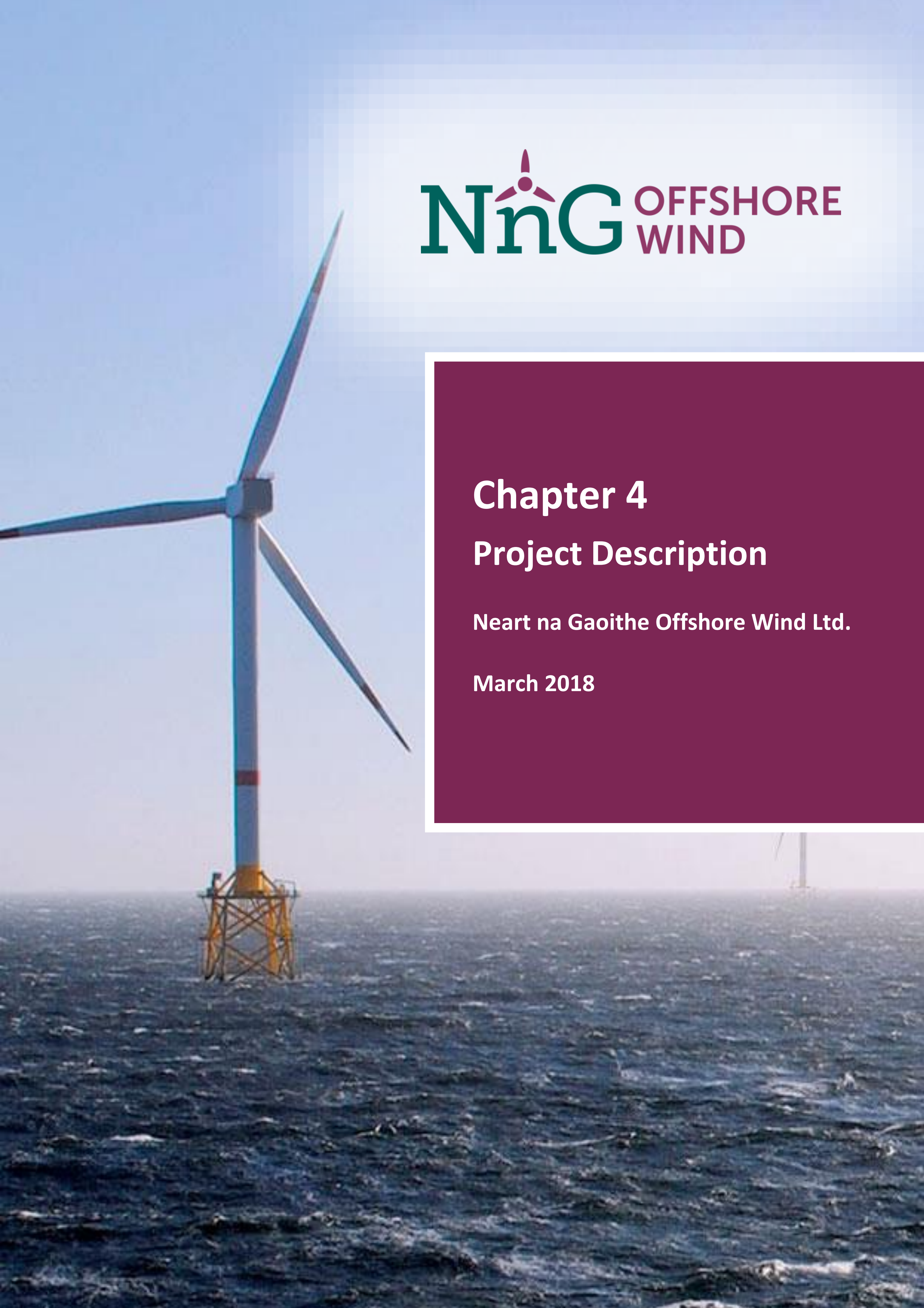

Chapter 4

Project Description

Neart na Gaoithe Offshore Wind Ltd.

March 2018

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4 Project Description

4.1 Introduction

1. This chapter provides a description of the components of the Neart na Gaoithe Offshore Wind Farm (the Project) and describes the likely activities associated with the construction, operation and maintenance, and decommissioning of the Project.
2. The Project description is based on a 'design envelope' (which captures the full range of potential design scenarios) and is intended to provide sufficient flexibility to accommodate further expected refinement in design as the Project moves through consenting and towards construction (see also Chapter 6: EIA Methodology for more on the use of the design envelope approach).
3. This chapter therefore sets out a series of design options and parameters, for which maximum values are typically provided. The maximum values set out in this chapter generally constitute the 'realistic worst-case scenario' in relation to the Project, although in some cases a minimum value may constitute the worst-case scenario. In each case the worst-case scenario for a particular impact or receptor is specified in the relevant topic chapter.
4. The fabrication of individual Project components is not the focus of this EIA Report and is not considered in this document in relation to the EIA process.
5. Preferred contractors for the supply and installation of the major Project components have not been identified at the time of submission of this consent application. The method of construction ultimately selected will be within the parameters of the design envelope described in this chapter and will be determined as part of the final engineering design and procurement process.

4.2 Project Location

6. The Project location (Development Area) comprises the Wind Farm Area and the Offshore Export Cable Corridor. The Wind Farm Area lies in the outer Firth of Forth and covers an area of approximately 105 kilometres squared (km^2). The Wind Farm Area is located approximately 15.5 km east of Fife Ness and approximately 29 km from the coast at Thorntonloch.
7. Water depths across the site range from approximately 40 to 60 metres (m) below Lowest Astronomical Tide (LAT).
8. The final, precise route of the Offshore Export Cables will lie within the Offshore Export Cable Corridor, running in an approximately southwest direction from the Wind Farm Area, making landfall at Thorntonloch beach to the south of Torness Power Station in East Lothian.
9. Figure 4.1 (Volume 2) shows the location of the Development Area, also highlighting the Wind Farm Area and Offshore Export Cable Corridor. The co-ordinates for the Development Area are given in Table 4.1.

Table 4.1 Development Area co-ordinates

Easting UTM30N	Northing UTM30N	Longitude (degrees decimal minutes)	Latitude (degrees decimal minutes)
Wind Farm Area Co-ordinates			
551736	6234720	002° 9.898' W	056° 15.271' N
552458	6229999	002° 9.255' W	056° 12.721' N
547554	6229998	002° 13.998' W	056° 12.752' N
545182	6229999	002° 16.293' W	056° 12.766' N
541685	6234997	002° 19.628' W	056° 15.479' N
541238	6235637	002° 20.055' W	056° 15.827' N
541026	6238611	002° 20.232' W	056° 17.430' N
543465	6242941	002° 17.826' W	056° 19.752' N
544801	6243993	002° 16.518' W	056° 20.312' N
546461	6243751	002° 14.910' W	056° 20.171' N
Offshore Export Cable Corridor Co-ordinates			
542888	6233277	002° 18.4792' W	056° 14.5455' N
543142	6232914	002° 18.2372' W	056° 14.3487' N
538777	6202296	002° 22.7292' W	055° 57.8662' N
539047	6202052	002° 22.4715' W	055° 57.7335' N
537836	6201965	002° 23.6358' W	055° 57.6926' N
537939	6201685	002° 23.5393' W	055° 57.5408' N
537646	6201808	002° 23.8203' W	055° 57.6086' N
537666	6201763	002° 23.8015' W	055° 57.5843' N

4.3 Project Overview

10. The Project will be capable of transmitting a maximum of 450 MW from the metering point on the Offshore Substation Platforms (OSPs). Key infrastructure is summarised below.

