except for agricultural lands where the minimum burial depth is 1.1m, and this may be increased in certain locations for example across some arable fields to allow for ploughing. The maximum trench width will be 1.2 m. It should be noted that this will also vary with depth of cover (the deeper the cables are buried the wider the trench may become), however 1.2m represents the maximum width.

Table 4-15. Design Parameters for Onshore Cable

Feature	Parameter
Maximum number of onshore cables	2
Length	7.1 km
Maximum number of trenches	2
Installation method	Open Cut Trenching and HDD (where required)
Maximum width of each trench	1.2 m
Minimum burial depth	0.9 m (general) to 1.1m (agricultural)
Working width of corridor	35 m
Separation distance between each cable	3 m to 5 m (centre to centre)
Maximum excavated material	15,500 m^3
Cable type	HVAC
Maximum voltage	66 kV or 132kV

4.6.4. Cable Joint Bays

134. Cable Joint Bays (CJBs) will be required every 1000 m along the cable route to connect the onshore cable sections. The joints will occur within the CJBs, which are typically slightly smaller than TJBs but are essentially the same design.

135. The CJBs will be excavated to approximately 12 m long, 6 m wide and 2.25 m below ground level. During the jointing operation the bay will typically be covered by a tent or a container to ensure the correct environmental conditions for the jointing work. The minimum depth of cover will be 0.9 m, except for in agricultural lands where the minimum depth of cover is 1.1 m, to allow for ploughing.

136. A working area of approximately 20 m x 20 m is expected to be required adjacent to the CJBs to provide space for the cable drums at one end, and the pulling equipment and auxiliary supply for the jointing work at the other end. This area will be contained within the OnECC. Following the cable jointing operation, the CJB will be backfilled and the ground restored as required. Following reinstatement, a manhole cover will be the only surface level structure visible of the cable corridor, providing access for maintenance.

Table 4-16. Cable Joint Bay Design Parameters

Feature	Parameter
Maximum number of CJBs	8
Length of each CJB	12 m
Width of each CJB	6 m
Depth of cover of CJB	0.9 m (general) to 1.1 m (agricultural)
Maximum depth of trench for each CJB	Up to 2.25 m
Maximum	1,300 m^3

4.6.5. *Onshore Substation*

137. The onshore substation transfers electricity from the proposed Project to the National Grid Electricity Transmission (NGET) system. The substation will comprise various components, including:

- Static VAR Compensators (SVC).
- Transformers.
- Electrical switchgear (either air insulated, or gas insulated).
- Static Synchronous Compensator (STATCOM).
- Reactive power compensation equipment.
- Harmonic filter switchyards; and
- Control building.

138. The onshore substation will be sited in the Substation Area, which is located within the OnECC, approximately 4 km from the landfall and approximately 1.5 km from the grid connection point at Pembroke Power Station as shown on **Figure 4-17**. Details on the site selection process for the Substation Area and how this was identified can be found in **Chapter 03: Site Selection and Alternatives**. It is likely that much of the substation equipment will be located externally (e.g. air insulated switchgear). All associated design details are provided below in **Table 4-17.**

Table 4-17. A summary of the key parameters associated with the proposed substation

Feature	Design Envelope
Substation maximum height	15 m
Maximum substation compound footprint (excluding SuDs and laydown area)	15,000 m^2
Maximum substation building length	95 m
Maximum substation building width	63 m

Feature	Design Envelope
Maximum switchgear number and voltage	5 x 66 kV
Maximum steel panelised security fencing height	2.4 m
Lighting type on access paths and electrical equipment (max)	10 lux
Sensitive lighting around security fencing (max)	2.2 lux
Additional area required for Sustainable Drainage Systems (SuDS)	1,709 m^2

139. The substation will occupy a maximum area of 126 m x 109 m (excluding SuDS and laydown area). The switchgear and control building will be the most visible elements of each substation. The height of the substation will depend on whether air insulated, or gas insulated switchgear will be utilised. The maximum height of the air insulated switchgear will be 8 m and if gas insulated switchgear is utilised it will be 15 m. The maximum control building height will be 15 m. Within the Substation Area, there will also be an additional area of up to 1,709 m^2 for a Sustainable Drainage System (SuDS). Access will be provided around the site by poured concrete footpaths and tarmac areas connecting the substation to the access road. **Figure 4-17** provides an indicative layout of the substation.

Figure 4-17 The proposed Project Substation compound

4.7. Construction of Offshore Infrastructure

140. This section provides an overview of the proposed construction methodologies and commissioning activities for the offshore infrastructure, including an overview of the proposed sequencing of activities.

4.7.1. Pre-Installation Activities and Surveys

141. A significant amount of work has been undertaken to define an Array Area and OfECC for the proposed Project that avoids a number of constraints and seabed features, and this is described in detail within **Chapter 03: Site Selection and Alternatives**. Work completed as part of the site

investigation phase includes site-specific geophysical and benthic surveys in Winter 2022/2023, a nearshore drop-down video (DDV) survey undertaken in Spring 2024, and a Multi-beam Echosounder (MBES) bathymetry survey in July 2024. Results of the nearshore benthic, offshore benthic and geophysical surveys and nearshore DDV survey are provided in:

- **Appendix 17A: Geophysical Survey Report;**
- **17B: 2024 Multibeam Echo Sounder (MBES) Survey Report;**
- **19A: Nearshore 2023 Benthic Survey Report;**
- **19B: Offshore 2023 Benthic Survey Report;**
- **19D: 2024 DDV Survey Report; and**
- **19E: 2024 Habitat Assessment Report.**

142. However, due to the timescales between the initial assessment and the commencement of offshore construction, further information will need to be acquired prior to finalisation of detailed design for the Project. This will be reported as part of the CBRA.

143. The following surveys and activities will be undertaken prior to the installation of WTGs and offshore export cables:

- **Geophysical and geotechnical surveys** (including multi-beam bathymetry, sub-bottom profile, side scan sonar, cone penetration tests) will be carried out prior to construction across the Array Area and in the OfECC, to gather further information on debris, boulders, presence of seabed features and available sediment depth, etc.;
- A CBRA will be produced post determination, drawing on the additional geophysical and geotechnical data. The CBRA will detail which type of cable protection measure would be utilised at which locations within the OfECC; and
- **Unexploded Ordnance (UXO) survey** will be conducted across the array area and the OfECC. These surveys will use a magnetometer to identify potential obstructions relating to maritime UXO. The likely number of UXO and detection methods will be confirmed from the UXO survey prior to the installation of offshore infrastructure.

144. Route clearance activities may also be required, which may include;

- **Pre-lay grapnel run:** should geophysical data present the requirement for a pre-lay grapnel run, this will be undertaken by a fishing vessel (or similar) to confirm the complete clearance of any abandoned fishing equipment or other debris, prior to installation of the offshore export cable(s).
- **Boulder clearance:** Where boulders are identified within the offshore export cable route, dedicated boulder grab equipment will be used to move larger boulders (more than 30 cm) a minimum 15 m perpendicular to the cable route. The boulders would be relocated within the OfECC, and no boulders will be removed from the seabed during this operation. The exact procedure which will be followed for boulder relocation and clearance is to be agreed with NRW post consent.

4.7.2. Site Preparation - Sandwave Levelling

145. To facilitate the construction of the proposed Project it will be necessary to level out areas of sandwaves identified on the seabed (see **Volume 5: Figure 17-22**). As a worst case scenario, in order to calculate the length, area and volume of sandwave levelling, the proposed Project specific geophysical survey data and bathymetry data was analysed, including sandwave crest widths,

lengths and heights throughout the OfECC. It is assumed levelling will be needed where sandwaves were identified. For areas of the OfECC where there is no project specific geophysical survey data available, General Bathymetric Chart of the Oceans (GEBCO) bathymetry data was analysed, and cross referenced to the proposed Project specific survey data. Where sandwaves were observed on the GEBCO bathymetry data, the same principles were applied for where sand dunes were observed from the survey data. An average height and width of the surveyed sand dunes was taken and applied to the GEBCO observed sand dunes. This approximated volume of the sand dunes was then used to calculate sand dune levelling in areas not surveyed. It has been assumed no sandwave levelling will be required in the section of the OfECC located on the eastern side of Turbot Bank (KP42 to KP38).

146. As a worst case scenario, it has been assumed that when sandwave levelling is required and will be carried out across a 25 m wide section of the offshore export cable route.

147. Geotechnical and geophysical survey data will be collected post consent to define the extent of sandwave levelling, and it is anticipated that the amount of sandwave levelling will be less than the worst case scenario.

148. It is anticipated that a dredging vessel will carry out the required sandwave levelling, utilising high-pressure water pumps to loosen the sediment of the seabed, which will be transferred to the vessel. Sediment will then be redeposited in the marine environment within the OfECC to avoid permanent loss of sediment.

149. It is anticipated that 30 days of levelling across 621,048 m^2 of the seabed will be required. It is anticipated that up to 900,520 m^3 of material will be moved during sandwave levelling works for both the OfECC and the Array Area. Each of these parameters are summarised below in **Table 4-18.**

150. Sandwaves are generally mobile in nature and, therefore, cables will be buried beneath the non-mobile seabed level to avoid the detrimental effect of natural sand wave migration. This will be achieved by removing the mobile layer of sediment before installation takes place using dredging technologies or flow excavators.

151. A dredge and disposal licence from NRW will be applied for separately post determination.

Table 4-18. Proposed design envelope for Sandwave Levelling

Sandwave levelling parameters	Design Envelope
Maximum length of export cable requiring sandwave levelling (per cable)	10,351 m
Average sandwave crest depth	2.9 m
Maximum width of seabed disturbance	25 m
Maximum area of seabed requiring sandwave levelling (per cable, including 20% contingency)	310,524 m^2
Maximum sandwave levelling duration	30 days
Maximum volume of material to be moved	900,520 m^3

4.7.3. Preparation and Assembly of WTGs and Platforms

152. Unlike fixed foundation offshore wind farms, most of the WTG and platform assembly for the proposed Project will not take place on-site. Instead, much of the assembly activity will take place onshore or in a port or harbour. This approach substantially reduces the extent of marine operations associated with the project construction and installation operations.

153. It is proposed that the WTGs will be installed on the floating platform at a nearby port facility and/or nearby sheltered waters prior to being towed to the Array Area. The final stages of the platform assembly, prior to the WTG integration, will also be undertaken at the same local port(s) where possible (i.e., if facilities are determined sufficient to support this work). If not fabricated at the assembly location, the WTG and substructure components will be transported by sea to the assembly port. The location for assembly of WTGs and platforms will be confirmed at a later stage during detailed design.