4.3.1 Offshore Wind Farm and Offshore Transmission Works

11. The Offshore Wind Farm will comprise a maximum of 54 turbines connected to each other and to OSPs via inter-array cables[1].

12. The Offshore Transmission Works (OfTW) will comprise up to two high voltage alternating current (AC) OSPs which will each connect to shore via two Offshore Export Cables.

13. The key components of the Project comprise:

- Up to 54 jacket foundations attached to the seabed with steel piles, plus ancillary equipment such as J-tubes and access facilities;
- Up to 2 jacket foundations for OSPs plus ancillary equipment such as J-tubes and access facilities;
- Up to 54 turbines (each comprising of tower sections, nacelle and three rotor blades);

[1] For the purposes of this EIA Report and the Application, the term 'inter-array cables' is taken to mean both the cables that connect individual wind turbines to form 'strings' (sometimes known as *intra*-array cables) and the cables that connect the strings of turbines to the OSP(s).

- Up to two OSP topsides housing electrical infrastructure and potentially welfare facilities for operation and maintenance staff (NB. for the purposes of this EIA Report, the term OSP is used to refer collectively to the platform structure and the topside);
- Up to 140 km of inter-array cabling including back-feeds between collector strings and up to 4 interconnector cables between the two OSPs (if two are installed);
- Two subsea Offshore Export Cables each of up to 43 km in length;
- Scour protection and cable protection, as required; and
- Meteorological mast (met mast).

Table 4.2: Summary overview of Project parameters

Parameter	Maximum design envelope
Wind Farm Area	105 km^2
Offshore Export Cable Corridor width	300 m
Offshore Export Cable length (per cable)	43 km
Distance from shore to closest point of Wind Farm Area	Approximately 15.5 km
Project Output	450 MW
Number of wind turbines	54
Number of OSPs	2
Number of met masts	1

4.3.2 Onshore Transmission Works (OnTW)

14. Planning permission for the OnTW was sought separately by NnGOWL under the Town and Country Planning (Scotland) Act 1997.

15. NnGOWL was granted planning permission for the OnTW by East Lothian Council in June 2013. The permission was subsequently amended by an application under S42 of the Town and Country Planning (Scotland) Act 1997 in November 2015, and implemented via an initial phase of work in August 2016.

16. Terrestrial underground cables will transmit the energy generated by the wind turbines from the landfall location to an onshore substation. The onshore substation will collect the power transmitted from the onshore export cables and transform it up to a higher voltage for connection and export to the national grid.

17. NnGOWL's grid connection agreement is to connect to an extension to the existing 400kV substation at Crystal Rig II onshore wind farm (see Figure 4.2, volume 2).

18. The consented OnTW includes:

- Transition pit landward of the mean high-water springs (MHWS) mark;
- Underground transmission cabling from the transition pits to the electrical substation;
- Electrical substation; and
- Underground transmission cabling from the electrical substation to the National Grid substation.

4.4 Construction and Installation of Offshore Infrastructure

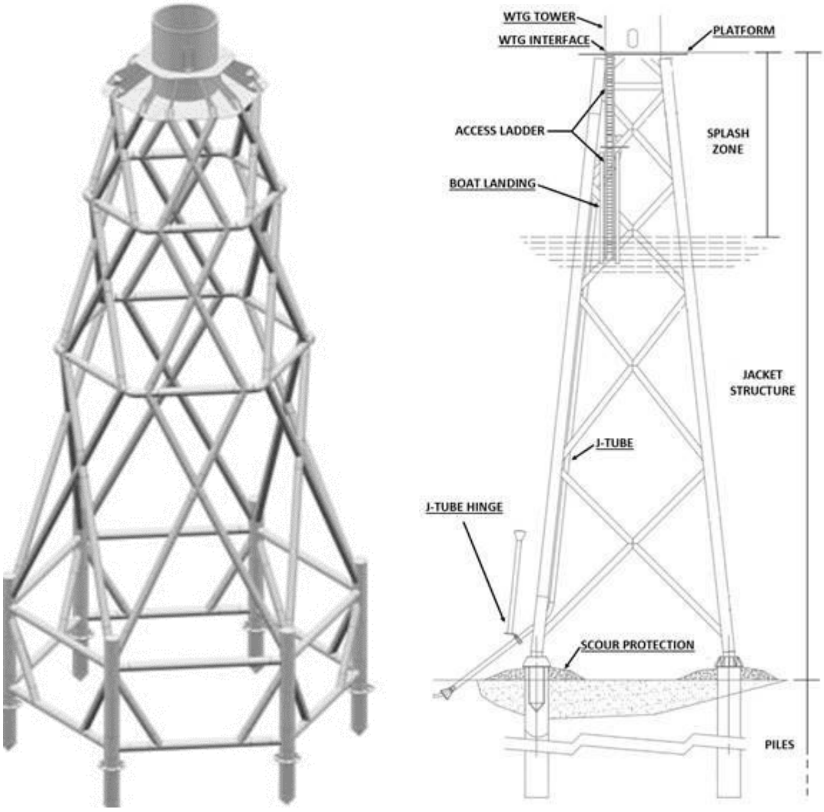
4.4.1 Wind Turbine Foundations

19. Steel jackets with pile foundations are considered the most appropriate turbine foundation design due to the prevailing site conditions and these are the only foundation solution being considered. For the purposes of this EIA Report, the term 'foundation' is used to refer collectively to both the steel jacket and the piles.

20. Steel jackets are formed of a lattice structure comprising tubular steel members and welded joints. Jackets are fixed to the seabed using steels piles below each leg. Jackets will comprise a maximum of six legs (Illustration 4.1).

21. Typically, piles of tubular steel are drilled or driven into the seabed sub-strata, relying on the frictional and end-bearing properties of the seabed for support.

Illustration 4.1: Illustrative steel framed jacket with pile foundations



4.4.1.1 Key design elements of wind turbine foundations

22. The dimensions for the key design elements of the wind turbine jackets and piles are summarised in Table 4.3 below.

Table 4.3: Wind turbine foundation parameters

Parameters	Maximum design envelope
Jacket type	Steel lattice
Jacket leg spacing at seabed level	35 m x 35 m
Details of seabed preparation	Clearance of any debris found A seabed template with up to 6 legs will sit temporarily on the seabed during pile installation for the turbine foundations.
Pile diameter	3.5 m
Number of piles per foundation	6
Pile penetration depth	50 m
Pile installation method	Driven only piling; Drive-drill-drive; or Drill only.