154. The WTGs and floating platforms to be deployed are demonstration units and will be designed for site specific conditions. Details of the preparation, assembly and load out of the WTGs and floating platforms are going through early evaluation stage and discussions with local ports to determine suitability and potential upgrades are ongoing.

155. **Figure 4-18** provides an overview of the different stages and the anticipated assembly activities are detailed in the following sections.

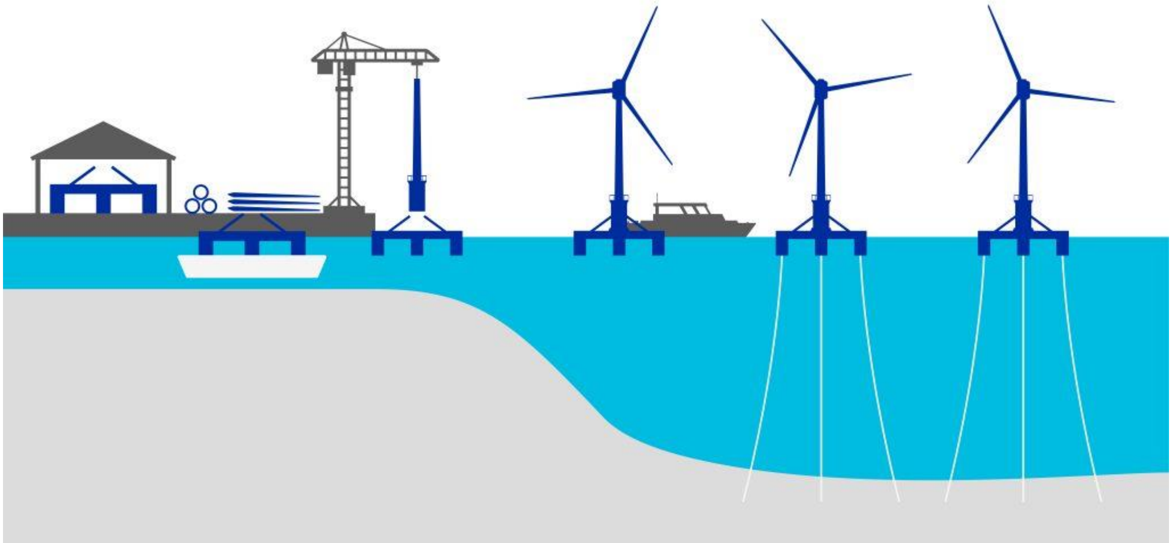

Figure 4-18. Infographic showing (from left to right): WTG and platform preparation, assembly, transport and installation

WTG and Floating Platform Assembly

156. The WTGs will be procured from an established offshore wind turbine manufacturer. The turbine hub, nacelle, blade and tower components will be transported by sea to a central assembly facility with direct access to waterways suitable for onward transportation to the installation site. As far as is practicable the components of the WTG will be delivered to the assembly site as pre-tested modules.

157. The floating platform technologies deployed will be of a modular design, enabling the key components to be manufactured and transported prefabricated to a central assembly site. Completed modules / sub-assemblies will be transported to the assembly location, for assembly,

load-out and WTG integration. Floating platform substructures will be assembled at the quayside either onshore, in a dry dock or on a semi-submersible barge, depending on technology-specific installation requirements.

WTG and Floating Platform Integration

158. The assembly of the WTGs and integration to the floating platform will be carried out in a predetermined sequential manner by a suitably qualified and experienced contractor under the direction of the installation contractor. Once each floating platform is complete, it is launched and then prepared for WTG integration.

159. It is anticipated that the integration process will be as follows:

- A heavy lift crane will be mobilised at the assembly port to be used in the integration process.
- The WTG modular components will be unloaded and stored in preparation for the assembly activities at a suitable port.
- The floating platform will be berthed securely so that the blades will be parallel to the quay.
- Assembly activities of integrating the tower to the floating platform are completed before the turbine nacelle and WTG rotors are installed port side.
- Once completed, the internal WTG components will be installed, integrated, and tested (e.g. generator / hub mechanical, hydraulic and electrical interface, High Voltage cable installation and connection and completion of all electrical and mechanical interfaces in the tower).
- Prior to installation a sequence of testing and pre-commissioning activities of the fully assembled floating platform and turbine will be completed at quayside to de-risk offshore activities and minimise commissioning time; and
- The complete floating platform will then be stored at a temporary anchorage point in a sheltered location while the other platform integration activities are completed.

4.7.4. Installation of WTGs and Floating Platforms

160. Once fully integrated, the complete WTG and floating platform assembly may be kept in wet storage at the quayside or nearby sheltered location, following which it will be towed to site and hooked up to the pre-installed mooring system, and the IACs (sometimes preinstalled) are laid and hooked up to the WTG. The exact sequence and timings of the installation process will be confirmed following detailed design and supply chain engagement.

161. A conventional transport vessel / tugboat and auxiliary tugboat will be used to tow the assembled floating platform, as illustrated in the example below in **Figure 4-19**.

162. Prior to arriving onsite, the mooring system and cabling will be surveyed by a Remote Operated Vehicle (ROV) to confirm no damage has occurred prior to connection.

163. The installation of the WTGs in the Array Area will generally immediately follow the towing operation and will require a conventionally sized anchor handling vessel to link the pre-laid mooring chains with the section of the chain that hangs from the floating platform. The transport vessel maintains the required position in each installation phase, and the auxiliary tugboat is used to control the orientation of the platform.

164. Platform mooring and anchoring installation and commissioning sequence will vary depending on the design adopted. Anchoring installation using drag embedment anchors and driven/impact pile anchors are described below.

Figure 4-19. Example of towing out of an offshore floating wind turbine

Anchoring Installation

Drag embedment anchors

165. The following key steps describe the installation of drag embedment anchors and chains, which are illustrated in **Figure 4-20**:

- The anchors and chains are lifted using an onshore crane onto the deck of the Anchor Handling Tug Vessel (AHTV) and fastened for transport.
- Once at the Array Area, the anchor is connected to the chain line and lowered from the back of the boat. To ensure that the anchor reaches the seabed in the right orientation a supporting second line may be used, which is later disconnected from the anchor. Drag embedment anchors will be dropped, with the falling energy embedding then into the seabed.
- Once the weight of the anchor penetrates the seabed, the vessel moves forward to further embed the anchor into the seabed. Tension is applied to the anchor, typically by using a reaction anchor with a tensioner. The tension in the line is monitored, and before the line is paid out completely an anchor proof test is undertaken using the pulling power of the anchor handling vessel. This allows the anchor to penetrate and reach the correct position; and
- Finally, the end of the line is connected using an auxiliary rope and a buoy to allow for easy connection.

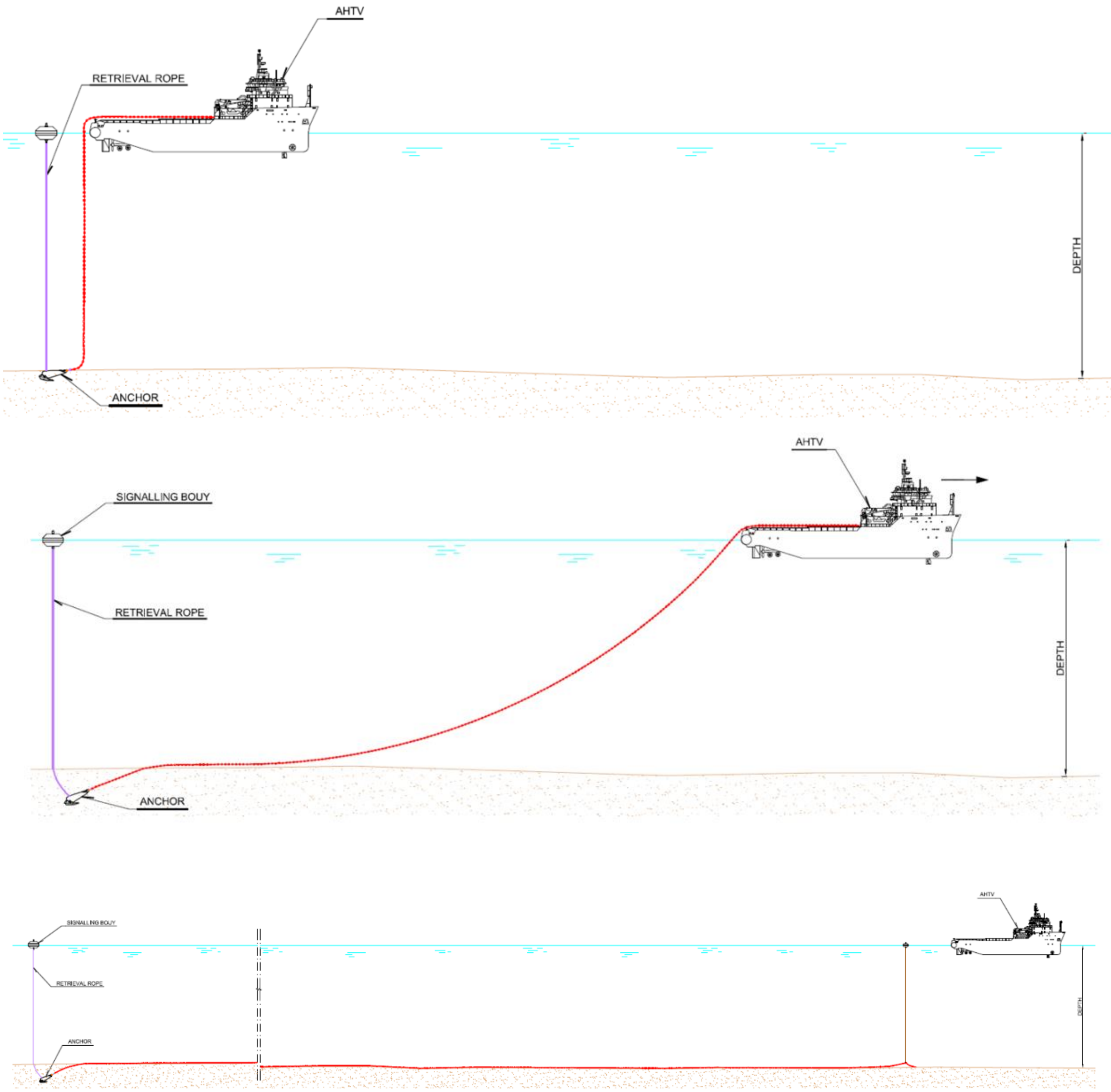

Figure 4-20. Overview of installation process for drag embedment anchors from the positioning of anchor (top) to the installation of anchor and chain (bottom)

Driven/Piled anchors

166. The following key steps describe the installation of driven/impact pile anchors:

- Driven piles are typically steel tube or H Sections, which are driven mechanically by a hammer or vibrated into the ground from a specialised vessel.
- The driving hammer picks up the pile and lowers it into position on the seabed.
- Various types of hammers are available with different impact energy, frequency, noise and vibration profiles and the exact driving methodology and hammer type will be selected to fit the soil condition to which the piles will be installed.

- The hammer selected is used to strike the pile into the seabed to the required design depth.
- Once installed to the required depth, the pile is then connected to the mooring lines.

Mooring Installation

167. The mooring system installation and commissioning sequence will vary depending on the mooring design adopted. Mooring installation for a catenary mooring system and a TLP mooring system are described below.

168. It is intended, to ensure efficient installations and avoid any simultaneous vessel operations, the mooring system will be installed and wet-stored prior to the floating assembly arriving at the site.

Catenary Mooring Systems

169. The following steps describe a general installation process for a catenary mooring system, illustrated below in **Figure 4-21:**

- The anchor handling vessel (AHV) recovers the pre-laid mooring line from the seabed.
- The end of the top chain section of the floating WTG is transferred to the AHV and both ends are connected on the deck of the vessel.
- The connected mooring line is released; and
- The process is repeated for the remaining mooring lines in alternative sequence, in order to ensure appropriate control of the platform.

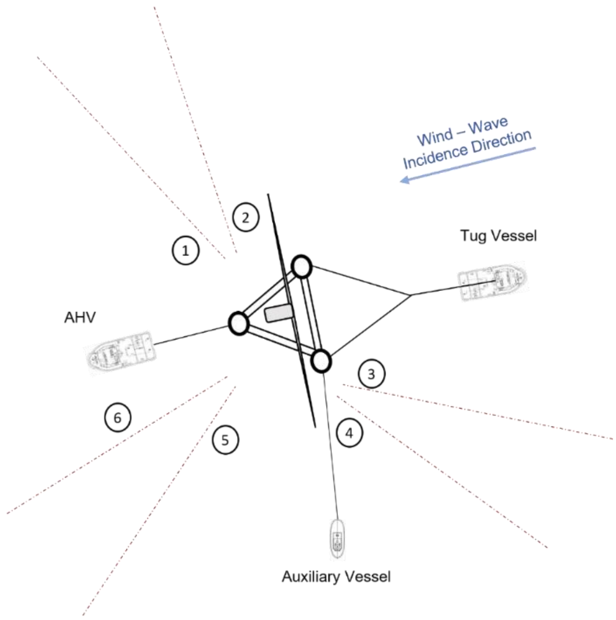

Figure 4-21. Overview of floating WTG mooring installation

TLP Systems

170. For a TLP mooring system the connection process is similar. However, once the TLP is stationed above the hook up point, the TLP will be lowered to the target water depth in a controlled manner using temporary pulling lines. The pulling will be achieved either by dedicated devices on the floater or from installation vessels.

Installation of Offshore Export Cables

171. The final offshore export cable route from the Array Area will be determined following pre-construction surveys, described in **Section 4.7.1.** Pre-installation activities will then take place to

remove any debris or obstacles along the full route of the offshore export cables. It is assumed that it will be possible to avoid any UXO encountered through micrositing of the cables.

172. Following the pre-installation activities, the export cables will be installed along the proposed route corridor using a dedicated cable laying vessel, supported by a ROV. Before the export cable installation activities begin, the ROV will perform a pre-lay survey, to verify if any changes have occurred since the previous surveys that could affect the cable installation.

173. The cable will be installed using either a cable plough or trenching tool, which will employ either mechanical cutting or jet trenching, depending on the seabed material encountered. Jet trenching burial and ploughing techniques are described in more detail below.

174. The cable is laid within the trench and buried to the target depth. Sediment disturbed will be re-deposited in locations that enable it to remain within the same sediment system, for example depositing upstream of cable trenches to encourage natural backfill (where appropriate).

175. At locations to be defined by the CBRA on the approaches to the nearshore area, the export cables may be surface laid and protected using an armoured cable protection system.

176. As the cable installation reaches the nearshore area wire cable pulling grips and messenger wires will be installed to facilitate pulling the cable to shore, as required, through the installed HDD ducts.

177. It is anticipated in the nearshore area from KP 46 to KP 48 (**Volume 5: Figure 4-1**), up to 4 small workboats will be needed to support the Shallow Cable Lay Barge to manoeuvre, tension and stabilise the cable while orientated to the correct position, before being installed using a jetting sled on board the Cable Lay Barge. The offshore export cables will be installed from the HDD exit point once pulled through the HDD duct, travelling from north to south, via simultaneous operations.

178. In relation to KP 42 to KP 46.5, where the offshore export cables are installed within the identified 'gap' in the annex 1 reef, the export cables will be manually encased in the iron articulated pipe on board, before being over boarded from the stern of the shallow Cable Lay Barge.

179. Once the cable end is secured onshore, the cable is then paid out to the seabed from a cable laying vessel. The vessel is set up as close to shore as possible, ideally during highest tide to maximise the working depth. The messenger wire (attached to a winch onshore) is towed out to the cable laying vessel by a rigid-hulled inflatable boat and then connected to the first end of the cable. The cable is over-boarded and pulled into the HDD duct using floats or roller stands as required.

180. Up to 4 small vessels may be used to support the cable in shallower waters (KP 48 – KP 42), to manoeuvre the cable around the identified corners and to help feed the cable in the approach to the shore. The cable will be pulled through the installed duct / along the trench to the onshore area, allowing the cable laying vessel to move off and start laying the remaining cable to the wind farm.

Jet Trenching Methodology

181. The preferred cable burial method is jet trenching burial, where sediment conditions allow, to minimise disturbance. Jet trenching burial is carried out by a remote operated tracked trenching machine which buries the cable to the target depth of 1.2 m using water jetting (the minimum burial depth is 0.8 m). This technique minimises seabed disturbance by narrowing the cable width route to up to 0.4 m, reducing the risk of cable damage and offers an efficient installation process. An example of jet trenching machinery is illustrated in **Figure** 4-22 below.

Figure 4-22. Jet trenching machinery (DEME, 2019)

182. Jet trenching machines use nozzles to inject water at high pressure into the sediment surrounding the cable, which fluidises the seabed in the immediate vicinity and allows the cable to sink under its own weight before the sediment resettles on top. Once the first trenching operation is complete, depressor depth data is evaluated to determine whether the target burial depth has been reached. If necessary, a second trenching operation is completed to ensure the cable is buried to the target burial depth. A hybrid tool capable of both chain cutting and jet trenching may be used in stiffer sediments where jet trenching is not possible. A summary of the maximum parameters related to cable jet trenching methods are presented in **Table 4-19**

Table 4-19. Proposed design envelope for Jet trenching cable burial

Jet Trenching Parameters	Design Envelope
Target cable burial depth	1.2 m
Maximum cable trench width	25 m
Maximum cable burial speed	1 m /min

Cable Ploughing Methodology

183. An alternative cable burial method that may be employed is the use of a subsea cable plough, which is towed along the seabed behind the cable laying vehicle (or by a remotely operated vehicle as a separate activity). Using the subsea cable plough, the offshore export cable is laid in a single pass from the HDD exit point to the first WTG in the sequence. As the cable is laid it passes through the plough, which lifts a wedge of sediment allowing the cable to be inserted below and buried into the seabed. Burial speeds can vary depending on the type of cable and seabed conditions, but typically reach 0.2 km/hr for an armoured cable. Once complete, a post-lay inspection will be carried out to ensure the cable is adequately buried.

Table 4-20. Proposed design envelope for cable plough burial

Cable plough parameters	Design Envelope
Maximum cable plough footprint width	15 m
Maximum cable plough footprint width either side of the centreline	7.5 m
Maximum cable burial speed	0.2 km/hr

184. An example of a typical cable plough is illustrated in **Figure** 4-23. A summary of the maximum parameters related to cable plough methods are presented in **Table 4-20.**

Figure 4-23. Illustration of a typical cable plough (KIS-ORCA, 2024)

External Export Cable Protection Measures

185. In the nearshore OfECC, from KP 38 to KP 48, in instances where the minimum depth of burial of 0.8 m is not achievable, ductile iron articulated pipe will be used to protect the offshore export cables, which will be encased around the cables before they are over boarded via the stern of a cable lay barge. The articulated pipe will be up to 500 mm diameter once installed per cable, and up to 11,000 m length of this form of protection may be required as a worst-case scenario, again per cable.

186. Post-installation cable inspection surveys will be conducted as standard by vessels with ROVs, to confirm the target burial depths (as defined in the CBRA) have been achieved and to identify where remedial cable protection measures will be required. Where the minimum cable burial depth cannot be achieved, cable protection measures will be used to protect the cables. For the offshore export cables, the target will be to achieve burial for 100% of the entire offshore export cable route. However, in a worst-case scenario, up to 2,400 m (4.9%) of the offshore export cables have been assumed to require standard cable protection measures such as rock protection, grout bags or concrete mattresses, and an additional 11,000 m (22.4%) of the offshore export cables nearshore assumed to require iron articulated pipe protection. Cable protection solutions are described in **Section 4.5.4.**

187. It should be noted that this is a worst-case estimate and during detailed design the requirement for cable protection will be reviewed, to reduce cable protection volumes wherever possible. The minimum depth of burial will be determined in the CBRA, which will also detail the exact location and volumes of cable protection required. It is expected that the minimum depth of burial will vary along the route depending on seabed composition and the environment.

188. The maximum width of post installation external cable protection along the cable route will be 5 m, which equates to a worst-case maximum seabed footprint of 12,000 m^2 of additional cable protection required, per cable. However, this would be fully within the area of seabed already disturbed by the cable installation activities. The maximum height above the seabed that the cable protection may protrude is up to 1.5 m, therefore the total volume of external protection anticipated to be required as a worst case is 36,000 m^3 across both offshore export cable routes.

189. **Table 4-21** presents the worst-case parameters for the offshore export cable protection.