Parameters	Maximum design envelope
Indicative foundation installation duration (per foundation)	Pile Driving (6-21 hours for up to 6 piles) Pile Drilling (62-180 hours for up to 6 piles) This includes time for setting up and changing equipment between piling locations. Jacket installation (12-24 hours). Concurrent piling activities: pile driving or pile drilling at two locations concurrently (either on same vessel or on an independent vessel)
Weight of jacket	1,000 tonnes
Diameter of main jacket tubulars	3m
Seabed occupied by jacket leg (piles and scour protection)	300 m^2 per leg for four-legged jacket. 108 m^2 per leg for a six-legged jacket.

23. The typical amounts of material per wind turbine foundation are:

- Jacket: up to 1,000 tonnes (steel);
- Piles: up to 300 tonnes per pile (steel);
- High strength grout for fixing jacket legs to piles: up to 30 m^3 per foundation; and
- Cementitious grout in annulus of drilled piles: up to 25 m^3 per pile.

24. The grout used in the annulus of drilled piles and for fixing the jacket to the piles is expected to be high strength anti-washout grout, such as Masterflow 9500. This is a blend of ingredients including, for example, Ordinary Portland Cement and a polymeric additive. The setting time of the grout is typically less than 10 hours.

25. In addition, it is likely that the jackets will require cathodic protection to prevent corrosion. Usually this takes the form of galvanic anodes; these are usually affixed during the fabrication process to parts of the jacket that will be submerged when installed in the final location, but can be retrofitted in-situ using Remotely Operated Underwater Vehicles (ROVs) or divers. A typical arrangement is shown on Illustration 4.2

Illustration 4.2: Anodes affixed to jacket members (source: Keystone)

26. In addition to this protection, the area of the foundation between the splash zone and the wind turbine tower may also be protected with the following coatings during fabrication:

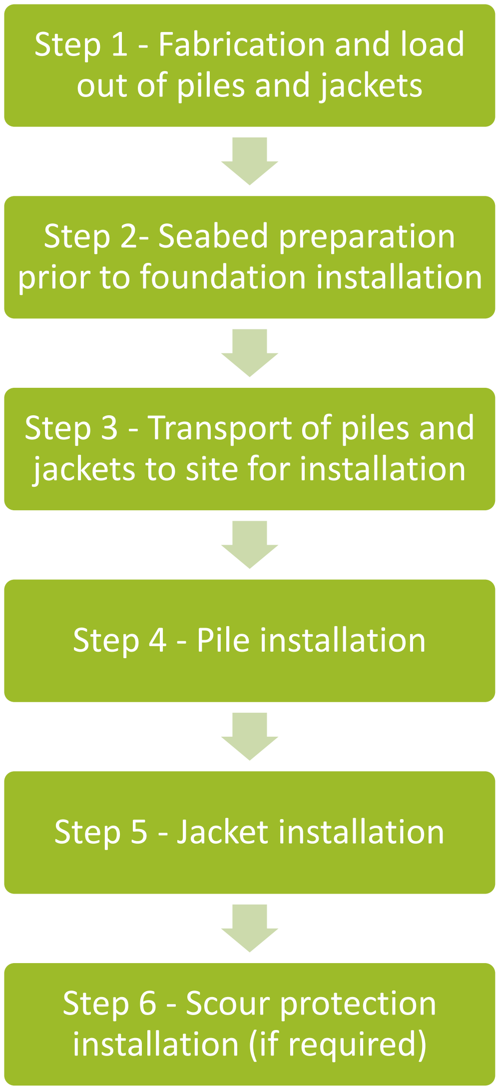
- Zinc primer applied preferably as a thermal spray;
- A silicon epoxy resin sealant;
- A coating of two-part liquid epoxy coating; and
- A final coat consisting of polyurethane, is applied by brush or spray, and is normally moisture curing and drying if solvent free.

27. All coatings/paints used will be suitable for the marine environment and will conform to the provisions of ISO 20340 and Norsok M-501 standards.

4.4.1.2 Installation of Wind Turbine Foundations

28. The installation of the foundations is likely to be performed in two separate operations/campaigns using different types of vessels and equipment. The pile installation may be performed well in advance of the jacket installation. The general sequence of foundation installation is shown in the flow chart in Illustration 4.3 below and subsequently described in more detail in the following sections.

Illustration 4.3: Foundation fabrication and installation sequence



Step 1: Fabrication and Load Out

29. The piles and jackets will be pre-fabricated at onshore fabrication facilities and transported to site (piles initially and later jackets with transition pieces attached) either by transport barges or by suitably equipped installation vessels. The onshore bases for fabrication have not yet been identified.

Step 2: Seabed Preparation

30. Seabed preparation necessary for piling and jacket placement is considered minimal, and at worst will consist of the removal of problem debris.

Step 3: Transportation for Installation

31. The piles and jackets will likely be transported directly from the onshore fabrication facilities to the Wind Farm Area. This may be carried out by means of a transport barge that does not have the required crane capacity for installation, in which case additional installation vessels will be required to complete the installation works.

32. Alternatively, transport and installation may potentially be carried out using a suitably equipped single vessel. In this case, it may be possible to transport multiple piles and jackets using a single vessel. An illustration of such a vessel is provided in Illustration 4.4 below.

Illustration 4.4: Transportation and installation vessel concept (Source: W3G Marine 2012)

Step 4: Pile Installation

33. The jacket can be pinned to the seabed in one of two ways:

- Using pre-installed piles installed with the use of a seabed piling template (as shown in Illustration 4.5); or
- Installation of piles after the jacket placement by either:
- Installing piles through special footplates on each leg of the jacket; or
- Installing the piles through the legs of the jacket.

Illustration 4.5: Jack-up barge installing seabed template (source: Fugro Seacore)

34. Owing to the nature of the seabed sediments at the site and the presence of shallow bedrock, there are three main installation methods that could be used for the installation of the piles:

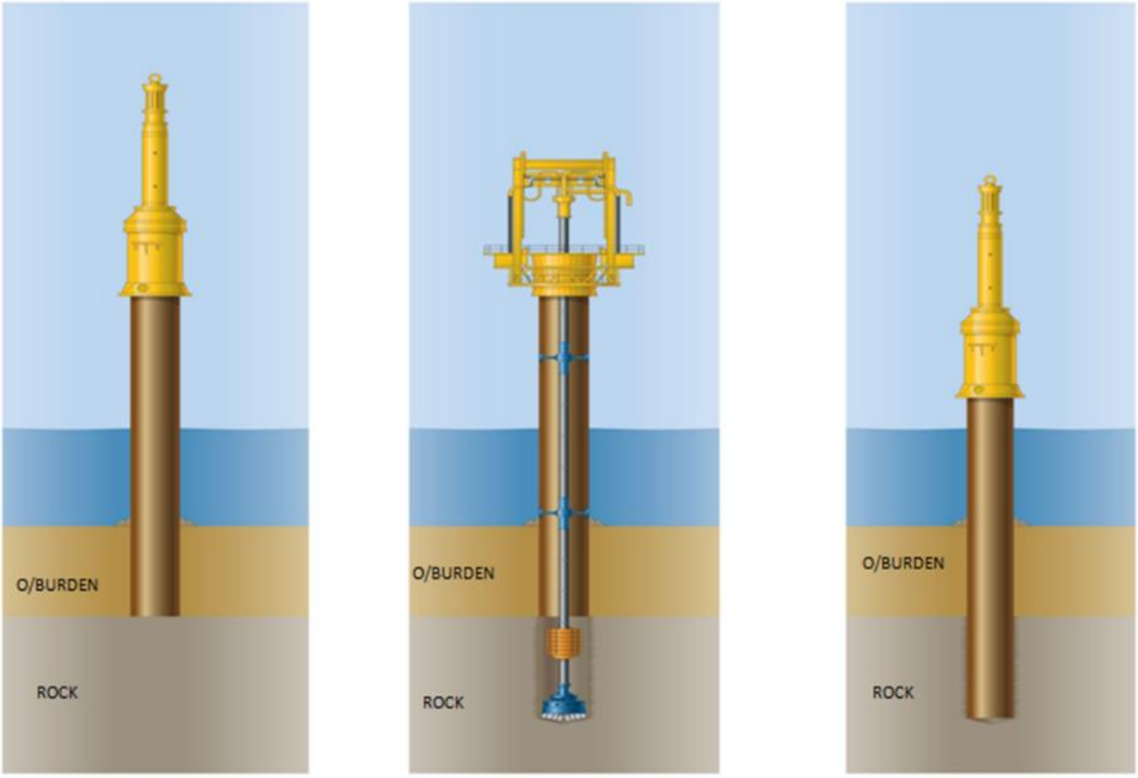
- Driven only pile - driving with a hydraulic hammer;
- Driven and drilled pile - the 'drive–drill-drive' method (as shown in Illustration 4.6 below) where successive driving and drilling phases are used; and
- Drill only pile - drilling out the entire hole for the pile and subsequently grouting the pile in (as shown in Illustration 4.7). In this method, a sacrificial casing may be installed by driving to bedrock level ahead of the drilling operation. This is to prevent the sediment layer collapsing in to the drilled hole prior to pile installation.

35. The ground conditions at each location will dictate the method that will be used for each foundation. Preliminary geotechnical investigations of the seabed suggest that:

- 0 to 10 % of piles can be installed by driving without assistance from use of a drill (i.e. driven only piling); and
- 90 to 100 % of piles can be installed using one or either of drive-drill-drive method or the drill only method. Where drill only is adopted, the sacrificial casing is expected to be driven to an average length of 30% of the pile length.

36. Whilst significant geotechnical data has been gathered to inform potential pile installation techniques, future geotechnical investigations will be used to refine these estimates.

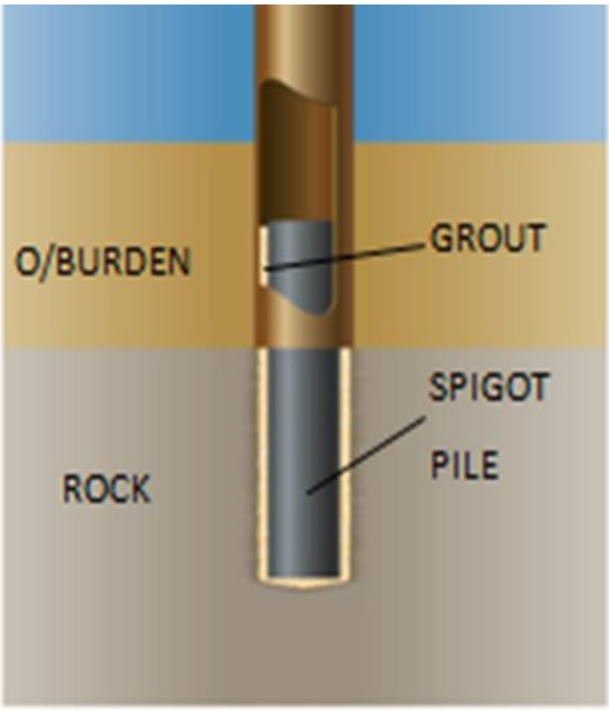
Illustration 4.6 Drive-drill-drive installation sequence for each pile (Source: Fugro Seacore 2012)



37. The ‘driven only’ piles will be installed without generating any arisings or rock fragments. The drive-drill-drive or drill-only pile installation methods generate rock fragments during the drilling element of the installation process. As these rock fragments are generated, they will be mixed with seawater and drawn into the inlet of a hydraulic chute at the drill-head. This will then be discharged from deck level on the supporting vessel and dispersed over the seabed surface adjacent to the pile installation works.

38. It is anticipated that guar gum will be used in drilling. Guar gum is used in drilling due to its ability to suspend solids; it regulates the viscosity of mud solution, and stabilises and regulates the flow properties of the drilling muds. Guar gum is a natural product that is biodegradable, has no bioaccumulation potential and is not a persistent, bioaccumulative, toxic (PBT) substance. Guar gum has little or no environmental impact. As is normal practice, the suspension of guar gum, water and fine rock particles will be discharged into the adjacent sea and the fine rock particles will settle out on the seabed.

Illustration 4.7 Grouted pile arrangement (Source: Fugro Seacore 2012)



39. Preliminary pile driveability studies have been completed to inform the selection of a maximum hammer energy that would be used to drive the piles into the seabed (and to inform the underwater noise modelling). As stated above pile driving using hammers may be used for each of the techniques under consideration:

- Drive Only – where pile driving will be continuous and used to achieve the full penetration depth;
- Drill-Drill-Drive – where pile driving will be intermittent and alternated with drilling; and
- Drill Only – where driving will be continuous but only be used for casing installation.

40. The pile driveability study has concluded that the sequence set out in Table 4.4 should be used for noise modelling to represent the worst case of continuous pile driving at a single pile location:

Table 4.4: Pile installation parameters

Parameter	Maximum design envelope
Soft start duration	30 mins
Applied hammer energy during soft start	360 Kilojoules (kJ) (20% of max energy for an IHC 1800 hammer)
Driving duration at maximum energy	up to 180 mins
Applied hammer energy at maximum energy	1,635 kJ (approx. 90% of max energy for an IHC 1800 hammer)

41. A jack-up platform or floating vessel will be used to install the piles (and also the jackets). Jack-ups require a footing on the seabed; to increase this footing area, and hence reduce bearing pressure on the seabed surface, the jack-up may use spud cans. Spud cans are conical shaped plates fixed to the

bottom of the jack-up legs; the diameter of the spud cans will vary depending on the jack-up barge and soil conditions, although a typical spud can diameter is approximately 8 m.

42. Depending on the number of piles and spacing, the jack-up may need to be relocated more than once to complete the full foundation installation process. Table 4.5 provides indicative details of the potential installation vessel activity.

43. If a floating vessel is used it is possible that anchors may be used to maintain position; the maximum expected anchor spread of a floating vessel up is 1.2 km. If a dynamic positioning (DP) system is deployed on the floating vessel the vessel holding position is maintained by thrusters and anchors may be unnecessary. The installation vessel (jack-up or floating) will require up to three support vessels. It is possible that up to four installation vessels will operate on site at any one time.

Table 4.5 Installation vessel parameters

Vessel Type	Vessel parameter	Minimum design envelope	Maximum design envelope
Jack up Vessel	Jack-up moves per foundation installation	1 (pile installation) 1 (jacket installation)	3 (pile installation) 1 (jacket installation)
	Leg spacing of jack-up	50 m x 50 m	100 m x 100 m
	Number of spud cans	4	8
	Spud can footing area (per vessel)	1 m^2 (leg area without spud can)	106 m^2
Floating Vessel	Number of anchors	0 (position on DP only)	8
	Anchor mooring length	200 m	1,200 m

Step 5: Jacket Installation

44. Once at the wind turbine position, the jackets will be lifted by crane barge, appropriately orientated and placed either on pre-installed piles in the seabed (or directly on to a prepared seabed in the case where piles are not pre-installed). In the former case, the jacket legs will incorporate pointed ends that are 'stabbed' into the pre-installed piles. In both cases, the annulus between the jackets legs at the pile wall will be grouted using a cementitious grout.

Step 6: Scour Protection Installation (if required)

45. As part of the final, detailed design phase, and prior to the start of construction, the need for scour protection around the foundation will be defined. Should scour protection be required, the area of seabed protected will depend on the number of jacket legs and the diameter of the piles. The area protected may be up to a maximum of 1,200 m^2. The volume of material to be placed on the seabed for the purpose of scour protection, should scour protection be required, is expected to be in the range of 200 to 600 m^3 per jacket.

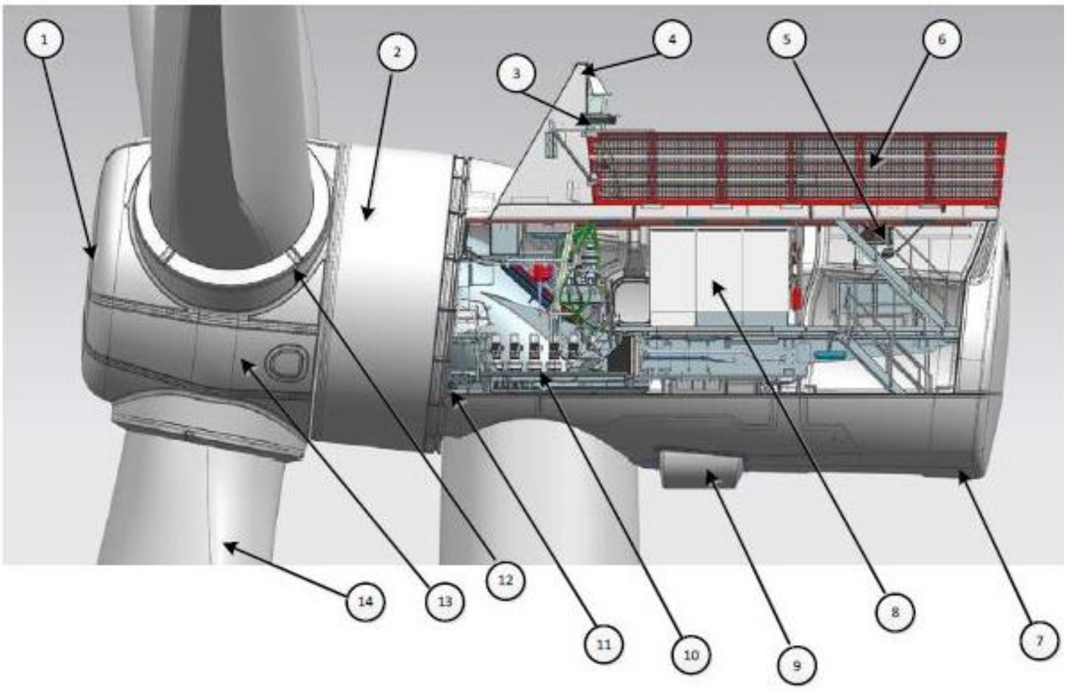
4.4.2 Wind Turbines

46. The turbines to be installed will be chosen based on a range of factors, including commercial availability and economics. Each turbine will have the same three bladed design overall incorporating the following internal mechanics (refer to Illustration 4.8).

- The blades or rotor converts wind energy to low speed rotational energy. The pitch blades are attached to the hub and the rotor is attached to the nacelle;
- The nacelle (see Illustration 4.8 and Illustration 4.9 below) houses the electrical generator, the control electronics, and a gearbox, if required, for converting the low speed incoming rotation to electricity;
- The tower supports the nacelle; and

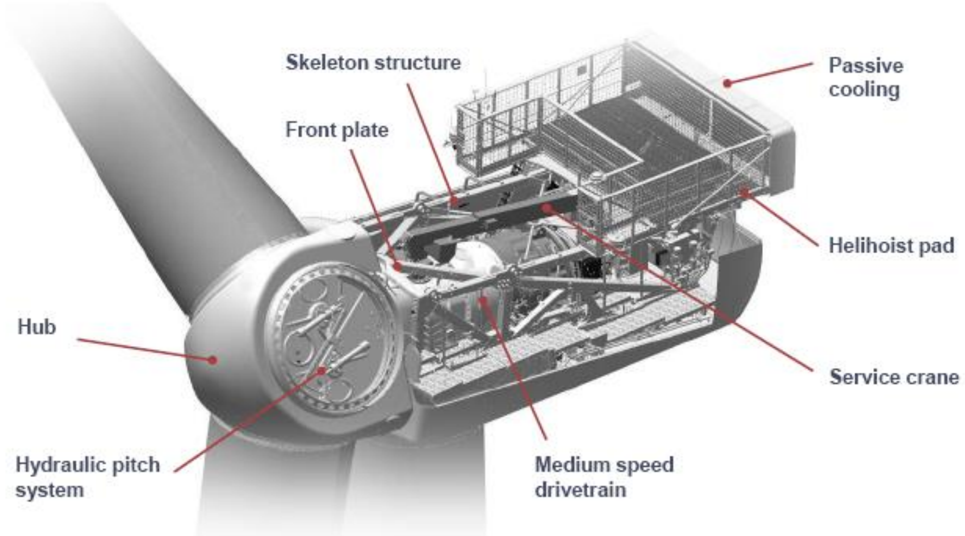
- The turbine transformer is either located within the wind turbine tower, usually at platform level above the foundation, or in the nacelle. The transformer is housed in a hermetically sealed unit and serves to step up the generator voltage to the inter-array voltage level.

Illustration 4.8: Components of a typical offshore wind turbine without gearbox (Source: Siemens Gamesa)



Item	Description	Item	Description
1	Spinner	8	Converters (2 pcs.)
2	Generator	9	Transformer
3	Wind Instruments and Aviation Light	10	Yaw Gear
4	Passive Cooler and Active Cooling Fans	11	Bed Frame
5	Portable Nacelle Service Crane	12	Blade Bearing
6	Heli Hoist	13	Hub
7	Canopy	14	Blade

Illustration 4.9: Components of a typical offshore wind turbine with gearbox (Source: Vestas MHI)



47. The Project requires flexibility in the choice of turbine to ensure that anticipated changes in available technology and economics can be accommodated. The design envelope therefore sets maximum and, where relevant, minimum realistic worst-case scenario parameters against which environmental effects can be assessed. The turbine options being considered range in power output. The turbine parameters outlined in Table 4.6 are considered to represent the worst-case design parameters associated with the turbines currently being considered. Illustration 4.10 defines the terminology used to describe the dimensions of the wind turbine.