Table 4-21. Proposed design envelope for offshore export cable protection measures

Offshore export cable protection parameters	Design Envelope
Cable protection type	Rock placement, concrete mattresses, sand grout bags
Grade of material	2 – 30 cm
Maximum % of offshore export cables requiring cable protection	4.9%
Maximum % of offshore export cables requiring iron articulated pipe protection	22.4%
Maximum width of export cable protection	5 m
Maximum height of export cable protection	1.5 m
Maximum diameter of installed iron articulated pipe cable protection	500 mm
Total length of export cable protection (per cable)	2,400 m
Maximum length of iron articulated pipe cable protection (per cable)	11,000 m
Maximum seabed footprint of export cable protection (per cable)	12,000 m^2
Maximum volume of export cable protection (total for two cables)	36,000 m^3

4.7.5. *Installation of Inter-Array Cables*

190. Installation of the IACs will most likely take place once the floating platforms and WTGs have been installed. Should installation of IACs occur before the floating platforms, the cables will be wet stored on the seabed and marked appropriately following consultation with the MCA and Trinity House.

191. As for export cable installation, pre-lay surveys of the proposed IAC route will be conducted using ROV and, if required any debris or obstacles will be removed. It is assumed that it will be possible to avoid any UXO encountered through micrositing.

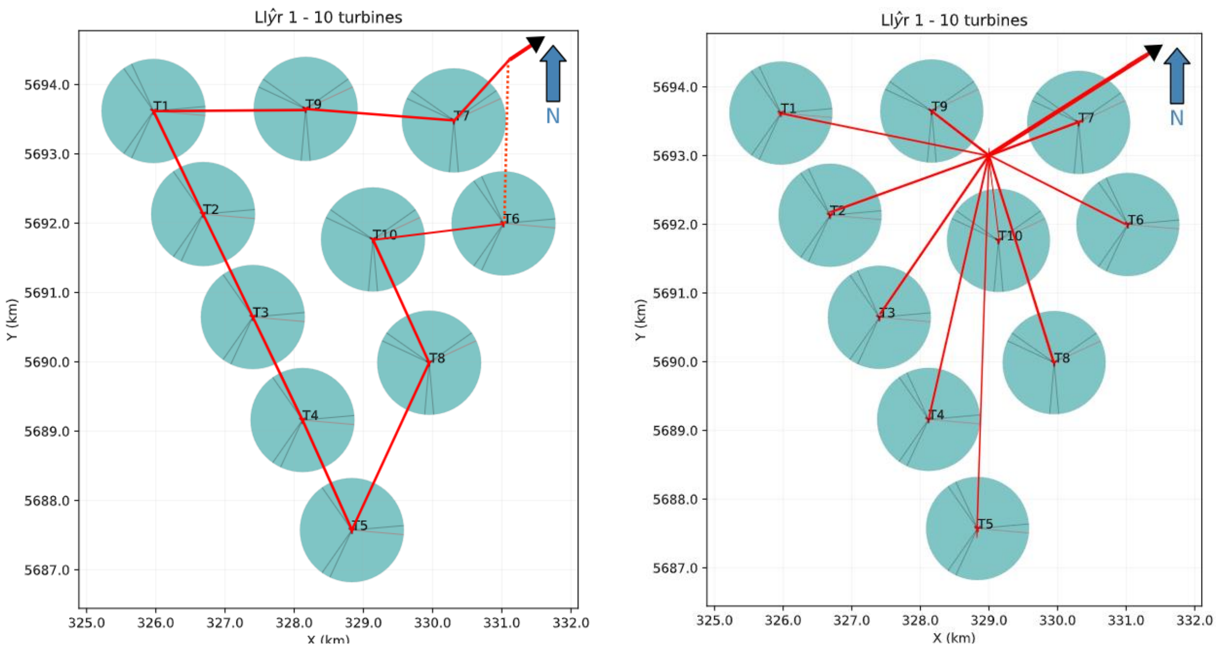

Figure 4-24 String (L) and star (R) formation IACs within an indicative example WTG layout. Representative schematic only, this does not show the defined WTG or IAC layout.

192. The IACs will be installed to form a 'string' or a 'star' formation from each WTG (**Figure 4-24**). If a string formation is used, the last IAC will connect to a central subsea connector as described in **Section 4.5.1**. During IAC installation the cable installation vessel moves to the site of the pre-installed floating platform where the cable is pulled into the floating substructure and secured. The cable is then deployed into the water column and the second end of the cable is then deployed and pulled and secured into another floating substructure or to the seabed touchdown point**.** Wire armour reinforcement surrounds the core of the cables connecting to the floating platform, to protect the cables from the bending and twisting forces caused by the currents. Buoyancy modules and weights are also used to create the Lazy Wave shape, as described in **Section 4.5.2**, which protects the cables from over-stressing.

External IAC Protection Measures

193. The IACs are not planned to be trenched / buried, unless required for physical stabilisation on the seabed, however, to provide a worst-case scenario, an allowance is given to burial of the IACs between each WTG and at the IAC touchdown point. Where it is not possible to achieve the target depth of 1.2 m for IACs, cable protection measures will be used to reduce the risk of damage to the cable. Cable protection measures will be the same as those presented for the offshore export cables.

194. It should be noted that this is a worst-case estimate and during detailed design the requirement for IAC protection will be reviewed, to reduce cable protection volumes wherever possible. As a worst case scenario, it is estimated that 20% of the IACs from the touchdown point will require cable protection, based on review of the geophysical survey data in the Array Area.

195. The maximum length therefore of cable protection over the IACs will be 3,420 m. The maximum width of cable protection for IACs will be 5 m, which equates to a worst case maximum seabed footprint of 17,100 m^2 of additional cable protection required. However, this would be fully within the area of seabed already disturbed by the cable installation activities. The maximum height above the seabed that the cable protection may protrude is approximately 1.5 m.

196. **Table 4-22** presents the worst-case parameters for IAC protection.

Table 4-22. Proposed design envelope for IAC protection measures

IAC protection parameters	Design Envelope
Cable protection type	Rock placement, concrete mattresses, sand grout bags
Maximum % of IAC requiring cable protection	20%
Maximum length of IACs requiring cable protection (total)	3,420 m
Maximum width of IAC protection	5 m
Maximum height of IAC protection	1.5 m
Maximum seabed footprint of IAC protection	17,100 m^2

Construction Vessels

197. Offshore construction activities will require a variety of different vessel options, contingent on the chosen anchor, mooring, and floating platform options selected, as well as the identified assembly port, and construction approach. Anticipated vessel types include:

- Construction Support Vessel: Required for most anchor and mooring installations;
- Anchor Handling Vessel (AHV): Necessary for most anchor and mooring installations;
- Seabed Clearance Vessel prior to installation activities;

- DP Cable Lay Vessel for IAC and offshore export cable installation; a dive support vessel may be needed for cable pull-in;
- Cable Lay Barge with shallow operating range and crane for nearshore cable installation works;
- Support vessels for operating the Cable Lay Barge;
- Rock Placement Vessel;
- Remote Operated Vehicles (ROV);
- Crew Transfer Vessels (CTV);
- Guard Vessels; and
- Survey Vessels.

198. Multiple construction vessel scenarios are under consideration for the proposed Project and therefore, different vessels may operate concurrently during installation.

199. Some vessels may originate from outside UK waters and in this instance standard measures for Invasive Non-Native Species (INNS) risk mitigation will be applied (**Appendix 4B: Outline INNS Plan**), and all vessels will comply with the International Maritime Organisation (IMO) Ballast Water Management Convention.

200. It is expected that 500 m safety zones will be in place around vessels which are restricted in their ability to manoeuvre and partially installed infrastructure. A safety zone application will be submitted to the Department for Energy Security and Net Zero (DESNZ) as the regulatory authority, which will be consulted on by the MCA, Trinity House and other shipping and navigation stakeholders, along with NRW as required. The safety zone application will be submitted prior to commencement of construction, post-consent.

201. Conservative vessel activity assumptions for offshore construction are provided in **Table 4-23.**

Table 4-23. Estimated vessel requirements during offshore construction

Construction Vessel requirement	Design Envelope
Maximum number of vessels used throughout construction	43
Maximum number of vessels on site simultaneously	17

4.7.6. Embedded Design Control and Mitigation Measures

202. The design of the proposed Project will include embedded design control and mitigation measures that are designed to mitigate potential impacts wherever possible. In addition, a number of management plans will form conditions to any consent granted and these manage offshore construction, operation and maintenance and decommissioning activities in line with guidance and best practice to further mitigate any potential impacts.

203. Additional mitigation for the proposed Project describes those measures which may be required in addition to embedded design control and mitigation and these measures are identified within the impact assessment undertaken and are detailed within each technical chapter (Chapters 7 to 28 of this ES).

204. A summary of the embedded mitigation measures for the proposed Project are presented in within **Volume 6, Appendix 32A Mitigation Measures.** A summary of environmental management plans associated with the proposed Project are presented in **Volume 6, Appendix 4C Post Consent Environmental Management Plans.**

4.7.7. Outline Offshore Construction Programme

205. A detailed construction programme for the proposed Project will be developed as design and procurement activities progress and full details of the construction programme, sequencing and installation methodologies will be confirmed prior to the commencement of construction and as a condition of consent. Offshore construction activities are planned to commence in Q1 2027. The installation of offshore components is likely to be completed over two years, with full commissioning of the wind farm in Q4 2028.

206. The current indicative construction programme is summarised in **Table 4-24** and outlines the key construction activities and when these activities are anticipated to take place.

207. The nature of offshore work requires operations to be planned on a 24-hour, seven days a week basis, however, work will not be continuous over the whole construction period and the durations presented are indicative and are subject to change. The durations provided include the time taken for transit from ports to the site, operational allowances, and accounting for weather-related downtime.

208. Details of maximum anticipated vessel requirements during the different installation activities are also provided. The quantity, type, and frequency of vessel movements during the construction phase have been established to serve as a basis for assessing the impact on various factors such as marine ornithology, commercial fisheries, and shipping and navigation.

Table 4-24 Anticipated Duration of Offshore construction activities

Installation	Anticipated maximum duration (days)	Anticipated maximum No. of vessels
Array Area		
Pre- Installation survey (inc. UXO clearance)	12	2 (+2 for the UXO survey)
Installation of site boundary navigation aids & navigation markers	6	1
Installation of mooring lines and anchors	100	4
Hook-up of floating platforms into mooring lines	60	8
IAC and cable protection installation	95	4
OfECC		
Pre-Construction Survey (inc. UXO clearance)	10	2 (+2 for the UXO survey)
Boulder Clearance	60	1
Pre-Lay Grapnel Run	50	1
Sandwave levelling	30	2
Cable installation	100	3
Installation of cable protection / crossing	40	2
Nearshore cable installation	42	5

4.8. Construction of Onshore Infrastructure

209. The following sections provide details of the key onshore Project components, including indicative values and parameters that provide the basis for the assessments presented in this ES. Details on the installation process for these various elements are covered separately below.