Illustration 4.10. Wind turbine dimensions, adapted from Renew (2011)

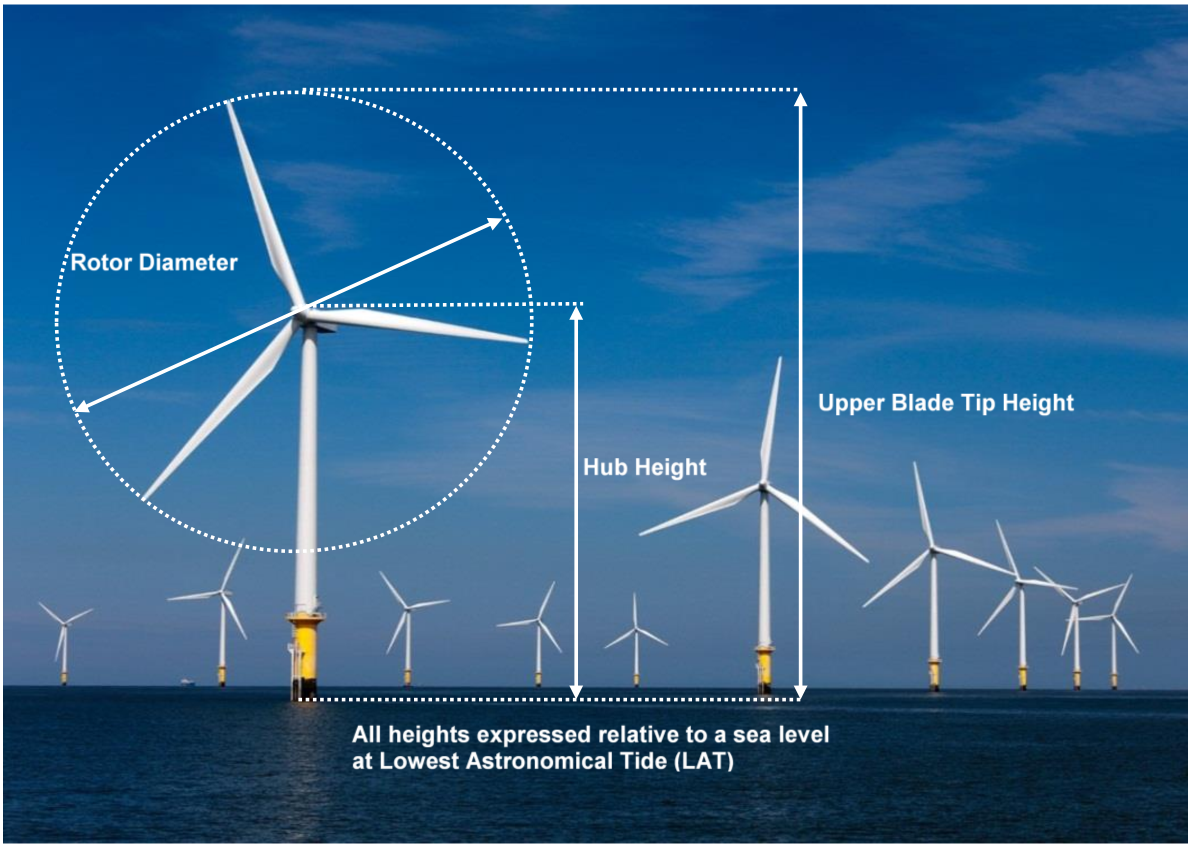


Table 4.6: Wind turbine design envelope parameters

Parameter	Minimum / maximum design envelope (or indicative range)
Number of turbines	54
Maximum rotor tip height (above LAT)	208 m
Rotor diameter	167 m
Maximum hub height (above LAT)	126 m
Minimum air gap clearance to blade tip (above LAT)	35 m
Maximum height of platform (above LAT)	21 m
Minimum wind turbine spacing (approximate)	800 m

4.4.2.1 Layout

48. The Project will transmit a maximum of 450 MW from the metering point on the OSP(s). The exact number of turbines required to reach this output will depend on the rated capacity of the individual turbines used, however the total number of turbines will not exceed 54.

49. For the purposes of conducting the EIA, an indicative layout has been developed based on the current understanding of ground conditions within the Wind Farm Area (Figure 4-3, Volume 2). The layout is based on the maximum design envelope of 54 turbine locations and 2 OSPs. The layout will be refined following further geotechnical investigations. The final layout will be confirmed post-consent and will be subject to consultation and approval by Marine Scotland Licensing Operation Team (MS-LOT).

4.4.2.2 Oil and Fluids

50. Each wind turbine will contain components which require lubricants and hydraulic oils in order to operate. The turbine transformer may be oil filled or ’dry type’. The volume of oil is dependent on the size of the turbine and typical maximum figures are shown in Table 4.7. The table presents the typical quantities of lubricating and hydraulic oils likely to be present in the turbine. The nacelle, tower and rotor are designed to retain any leaks.

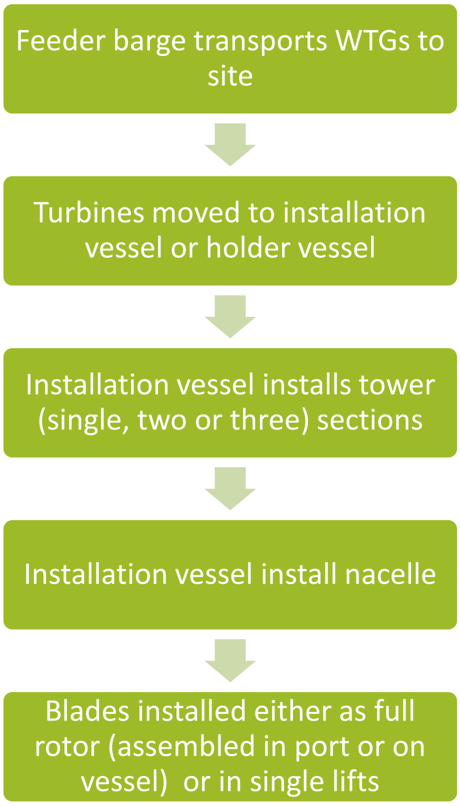
Table 4.7: Wind turbine oil and fluid parameters

Wind turbine oil or fluid	Maximum design envelope
Grease	250 litres (l)
Hydraulic oil	600 l
Gear oil	2,100 l
Transformer silicon / ester oil	3500 kilograms (kg)

4.4.2.3 Installation of the Wind Turbines Generators

51. Turbine installation will follow on from the installation of the foundations and will, preferably, take place after the installation of the associated inter-array cable. Turbines are likely to be transported from a pre-assembly harbour where some pre-assembly of, for example, tower sections will take place.

Illustration 4.11: General sequence of turbine installation



52. A typical indicative installation process detailing the base case turbine installation scenario is outlined in Illustration 4.11; however, this may be subject to change following the selection of the turbine supplier.

53. Wind turbine sub-assemblies (nacelle, rotor blades and towers) will be loaded either on to the installation vessel or on to a feeder vessel and shipped to the installation site. Depending upon which vessel is used it is likely that between three and ten complete wind turbine sub-assemblies will be loaded at a time.

54. At the installation location, the tower will be erected first, followed by the nacelle and blades. The blades may be installed one at a time (single blade installation as shown in Illustration 4.12) or pre-assembled.