4.8.1. Pre-Construction Surveys and Early Construction Works

210. Detailed pre-commencement surveys (such as geophysical, geotechnical, ecological, and archaeological surveys) will be conducted before works commence at the landfall, the cable corridor and substation work areas. The results of these surveys will then inform and support the selection of the final locations. As described in **Section .6.3,** micrositing within the cable corridor will take place to make minor adjustments to accommodate constraints and any unexpected on-site conditions identified ahead of installation.

211. In addition, the following activities will be undertaken prior to the commencement of construction:

- **Soil strip:** prior to cable installation, topsoil will be removed, set aside and handled in accordance with Soil Handling and Storage Plan (see Volume 6, Appendix 4C, Environmental Management Plans).
- **Vegetation clearance:** clearance of hedgerows and other vegetation to facilitate the construction of the substation, associated access roads and, in some cases along the onshore cable route. This will be undertaken only where completely necessary and will be kept to a minimum.

212. Construction will commence with the installation of temporary access roads, laydown areas and Temporary Construction Compounds (TCCs), where required, for each construction works location (e.g. the landfall, along the cable route and at the substation location).

213. Any necessary preparatory work will be undertaken to existing infrastructure, utilities and services (where required) to enable access and construction activities. Laydown areas will be established to allow the onshore infrastructure for the landfall, the cable corridor and substation to commence construction.

214. Preparation of laydown areas will typically involve the removal and appropriate storage of topsoil (for later reinstatement) and, where required, the creation of TCCs and temporary access roads typically using crushed stone potentially overlain on a reinforcing geotextile membrane. This is further detailed in the sections below.

215. If no direct access is available to the laydown areas from the local highway network, a temporary haul road for the cable corridor route and construction access arrangements for laydown areas may be required. If needed, temporary access tracks and haul roads will be constructed and will typically be up to 15 m wide, including verges and drainage channels, the width will depend upon topography and access requirements. The method of construction will also depend on ground conditions and topography.

216. Any topsoil and subsoil excavated during site preparation will be stored separately alongside the laydown area in accordance with best practice so that it can be reinstated as appropriate once construction activities are complete. Excess material will be disposed of accordingly at a registered landfill. Standard practice will be for areas of temporary land take to be reinstated to their original condition in agreement with and to the satisfaction of the landowner.

217. The removal (or height reduction) of trees, hedgerows and ground vegetation will be kept to a minimum but where necessary will be completed in accordance with best practice methods and

with the necessary licences are in place. Hedgerows will be replaced wherever possible although trees cannot be planted within 3 m of any sections of underground cable that have been installed.

4.8.2. Cable Installation at Landfall

218. The cable ducts at the landfall will be installed by HDD from the onshore site at the landfall with an exit point below the extreme low water mark. The total length of the HDD works will be up to 1,300 m. A summary of parameters relating the cable ducts and HDD activity at the landfall is included below in **Table 4-25**. The precise location within the offshore and onshore export cable corridors will be finalised following completion of the pre installation surveys and preparation activities and definition of the location of the onshore jointing pit to ensure there is a straight run from onshore to offshore for a simple pull-in.

219. The cable installation will be undertaken in four stages:

- **Stage 1** – This involves drilling a small diameter pilot hole, that is stabilised by filling the hole with drilling mud/fluid (typically bentonite clay and water). The drill mud/fluid used will be benign and will pose little or no risk to the environment (PLONOR). Drill pipes (approximately 9 m in length) are added in succession to the end of the drill string on the drilling rig to maintain an open bore and extend the drilling operation. Thus, the pilot hole continues to be drilled from the compound until the drill bit reaches the offshore exit point.
- **Stage 2** – Forward Reaming operations - this involves increasing the size of the pilot hole to the diameter required for cable installation (this will be approximately 1.3 times the outer diameter of the conduit size). This is achieved by retracting the pilot hole assembly and replacing the drill bit with a hole opener (since the soil is expected to be medium rock) at the onshore entry point and then pushed towards the offshore exit point at the seabed.
- **Stage 3** – Installation of the High-density polyethylene (HDPE) Conduit – Following the retraction of the drill string hole opener, it is replaced with a drill rig with the Pipe Pusher. This machine is fitted with 4 radially positioned tracks through which the HDPE conduit is pushed into the drilled hole. For this push operation, it may be required to have a marine spread to assist. In addition, the HDPE conduits need to be stringed out, welded and tested prior to push in operations. The required construction area will (ideally) be behind the drill rig in a straight line.
- **Stage 4** – Finally, a messenger wire is inserted within the duct to enable future cable pull in operations. The ducts are then capped (to avoid the build-up of debris) until it is time to install the cable.

220. Up to two ducts will be required to accommodate up to two offshore export cables. In the event that a bore fails, it would be abandoned and backfilled and the ground re-instated.

221. The total drill cuttings volume for the HDD works will be up to 1700 m^3 based on the volume of drill cuttings per cable (850 m^3), 900 mm diameter of the reamed borehole plus a 25% bulking factor.

222. The HDD will require a temporary landward HDD construction compound of approximately 7,500 m^2 during construction to accommodate the drilling equipment and ancillary plant. The HDD compound will be set back approximately 400 m from MHWS which will provide sufficient space for the arced drill profile to pass beneath the intertidal area and exit onto the seabed below MLWS.

223. There will be up to 100 m^2 of protection, such as rock placement and/or concrete mattresses, at HDD exit point (total for two bores). Any cable protection installed at the HDD exit will not exceed pre-construction seabed level.

Table 4-25. A summary of the key parameters for the HDD duct installation

Feature	Parameter
Total number of HDD ducts	Up to two
Maximum diameter of each HDD duct	900 mm
HDD compound area	7,500 m^2
Total drill cuttings volume	1,700 m^3
Total length of each HDD	1,500 m
Excavation pit surface footprint (for 2 boreholes)	100 m^2
Excavation pit depth	3 m
HDD exit point depth	5 to 8 m LAT
Excavation pit cable protection footprint (2 boreholes)	100 m^2

224. There may be a need for 24 hour, seven days per week working during the HDD works to allow for successful drilling to be completed.

225. The installation sequence for the cables will be defined by the installation contractor, however it is anticipated that the sequence of installation will be as follows.

226. The end of the cable duct will be dug out using an excavator on a jack-up barge. The material excavated will be placed to the side (and re-placed following completion of the cable installation). A submarine cable will then be floated to the HDD exit duct point.

227. At the initial installation, the vessel will set-up as close to shore as feasible, ideally during highest tide to maximise the working depth. The messenger wire (attached to a winch onshore) will be towed out to the cable lay vessel by a RIB (rigid-hulled inflatable boat) and then connected to the first end of the cable. The cable will be over-boarded over the vessel chute and pulled into the HDD duct using floats or roller stands as required.

228. The cable will have a wire sock cable grip to facilitate the pull-in operations to shore. The cable grip (see example in **Figure 4-25**) will be connected to messenger wires for pull-in operations. After the securing of the cable end onshore, the cable is then paid out to the seabed, away from the shore from the cable lay vessel.

Figure 4-25. Cable Grip arrangement for the Cable Pull

229. A secondary vessel may also assist in supporting the cable in the shallower water depths and feeding the cable into the shore approach section. The cable will be pulled through the installed duct and secured in the TJB allowing the lay vessel to move off and commence lay of the remainder of the cable to the Array Area.

4.8.3. Landfall and Transition Joint Bay

230. The landfall site for the proposed Project is Freshwater West as discussed in **Chapter 03: Site Selection and Alternatives**.

231. Two TJBs are required to join the offshore cables to the onshore cables and provide a stable, clean, and safe working environment for cable joining. Typically, TJBs are located immediately behind

the beach area such that the offshore export cables are not installed on land over any significant distance. In the case of the proposed Project, the TJBs will be constructed up to 630 m landward from MLWS at Freshwater West.

232. The works at the Landfall and TJB will include the following:

- Construction of the HDD temporary construction compound for both the HHD drilling and TJB construction.
- HDD works.
- Construction of TJB and the adjacent earth link box.
- Installation of offshore export cables (cable pulling).
- Installation of and jointing to onshore export cables; and
- Backfilling and re-instatement works.

233. TJBs are typically constructed of reinforced concrete and will be buried to a minimum depth of 0.9 m. Planned inspection and maintenance activities will be via link box manholes, typically located adjacent to the TJBs. The TJBs will be backfilled with a suitable material and selected subsoils.

234. Once the joint is completed the TJBs will be covered and the land above reinstated, it is not expected that any access will be required in the operational phase. However, unplanned works such as unforeseen repair may be required.

235. Landfall construction activity is anticipated to take approximately 24 to 64 weeks including HDD drilling and cable pulling.

4.8.4. Installation of Onshore Cables

236. Given that the onshore cable corridor described in **Section 4.4.1** will intersect numerous obstacles and crossings several pre- installation and construction activities are necessary. Further detail about such crossings where pre- installation and construction activities are required are listed below.

237. Preliminary site works will be required before construction within each cable route section can commence. These may include:

- Fencing.
- Upgrade of existing or installation of new access from the public highway where required.
- Utility diversions and installation of temporary site drainage where required.
- Archaeological and ecological survey and mitigation works as necessary.
- Vegetation clearance; and
- Establishment of temporary construction compounds, offices, welfare facilities, security, wheel wash, lighting, and signage.

238. Construction activities for each section of the cable corridor may include:

- Topsoil removal (to edge of laydown area).
- Temporary haul road installation along all sections of the route.
- Trenchless duct installation (e.g. HDD) beneath obstacles (such as roads, railways, rivers and drains).
- Installation of header or interceptor drains at cable corridor boundaries.
- Trench excavation (up to two; one for each cable).
- Duct and tile installation.
- Trench backfilling.
- Existing field drainage repairs (where disruption occurs).

- Cable joint bay (CJB) installation (including French drains to prevent water pooling above joint bay).
- Cable installation (pulled through ducts from each joint bay).
- Cable jointing; and
- Cable testing and commissioning.

239. Once commissioning is complete, demobilisation and reinstatement will take place. Key activities in this phase will include:

- Removal of haul road.
- CJB ground re-instatement.
- Replacement of topsoil.
- Landscaping and hedge re-planting, where appropriate; and
- Demobilisation and fence removal.

240. The primary cable installation method will be open-cut trenching unless crossings are required. These are further described below.

241. During the installation of the cables, construction materials and plant may be temporarily stored outside of temporary construction compounds and within the cable corridor as they will need to be laid out prior to installation.

Open Cut Trenching

242. The onshore cable trenches will be excavated, typically utilising tracked excavators. The excavated subsoil will be stored separately from the topsoil, with the profile of the soil maintained during the storage process. Soil may be stored immediately adjacent to the trench or stored elsewhere within the development boundary at temporary construction and laydown areas.

243. Topsoil will be reused for reinstatement following the completion of construction. Any remaining excess soil will be used on site wherever possible (e.g. for landscaping works), otherwise it will be disposed offsite at a registered landfall.

244. A pre-construction drainage plan will be developed and implemented to minimise water within the trench and ensure ongoing drainage of surrounding land. Where water enters the trenches during installation, this will be pumped via the appropriate means to remove sediment, before being discharged into local ditches or drains, via temporary interceptor drains.

245. The trench will typically be made by digging up ground along the route with a large excavator. A 5 m wide corridor will be required for heavy vehicle access (earth digging equipment and lifting equipment for the cable drums) along the side of the trench, and a further 5 m will be required for lay down of equipment, topsoil, and spoil from the trenching. Another 1.5 m (depending on method of trench shoring) is required from the edge of the trench on each side for safety and to prevent trench collapse under load, and a final 3 m to 5 m should be provided on the far side of the trench for access, storage or working as required. The overall working corridor width will be

35 m. Figure 4-26 provides an indicative cross section of the trench corridor.

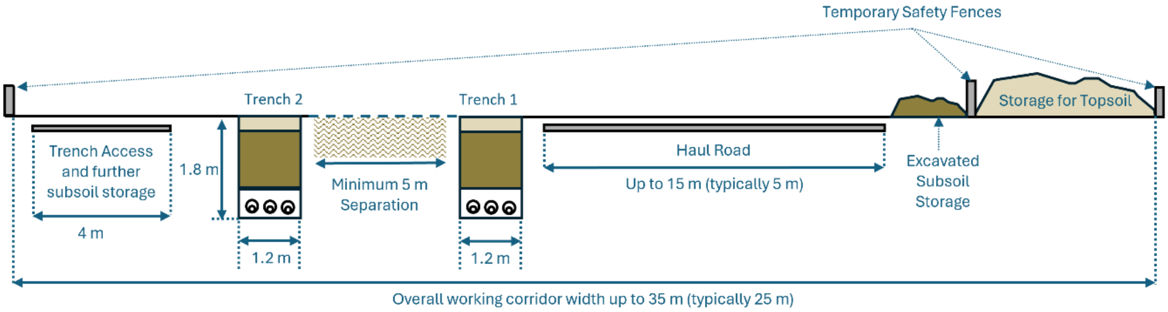

Figure 4-26. Cable Grip arrangement for the Cable Pull

246. Ducts would then be laid on top of fine aggregate/sand. Underground hazard warning tape or protective cover tiles may be placed at a level during the backfill process. The cables would then be drawn through the buried ducts at CJBs.

247. Following duct installation, the trench will be backfilled with sand and/or stabilised material to approximately 75 mm above the top of the power cable ducts. The native material removed during construction (providing it is thermally suitable) will be replaced on top of the protective cover (marked with tiles/hazard warning tape) and any large and sharp stones removed. Finally, the trench will be covered with a minimum of 300 millimetres topsoil, using the native topsoil, up to the surface level, and the temporary access land is restored as close as possible to its original conditions. This is presented in **Table 4-26.**

Table 4-26: Open Cut Trenching Parameters

Feature	Design Envelope
Maximum number of trenches	2
Minimum trench depth	1.8 m
Heavy vehicle access along the side of the trench	5 m
Trench edge required for safety and to prevent trench collapse	1.5 m
Far side trench access, storage or working requirements	5 m
Trench backfill	75 mm
Trench topsoil	300 mm

Cable Pull-Through

248. Following installation of the ducts along the cable route, the cabling itself will be installed. The cable pulling operations are performed from the CJBs, with the cable drums situated at the next CJB along the route (a distance of approximately 1000 m).

249. At one end of the ducted section, the cables are delivered on cable drums on the back of a low loader. Once on site, the cable drums are off loaded into position by crane and then placed onto frames and their protection removed. At the opposite end of the cable ducts, i.e. at the next CJB, a heavy-duty winch is brought to site and located within the CJB. The pulling wire is then attached to the end of the cable and winched through.

250. The cables are then joined together. Once the pulling and jointing is complete, the CJB is filled with the appropriate backfill materials, covered and reinstated to its former condition. Following completion of cable installation, all work areas will be reinstated to pre-construction conditions.

Crossings

251. The OnECC crosses obstacles of various nature for which special installation techniques must be considered. The types of obstacles identified along the OnECC site boundary include:

- Major roads.
- Minor roads.
- Watercourses.
- Trees and hedgerows.
- Existing major utilities; and
- Environmentally sensitive areas.

252. Several potential crossing points with the onshore cable have been identified:

- Three watercourses. The most significant watercourse crossed is northeast of Neath Farm, at Neath Bridge. The other two watercourses are assessed as being minor in nature.
- Seven roads and public rights of way. These include:
    - B4320, Wallaston Green to Junction B4319 near Broomhill Cottage.
    - U6305, junction B4320 to Rhoscrowther Village (a minor public road heading north from the B4320 towards Neath Bridge).
    - U6306, junction U6307 to Hoplass Farm.
    - U6307, Wallaston Cross to Valero (access road leading to the Valero Oil Refinery).
    - C3101, Pwllcrochan to Wallaston Cross (access road leading to Pembroke Power Station).
    - Public footpath SP34/6 (access road leading to Greenlink Converter Station and Lambeeth Farm); and
    - Public footpath SP34/5 (Pembrokeshire Coast Path).
- Eight underground utilities. These include:
    - Water main and telecommunications buried in the B4320.
    - Greenlink Interconnector (only for south landfall site; location varies depending on whether cable is routed along a second HDD beneath Kilpaison Burrows or around Kilpaison Burrows).
    - Water main and telecommunications buried in the access track providing access to the BP Tank Farm through Kilpaison Burrows.
    - Telecommunications buried in the U6305 (junction B4320 to Rhoscrowther Village).
    - Telecommunications buried in the U6307 (Wallaston Cross to Valero).
    - Valero high pressure oil pipeline.
    - Water main and telecommunications buried in C3101, Pwllcrochan to Wallaston Cross
    - Greenlink Interconnector and Project Erebus (once 132 kV outgoing from the Llŷr substation).

253. These points along the OnECC are identified on **Volume 5: Figure 4-5**. In order to cross the above obstacles, the following methods will be used.

Open Cut Trenching in roads

254. Cables across minor roads will be installed using an open cut trenching method; where the road surface is removed and the earth underneath is excavated in the form of a trench, removed, and temporarily stored. The cables are then buried and the road reinstated to pre-existing conditions.

255. The laydown area will typically be the same as for a green field installation, especially if the road is to be completely closed off during works. It may be possible to keep one lane of the road open

by installing and trenching through one lane of the road at a time while keeping the other lane open. This could require 24 hours working to minimise the disturbance.

256. Prior to installation within a road, a traffic light system is brought to site for a two-lane road, to control traffic flows so that only a single lane is closed (for the trench) when and where possible. For single-lane roads, the road must be fully closed when work is being undertaken.

257. After installation, the verge and areas used for joint bays and trench construction will be fully reinstated using native topsoil removed during excavation works and left as near to its pre-construction condition as feasibly possible. The laydown area is demobilised of plant, with safety barriers, signage, and traffic lights removed/moved on.

258. Activities that will require road closure will be agreed in advance with the local authority and mitigation will be detailed in a Construction Traffic Management Plan (CTMP).

Trenching through small watercourses

259. Occasional minor watercourse crossings may need to be carried out using dry open cut trench methodology. The water flow will be maintained by damming and, if necessary, over pumping or using temporary “flume” pipes installed in the bed of the watercourse. Details of these methods are outlined below.

260. For both methods, the site will first be prepared by stripping the topsoil from the banks and areas adjacent to the watercourse crossing and storing it separately within the laydown area. When using the temporary “flume” pipes in the bed of the watercourse method a suitably sized flume pipe (usually selected by the contractor in agreement with NRW) is then installed over the point of the proposed crossing. It must be ensured that it extends on each side of the watercourse to a distance at least equivalent to the depth of the proposed excavation. The flume pipe is then bedded and packed or surrounded with soil filled sandbags to create a seal or dam across the watercourse. A flume pipe bridge will have been installed, during the preparation of the working width, adjacent to the trench-line flume to enable passage of plant and materials along the cable route.

261. Excavation of the riverbed then proceeds beneath the trench-line flume pipe. The excavated riverbed material will be stored within the laydown area separately from the bank material. De-watering and/or trench supports may be used to facilitate safe excavation.

262. If damming and over pumping methodology is adopted, then soil filled sandbags are used to create a seal or dam across the watercourse. However, flume pumps are not installed in the riverbed but adjacent to the river instead. The discharge hose will be directed through a filtering medium to limit silt carry over before the pumped water is allowed to percolate back into the watercourse.

263. Within both methodologies the cable is then installed in the trench and checked to ensure that a minimum cover of 2 m (rivers) and 1.7 m (ditches) exists below the clean hard bed of the watercourse and the top of the cable. The cable may be protected by thick concrete protection slabs if appropriate.

264. Initial backfilling will take place using excavated subsoil free of large stones or other deleterious material. Final reinstatement will use the stored riverbed materials. The riverbanks are then reformed to their original profile to the satisfaction of both NRW and the landowner. Hard landscaping will be avoided where possible.

265. The flume pipe and packing or bags are removed once the bed materials and bank profile is reinstated. Final bank reinstatement may require further measures to stabilise the banks and prevent erosion. Geotextiles such as ‘GeoJute’ may be used in conjunction with seeding of an appropriate grass mix. Heavier solutions such as the importation of locally sourced large stones or rocks will only be used with Lead Local Flood Authority (LLFA) approval.

266. Ecological and hydrogeology pre-construction surveys will be undertaken along the route to identify any sensitivities that should be avoided. All works will seek to minimise disruption to the free passage of fish and aquatic animals with appropriate actions taken dependant on sensitive species which are present. These mitigations may include screen intake, relocation of stranded wildlife, use of electro-fishing by qualified specialists as required and transplanting or watering sensitive aquatic vegetation.

Trenchless Installation (HDD)

267. Significant obstacles, such as watercourses, existing utilities or roads, may be crossed by way of HDD to avoid disturbance. With HDD, a hole is bored, and a duct installed under the crossing to emerge at a target point on the opposite side.

268. Location of the drill bit is monitored using the HDD locating system. An electronic transmitter in the drill head sends information to the locator operator's receiver.