55. The vessels to be employed for this installation will largely be determined by the final choice of wind turbine model and the availability of suitable vessels at the time of installation. In general, the installation sequence depicted above is expected to be followed, whereby separate vessels are used for the transport and installation of each wind turbine. This may, however, potentially be carried out using a single larger floating vessel, should such be commercially available at the time of construction.

56. The installation of each wind turbine (tower, nacelle and blades) is expected to take between approximately 12 and 24 hours.

Illustration 4.12: Wind turbine single blade installation (Source: Siemens Gamesa)

4.4.2.4 Turbine Commissioning and Testing

57. Turbine installation will preferably not commence until a power supply from the onshore grid connection is available. Once each turbine has been installed and the cabling connected, a process of testing and commissioning will be carried out before the turbine is put into service. Testing and commissioning of each turbine is estimated to take approximately eight days.

58. The turbine testing process consists of checking all of the control systems on the turbine, generator, switchgear, transformer gearbox (if required), yaw control and meteorological measurement functions, before running up the turbine through its normal design sequences. All interlocks and safety systems are checked for functionality in both the static and running modes. Ancillary systems such as the hydraulics also go through a pre-testing regime before the turbine is rotated. A standard checklist will be prepared before the turbine is put into service. The last phase of the commissioning is

energising the turbine via the inter-array cables. In the event that the grid connection is not completed at the time of wind turbine installation, an alternative method involving a temporary power supply will be implemented (see Section 4.4.5.6).

4.4.3 Met Mast

59. Meteorological or anemometry masts (met masts) are typically installed on site to measure wind speed and direction over a given time period.
60. It is currently planned for one offshore meteorological mast to be installed within the Wind Farm Area.
61. The met mast will be up to 140m high (above LAT). Anemometers will be located on the mast to measure wind speed and direction. Additional instrumentation will include sensors to measure wave height and direction, sea temperature and salinity, and structural response data. Safety features will include a fog detector that will provide input signals to trigger a fog horn.
62. A typical met mast is shown in Illustration 4.13.

Illustration 4.13: Met mast at Hornsea offshore wind farm (Source: SMart Wind)

63. As per the turbines and OSP(s), the met mast will be supported on a steel jacket with pile foundation with a maximum of four legs (supported on one pile per leg); the key parameters are summarised in Table 4.8, with other maximum dimensions and installation techniques as per those described for turbine foundations.

Table 4.8: Met Mast parameters

Parameter	Maximum design envelope
Number of met masts	1
Maximum height	140 m (above LAT)
Jacket leg spacing	35 m x 35 m
Foundation pile diameter	3.5 m
Foundation material	Steel (jacket and piles)
Pile depth below sea-bed	50 m

Parameter	Maximum design envelope
Met mast safety features	▪ Fog Detector – VF-500 Visibility Sensor: Uses forward scatter sensor technology to measure visibility in all weather conditions. The visibility sensor acts as the on/off switch for the foghorn. ▪ 2 nautical mile (NM) fog horn: Automatically broadcasts (when required by the fog detector) a 360° beam of sound to a pre-selected code audible for 2 NM. Sound Signal: Morse.

4.4.4 Offshore Electrical Infrastructure

64. The electricity generated by the turbines offshore will be transmitted to the national grid; it is anticipated that the following infrastructure will be required offshore for the purposes of transmission:

- A maximum of two 43 km long Offshore Export Cables, each comprising of an electricity cable and an internal fibre optic cable from the OSP(s) to the landfall location at Thorntonloch. An option to install separate fibre optic cables, laid in parallel with the power cables in the same cable trench is also being considered in place of internal fibre optic cables;
- Up to 140 km of buried inter-array cables (including backfeeds) linking the wind turbines in strings and connecting cables from wind turbines to the OSP(s). An option to install separate fibre optic cables, laid in parallel with the inter-array cables in the same cable trench is also being considered in place of internal fibre optic cables;
- Up to two OSPs; and
- If two OSPs are installed, up to four interconnector cables may be installed between the two OSPs to ensure standby power supply to each OSP.

65. Several different design options for the electrical systems are being considered and the final decisions will be reliant on the final turbine and inter-array cable voltage choice.

4.4.4.1 Offshore Substation Platform(s)

66. The purpose of the OSP is to transform the electricity generated offshore from medium voltage (MV) (up to 72.5 kV) to a higher voltage (220 kV). This increase in voltage allows the power to be transmitted to the onshore substation efficiently and with lower transmission losses. There will be a maximum of two high voltage alternating current (HVAC) OSPs installed within the Wind Farm Area.

67. The location of the OSP(s) will be confirmed following detailed geotechnical investigations and finalisation of inter-array cable layout design.

68. Each OSP will consist of a steel jacket with piles foundation and a topside which houses the electrical equipment in addition to other people facilities.

4.4.4.1.1 *Topside Design*

69. The topside structure will accommodate the OSP electrical equipment and provide access and temporary or emergency accommodation for personnel as well as areas for cable marshalling and other services. The topside size and weight are determined by the equipment that is to be accommodated at the substation. Due to the offshore conditions, the OSP(s) will be built to withstand corrosion and prevent equipment damage; hence, all electrical equipment is enclosed to protect it from the environment.

70. The main parameters of the OSP are shown in Table 4.9.

Table 4.9 Topside Design Envelope Parameters

Parameter	Maximum design envelope (or indicative range)
Number of OSP(s)	2
Maximum height of topside (above LAT)	21 m
Height to top of crane / helicopter pad (above LAT)	60 m
Length x width of topside	40 m x 40 m
Weight of topside	1,000 to 3,500 tonnes

71. The OSPs will incorporate more than one deck and each deck will contain different modules, enclosures or systems including, for example:

- Transformers;
- Transformer cooling system;
- Transformer dump tank;
- 220 kV gas insulated switchgear room;
- MV (rated up to 72.5kV) switchgear;
- Heating, ventilation and air conditioning;
- Fire suppression systems;
- Temporary emergency diesel generation system;
- Batteries, battery chargers and Uninterruptable Power System (UPS);
- Control and protection room;
- People facilities (possibly including temporary or emergency accommodation and lifeboats); and
- Helicopter pad or helihoist platform.

72. If only one OSP is used there could be up to six transformers (two large power transformers and four small auxiliary transformers and associated equipment). If two OSPs are used, one large power transformer and two small auxiliary transformers will be accommodated within each.

73. The major plant items likely to be present on each OSP for the two OSP scenario are summarised (in Table 4.10).

Table 4.10 Summary of major plant contained on each OSP (for the two OSP scenario)

OSP plant item	Quantity	Features
Transformer	One large transformer and up to 2 small auxiliary transformers on each of the two OSPs.	Oil filled transformer complete with oil bunding designed to capture any leakages. NB. gas-insulated (using sulphur hexafluoride (SF_6)) and dry auxiliary transformers are also being considered, which would not require oil.
Transformer cooler	To be determined during detailed design of the transformer.	Contained within ventilated (louvres on external wall), perimeter enclosure
Medium voltage switchgear	One 33 kV switchboard with a minimum of 11 circuit breakers on each OSP.	Modular, gas insulated switchgear (up to 72.5 kV)
220 kV breakers	One on each OSP	Modular, gas insulated unit. Number depending on final design of protection system

4.4.4.1.2 Foundation Design

74. Each OSP will be supported by a steel jacket with piles foundation. Table 4.11 below shows the dimensions of the key design parameters for the OSP foundation.