269. Typically, each bore will accommodate a single cable, including the three power cables laid in trefoil and the fibre optic bundle. Therefore, separate drills will be required for each cable crossing. Alternatively, subject to final contractor specification, each power core of the cable may require a separate bore and duct, laid in flat formation.

270. The length of the pipeline will determine the size and weight of the drill rig required, and therefore the size of the HDD compound required. The maximum temporary HDD compound size will be 50 m x 50 m.

4.8.5. Onshore export cable and joint bay work programme

271. Greenfield cable installation work is expected to take place from 7 am to 7 pm, Monday to Saturday. Certain tasks may require round-the-clock work, specifically for crossings with extended disturbance lengths (e.g., road crossings) and HDD crossings. This may also apply to areas governed by commercial agreements that specify specific working times or time windows. Where 24-hour operations are necessary, prior consent will be obtained from the local authority through Section 61 consent, pursuant to the control of Pollution Act 1974.

272. The cable installation will likely proceed sequentially along the cable route, starting from either the landfall or the onshore substation. If time constraints demand, concurrent installation may be carried out. As a conservative estimate, the cable installation rate for a single cable in a single trench through greenfield is around 50 m to 60 m per day (See **Table 4-27**). This includes activities like constructing the haul road, excavating the trench, installing the cable, and reinstating the ground. This estimation does not account for CJBs and is applicable to agricultural fields meeting the typical working corridor requirements. Considering the approximately 7.1 km length of the onshore cable route, the installation is estimated to take up to 72 weeks, disregarding any sensitivity constraints.

273. Each CJB requires approximately 10 days for completion, starting from the delivery of the jointing tent until its removal and reinstatement. This timeframe encompasses joint creation, cable jointing, and ground reinstatement.

Table 4-27: Onshore export cable and joint bay work programme dates

Feature	Programme
Greenfield cable trench installation	50 – 60 m per day
Road open trench installation	5-10 days

Feature	Programme
Road or river HDD	5-10 days
CJB installation and cable pull through	10 days per CJB

4.8.6. Onshore Substation

274. The construction of the onshore substation will require a number of construction facilities including:

- Cable drum laydown area.
- Site and administration offices.
- SuDS.
- Secure material storage; and
- Areas for storage of plant and other construction machinery.

275. Transportation of equipment will use local roads including the B4319 and B4320 to access the substation access road. A transport assessment has been undertaken of the outlying area to ensure the feasibility of Heavy Goods Vehicles (HGVs) to access the substation works area. Any components which can be classed as abnormally large loads will be delivered using flatbed trucks following extensive planning to prevent transport disruption.

276. Generally, work is expected to occur between 7am and 7pm, Monday to Saturday. However, certain operations such as oil filling and power transformer testing may require 24-hour working.

277. Under a conservative scenario, the construction of the onshore substation is estimated to take 1.5 years of continuous work. A further three to six months may be required at a later stage, following construction, for the final assembly and commissioning of the substation.

4.8.7. Temporary Construction Compound

278. Temporary construction compounds will be required along the cable corridor for the duration of the cable installation works. The compounds will provide secure storage locations for heavy duty plant, local site management offices, welfare, and local first aid points, and will also provide space for storage of cables, optical fibres, ducts, and other supplies required to complete the installation works.

279. Up to five temporary construction compounds will be formed in total (consisting of one main compound (100 m x 50 m) near to the substation, and four smaller (50 m x 50 m) satellite compounds).

280. The compound base area will be constructed by removing the topsoil and setting aside for reuse, laying a geotextile membrane or similar separation membrane directly on top of the subsoil, over which layers of granular stone will be spread. Alternatively protective matting, a temporary metal road surface (i.e., trackway) or a tarmac surface could be used. Once the compound has been constructed, foundations for the site cabins will be installed.

281. Storage areas for excess soil generated in construction activities will be used depending on the construction scenario. In areas where damming and over pumping is required generated soil will be used in the damming process utilising sandbags. Elsewhere any excess soil will either be disposed of in registered landfall sites or used in landscaping around the substation site.

282. The compounds will have sufficient space to ensure no vehicles are parked on the public highway.

283. Access to the construction compounds will be undertaken via temporary gravel roads which will be constructed for the proposed Project with associated hardstanding areas. Hardstanding areas will be large enough to facilitate use of the plant outlined in **Section 4.8.8** below. Specific routes

for construction vehicles will be confirmed prior to construction and in consultation with the local authority.

284. The exact locations of the temporary construction compounds will be determined post-consent, once the onshore export cable route has been refined and set.

4.8.8. Construction Plant

285. A variety of construction machinery and plant will be required to facilitate the onshore works, including:

- Excavators.
- Generators.
- HDD rigs.
- Drill fluid recycling systems.
- Mud pumps.
- Power packs.
- Bulldozers.
- Dump trucks.
- Tracked excavators.
- Wheeled loaders.
- Mobile cranes; and
- Truck mounted concrete pumps and boom arms.

4.8.9. Construction Lighting

286. It is anticipated that lighting will be required within the compounds. Where possible, the lighting will be timed to be used only when required (except for instances of safety and security where it will likely be required 24 hours). For the substation construction site, equipment and compounds will require lighting to the brightness of 10 lux. Fencing will require 2.2 lux and brightness of 110 lux will be used for entry points.

4.8.10. Construction Waste Management

287. Waste generated due to onshore construction activity will be managed in accordance with the Department for Food and Rural Affairs' (DEFRA) Waste Management Hierarchy.

288. To implement DEFRA's recommendations, an estimate of the materials used, and waste generated in construction of the onshore infrastructures of the project is provided below:

- **Soil Waste:** All soil waste generated in the onshore cable construction process will be managed and stored responsibly. This will predominantly be achieved via backfilling of trenches or using in damming or landscape activities elsewhere in the construction process, such as at the substation site or water courses. It is estimated that 52,100 m^2 of soil waste will be produced in onshore cable construction activities. This includes an estimated 25,000 m^2 of topsoil and 27,100 m^2 of sub surface generated soil waste.
- **HDD Drilling Fluid:** Drilling fluid used to lubricate the drill bit during HDD activities is potentially hazardous if excess waste reaches the surface about the drill borehole. In case of occurrence, a comprehensive waste management plan will be required as a condition of consent and will set out waste management measures including the separation and treatment of drill cuttings and liquid components of the drilling fluid.
- **Temporary Works Construction Materials:** Any waste from construction materials needed for temporary works areas during the TJB construction, onshore cabling, and HDD drilling will be reused or disposed of responsibly.

289. An Outline Site Waste Management Plan (SWMP) is provided in **Appendix 4A: OCEMP (Section 4.4.55).** The Outline SWMP provides an overview of what will be included within the final SWMP that will be developed by the Principal Contractor. The final SWMP will identify obligations with regard to waste legislation, provide the details regarding roles and responsibilities of the Applicant and its contractors (including any subcontractors) to ensure that obligations (under waste legislation) and current environmental best practice are complied with.

4.8.11. Outline Construction Environmental Management Plan (OCEMP)

290. A CEMP secured as a planning condition requirement will set out the environmental measures to be applied on the Project, including details of any mitigation and how it will be managed through the construction phase.

291. An Outline CEMP (Volume 6, Appendix 4a) has been provided alongside this ES and has been assumed to be adopted for the purposes of the assessments in the ES. The purpose of the Outline CEMP is to set out the measures which will be taken to manage the potential environmental impacts of construction of the proposed Project and limit the disturbance from onshore construction activities such as site preparation, material delivery and removal, works activities and site reinstatement as far as is reasonably practicable.

292. The Outline CEMP also introduces outline environmental management plans which are provided as Appendix 4C (Volume 6).

4.8.12. Outline Onshore Construction Programme

293. A detailed construction programme for the proposed Project will be developed as design and procurement activities progress and full details of the construction programme, sequencing and installation methodologies will be confirmed prior to the commencement of construction and as a condition of consent. Onshore construction activities are planned to commence in Q1 2027. The installation of onshore components is likely to be completed over 18 to 24 months in Q4 2028.

294. The current indicative construction programme is summarised in **Table 4-28** and outlines the key onshore construction activities and when these activities are anticipated to take place.

295. Generally, work will be undertaken 7am to 7pm Monday to Saturday, however some works may require 24 hour working (e.g. HDD at the landfall, road and river crossings). Any works requiring 24 hour working will be agreed in advance with the local authority.

Table 4-28 Anticipated Duration of Onshore Construction Activities

Installation	Anticipated duration
Landfall HDD works	24 - 64weeks
Onshore cable route installation	38-72 weeks
Substation	78 weeks

4.9. Operation and Maintenance of Offshore Infrastructure

296. This section describes the key maintenance activities envisaged during the operation of the proposed Project, which includes maintenance of the WTGs, floating platforms and cables throughout the 30 year operational life.

4.9.1. WTG and Floating Platform Substructure Maintenance

297. In-service inspection, maintenance, and monitoring of the WTGs will be carried out in accordance with the service requirements provided by the WTG manufacturer. Each year it is anticipated that between two and 12 vessel visits would be made to the WTGs for maintenance purposes.

298. The accessibility requirements for floating WTGs are anticipated to be similar to fixed bottom installations and is anticipated to include a boat landing platform at the base of the WTG structure to enable access for maintenance.

299. Workers will be transported on a Crew Transfer Vessel (CTV) and will access the WTG using a ladder. Operation and maintenance activities, such as servicing equipment or replacing parts and machinery, will be enabled through hoisting on to a landing platform from the deck of the boat below. Helicopter access will also be required, particularly during bad weather or winter months and will be designed in accordance with the relevant CAA guidance and standards.

300. Each WTG will have an internal crane system to enable components to be changed onsite. For major repairs, there may be a requirement to tow an individual WTG back to port, and the floating foundation, moorings and electrical cables will be designed to allow safe disconnection of the structure from its moored position. The structure will also be designed to allow for towing with conventional tugs between the windfarm and the port. Disconnection and towing activities would largely mirror the installation process, in reverse order.

301. The floating platform will also undergo regular corrective, condition based and/or calendar-based maintenance activities including visual inspection, fault finding inspection and component exchange. The floating platform will be designed to accommodate marine growth, however, growth levels will also be inspected as part of the standard maintenance visits, at a frequency to be determined post consent and marine growth removal will be carried out using water jetting tools, if required.

302. During the operation and maintenance activities such as blade replacement, a temporary 500 m safety zone around infrastructure that is undergoing major maintenance will be applied.

4.9.2. Mooring and Anchor Maintenance

303. Mooring and anchor monitoring, inspection and maintenance will be in line with expectations laid out by the Health and Safety Executive (HSE) and MCA for floating wind (HSE / MCA, 2017). The overall operation and maintenance strategy for mooring and anchor maintenance will be developed post-consent, during the detailed design stage. However, it is anticipated that inspections will follow the inspection requirements set out by the mooring line and anchor manufacturer.

304. The inspections will be undertaken via conventional periodic visual methods, using ROVs, and will include a check of the anchor condition, for evidence of displacement, a check of the mooring line condition, including evidence of corrosion and checks of connection points for general wear and tear. Marine growth levels will also be monitored with subsequent removal if required, as for the floating platforms. Mooring lines will also be checked for any debris accumulation such as abandoned fishing gear and/or general marine rubbish, and this will be collected and removed if required.

4.9.3. IAC and Offshore Export Cable Maintenance

305. Once buried, submarine cables are unlikely to require routine maintenance and there should be no need for scheduled repair or replacement. However, it is likely that regular inspection surveys will be undertaken of both dynamic, protected and buried cables.

306. As a worst case scenario, up to 5 cable repairs are assumed to be required over the lifetime of the proposed Project.

307. An assessment of the potential future risk of cable exposure will be completed to define the frequency and location of operation and maintenance inspections to be undertaken by a qualified contractor. Periodic ROV visual inspections will be undertaken of the integrity and condition of

the subsea cables to ensure these remain buried and undamaged. Dynamic cables will also be periodically inspected which will include buoyancy aid checks, monitoring for cable fatigue and monitoring of cable touch down points to check for any seabed scouring.

308. In the event of cable exposure, the cable would be reburied, or additional protection installed, to maintain the target burial depth of the cable and to meet the CBRA parameters. In the event of cable failure, the cable will be recovered from its trench or from the water column and necessary repairs will be made (i.e. splicing in a new cable section or cable replacement), with the same approach taken as for a cable exposure.

309. Where cable failure or exposure has been identified, NRW will be notified in advance of any maintenance or rectification work and all work will be carried out in compliance with the relevant legislation.

4.9.4. Operation and Maintenance Vessels

310. Operation and maintenance activities can be categorised into two main types: planned / preventative and unplanned / corrective maintenance. Planned or scheduled maintenance includes general inspections, planned repairs and servicing while unplanned or corrective maintenance includes fault rectification and unexpected repairs.

311. Planned maintenance activities are likely to take place during the summer months when sea conditions are more favourable, whereas unplanned maintenance by its nature can't be foreseen and, as such, may take place at any time of year.

312. Operation and maintenance activities are expected to be coordinated from an onshore harbour base located in close proximity to the proposed Project. A variety of vessel types are likely to be used depending on the type of maintenance that is required. The most likely vessels used for routine planned maintenance will be CTV's, ROV's, SOVs and survey vessels. However, for unplanned maintenance and repairs, there may be a requirement for different and/or larger vessels.

4.9.5. Lighting, Marking and Safety Zones

313. The Array Area will be designed and constructed to satisfy the requirements of the CAA, MCA, Milford Haven Port Authority (MHPA) and Trinity House in respect of aids to navigational markers, lighting, and signage. These will be installed within the Array Area to mitigate potential risks and provide warning to marine operations, other sea users and the aviation industry as far as possible.

4.10. Operation and Maintenance of Onshore Infrastructure

314. This section describes the key O&M tasks envisaged during the operation of the proposed Project. The proposed Project will be operational for a period of 30 years from final commissioning.

4.10.1. Cable Operation and Maintenance

315. Cable systems are highly reliable and typically do not require intrusive maintenance. Maintenance of onshore export cables primarily involves annual visual inspections along the cable route to check for any potential impact from external factors such as heavy loads. Access to the main onshore export cable lengths outside of the CJBs is limited, so specific maintenance on the onshore export cable would only be conducted on the section where a problem is identified. In such cases, a section (usually tens of meters long) would be removed, a new section (cable spare) would be spliced in with field joints, and the cable would be reinstalled.

316. During repair works, a minimum of two persons will be present at the site (24 hours a day, seven days a week) to ensure safety, as the substation is located in a rural area. In maintenance activity

extra lighting will be required this will vary depending on the specific maintenance activity and appropriate to the safety of the workers.

4.10.2. Substation Operation and Maintenance

317. In the initial five to ten years of operation, the maintenance needs of the substation will be relatively low compared to later stages of its lifespan. This will be taken into account for future work planning on the onshore substation.

318. As the substation ages but remains within its working life, more extensive maintenance may be required. This proactive maintenance approach addresses potential issues before they occur, as opposed to a corrective maintenance program that responds to problems after they have happened, potentially resulting in revenue loss in the worst-case scenario. Some major overhaul procedures may necessitate the shutdown of specific substation equipment.

319. The substation will also be complemented with security infrastructure such as 2.4 m high, galvanised steel panelised fencing, CCTV, motion sensor lighting as well as security alarms. Different lighting will be used throughout the substation site. This will include 10 lux along access paths and electrical paths and further 2.2 lux lighting around the security fencing. In a worst case scenario this lighting will be operated for 24 hours although ideally these will only be used when required.

320. Indicative operational noise relating to the onshore substation is detailed below in **Table 4-29.**

Table 4-29 A summary of operational noise from all planned substation equipment

Substation Equipment	Sound power level at source dB(A)
Grid Transformer main tank	72
Grid Transformer coolers	76
Auxiliary Transformer	60
Harmonic Filter	85
Shunt reactor main tank	76
Shunt reactor coolers	75
STATCOM/ SVC switched reactor	80
STATCOM heat exchanger cooling	76
Voltage Source Converter (VSC) air cooled reactor	76
STATCOM cooling plant pumps	85

4.10.3. Operational Working Hours

321. During the operational phase (for any repair works at the substation), there will be a minimum of two persons on site at any one time (24 hours per day, seven days per week). This is a critical health and safety measure as the substation is located in a rural area. Offshore working will operate on a 24/7 schedule.

4.10.4. Commissioning

322. Following the installation of the WTGs offshore, these will undergo testing and commissioning. The commissioning period is expected to be complete within six months from Q3 to Q4 2028.

323. The commissioning of the onshore substation will be determined by the final design and the schedule will be based on the specific circumstances at that time.

324. It is generally expected that the commissioning will be supervised and directed by a commissioning engineer, who is distinct from the construction engineer responsible for installation. This method ensures that two competent and experienced individuals inspect each component, therefore, minimising the likelihood of any issues.

325. All testing equipment utilised during the plant commissioning will possess a valid calibration certificate. Any testing equipment employed during a specific test will be documented on the relevant test form.

326. All commissioning activities will adhere to the site safety rules, which include the appropriate isolation and earthing certificates, work permits, and test sanctions.

4.11. Decommissioning

4.11.1. Decommissioning Approach

327. Under Section 105 of the Energy Act 2004 (as amended) (UK Parliament, 2004), developers of offshore renewable energy projects are required to prepare a Decommissioning Programme for approval by the Regulator and a Section 105 notice is issued to developers by the Regulator following receipt of consent. Developers are then required to submit a detailed plan for the decommissioning of the project, including anticipated costs and financial securities.

328. The overarching principles that will be followed when developing a decommissioning strategy for the proposed Project are derived from the Department of Business, Energy and Industrial Strategy (BEIS) Guidance Note (2019) (BEIS, 2019). In line with this guidance the decommissioning strategy will consider:

- The Best Practicable Environmental Option (BPEO), which is the option that delivers the most benefit or least damage to the environment at an acceptable cost, both in the short and long term. This involves balancing the reduction in environmental risk with practicability and the cost of reducing the risk.
- Safety of surface and subsurface navigation.
- Other uses of the sea; and
- Health and safety considerations.

329. In addition, the proposed Project will adhere to the principles of:

- Sustainable development, and will seek to ensure that, as far as reasonably practicable, future generations do not suffer from a diminished environment, or from a compromised ability to make use of marine resources.
- The polluter pays principle, which acknowledges the proposed Project's responsibility to incur the costs associated with its impact on the environment; and
- The waste hierarchy and will seek to maximise the re-use and recycling of materials wherever possible.

330. The proposed Project has an anticipated lifetime of up to 30 years from full commissioning, and therefore advances may be made in the approach to decommissioning, or changes may be made to legislative requirements for decommissioning at this time. Details of the proposed decommissioning strategy will be agreed towards the end of the 30 years operational life of the proposed Project, in line with the applicable legislation and taking into account guidelines at that time. This will include the decommissioning programme, activities involved and the arrangements for post-decommissioning monitoring, maintenance, and management of the proposed Project. Engagement with regulators and stakeholders will also be undertaken prior to decommissioning.

331. The decommissioning phase of the proposed Project is expected to be complete within 12 months, between 2052 and 2054.

4.11.2. Decommissioning Process

332. The decommissioning process for the proposed Project will largely mirror the installation process, in reverse as set out below:

- WTGs will be de-energised and IAC cables disconnected and recovered or laid down for later recovery.
- Floating platforms will be disconnected from their moorings and the platform and WTG will be towed to local ports for disassembly.
- Anchors and moorings will be dismantled and recovered to shore for onshore disposal. However, if piles have been used as the anchor solution these will be cut off below the seabed level and the remaining structure recovered to the surface for onshore disposal; The decision to leave piles in situ would be agreed with the Regulator and relevant consultees to ensure this represented the most suitable approach.
- Both IAC and offshore export cables will be lifted from the water column or seabed using a grapnel and/or ROV and cables will be recovered to a vessel for onshore disposal. The recovery vessel will either spool the recovered cable into a carousel or will cut the cable into lengths as it is bought aboard, before being transported to shore.
- In the case of dynamic cables, buoyancy modules will also be removed and recovered to the vessel.
- Cable or scour protection will be recovered using a grab vessel and suitable barge for transport to shore.
- Once onshore project components will be processed and disposed of in accordance with relevant regulations at the time of disposal.

333. It is acknowledged that NRW has previously expressed a preference for buried cabling to be removed on decommissioning, however, there remains strong technical and environmental arguments to retain cables in-situ along with any cable and scour protection. The case for cable and cable/scour protection recovery will be the subject of an environmental and economic assessment in the years leading up to decommissioning, including discussions with relevant stakeholders and a review of industry best practice at the time to determine the most appropriate approach for the proposed Project.

334. Should any infrastructure be decommissioned in situ, some post-decommissioning activities may be required to identify and mitigate any unexpected risks to navigation or other users of the sea. This includes, for example, anchor piles or cables becoming exposed through natural sediment movement. The requirement for any post decommissioning monitoring will be determined based on the scale of the remaining infrastructure, the risk of exposure and the risk to marine users alongside relevant guidance and industry best practice. This will be discussed and agreed with relevant stakeholders through the decommissioning strategy.

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