Table 4.11 OSP foundation design envelope parameters

Parameter	Maximum design envelope (or indicative range)
Jacket type	Steel lattice
Jacket leg spacing at seabed level	60 m x 60 m
Details of seabed preparation	Clearance of any debris found. A seabed template with up to 8 legs will sit temporarily on the seabed during pile installation for the OSP foundations.
Maximum pile diameter	3.5 m
Maximum number of piles per foundation	8
Maximum pile penetration depth	50 m
Pile installation method	Drive only, drive-drill-drive or drill only
Indicative foundation installation duration (per foundation)	Pile Driving (maximum of 21 hours for up to 8 piles) Pile Drilling (maximum of 180 hours for up to 8 piles) This includes time for setting up and changing equipment between piling locations. Jacket installation (maximum of 24 hours).
Weight of jacket	2,500 tonnes
Diameter of main jacket tubulars	3 m
Seabed occupied by jacket leg (piles and scour protection)	300 m^2 per leg

75. Scour protection, if required, will be similar to the scour protection outlined under Section 4.4.1 for wind turbine foundations, the quantity will depend on the final foundation design.

4.4.4.1.3 *Hazardous Substances*

Transformer Oil

76. Oil is used primarily as a cooling medium for transformers. Each transformer will be filled with up to 2,500 l of oil at the docks in advance of transportation offshore.

77. An oil collection (bunding) system will be installed underneath the power transformers. This will consist of collection pans, which cover areas at risk from spillage, including the transformers. Oil-resistant and fire-resistant plastic or rubber liners may be installed on the floor or underneath/around catchment pans for added protection. The collection pans will feed into an oil sump that will have a capacity of at least 110% of the stored volume of oil.

Sulphur Hexafluoride (SF_6)

78. SF_6 is used in gas insulated switchgear as an arc-quenching agent. It facilitates the design of compact and highly reliable switchgear. SF_6 is likely to be used in the MV and 220 kV switchgear and may be considered for use in the HVAC transformers. SF_6 switchgear is long established and is a proven product used both onshore and offshore.

79. Under operational conditions, including fault conditions, SF_6 remains completely inert and is totally contained within the switchgear. Normal risk mitigating measures include switchgear SF_6 pressure monitoring. The SF_6 components of gas-insulated switchgear are designed to be maintenance free for their life.

Batteries

80. A direct current (DC) system consisting of dry type valve regulated lead acid (VRLA) batteries, battery chargers and a distribution board will all be housed in standalone floor mounted cabinets to cater for the OSP 48 volt (V) DC supplies. The batteries will be mounted on terraced shelves covered with an acid resistant sheet behind secure front opening doors. Telecommunications equipment may have

dedicated batteries such as nickel cadmium. These battery cells typically have a design life of 10 to 12 years and will be recycled and properly disposed of at the end of their useable life, and replaced with equivalent.

Diesel Fuel

81. There may be a diesel generator, with integral fuel tank included at the OSPs, which will be used to provide emergency electrical supplies for a period of time in the event of loss of connection to shore. The amount of fuel needed will be based on the auxiliary load of the OSP and the suggested runtime fuel needed for emergencies. Based on existing wind farm experience, a diesel fuel volume of the order of 10,000 l is anticipated. Standard offshore practice, using containerised bunded generator sets, or generator sets enclosed within a purpose-built enclosure will be used. The generator will run for test purposes, typically at 1-year intervals. Fuel top-ups to replace volumes of fuel used in testing, will take place using a flexible retractable hose from a licensed diesel supply vessel. Alternative designs are also being considered with no permanent diesel generator installed on the OSPs; in this scenario provisions will be in place to connect a diesel generator quickly to the OSP with the diesel generator and fuel tank being brought from shore as required.

Fire Extinguishing Agents

82. A fire detection and suppression system complying with relevant regulations will be installed during the manufacturing of the topside. As a minimum, this will comprise mains powered smoke detectors with rechargeable battery backup. These detectors will be wired through to the site remote telecommunications supervisory control and data acquisition (SCADA) system and control operators onshore will be alerted of a fire at the OSP. A fire suppression system will be in place and manual fire extinguishers with appropriate extinguishing agents will be installed in all rooms.

Anti-Corrosion Coatings

83. The steelwork and other materials vulnerable to corrosion used in the construction of the topside will be either hot dip galvanised or coated with other corrosion protection coating during fabrication. Electrical equipment such as cooling radiators can be coated to provide resistance to scratches and impacts. Minor volumes of touch up corrosion protection coating (anticipated less than 50 l) will be housed on the OSP to deal with any areas that require maintenance.

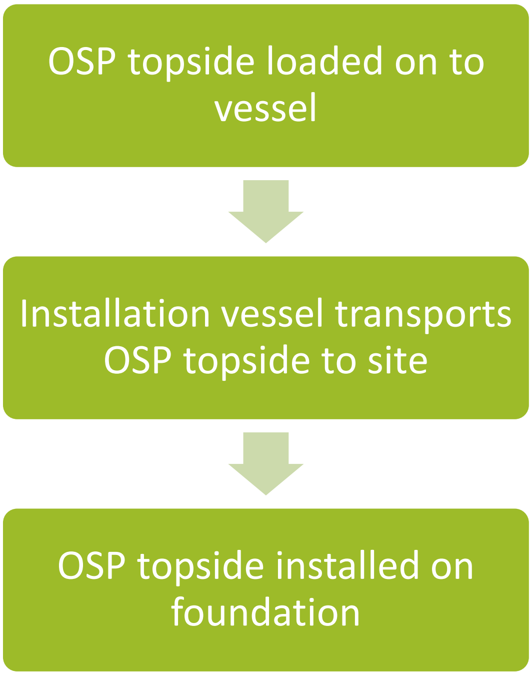
4.4.4.2 Installation of the OSP

84. Installation of the OSP foundations will be similar to the process for the installation of the wind turbine foundations described in Section 4.4.1.

85. Installation of the topside is expected to follow the general sequence shown in Illustration 4.14. The complete topside will be manufactured onshore and all electrical and mechanical equipment will be installed and pre-commissioned onshore before being transported offshore.

86. The topside will be transported offshore on either a barge that does not have an installation capability or on a heavy lift vessel that does have an installation capability. If a barge is used for transport, a separate heavy lift vessel or a jack up vessel will be used for lifting the topside onto the pre-installed foundation; it is likely the installation vessel will be supported by up to four vessels including tugs and fast response vessels.

Illustration 4.14: General sequence of topside installation



87. Once the substation is in place, the inter-array, interconnector and Offshore Export Cables will be brought into the topside and the OSP commissioning work will be undertaken.

88. Total installation is expected to take approximately 30 days per OSP exclusive of weather downtime. Illustration 4.15 shows an example of a fully installed OSP.

Illustration 4.15: Installed substation (Pictures courtesy of CG. Copyright ®vanoordbv-mennomulder.com)

4.4.4.3 OSP Interconnector Cables

89. In the event that two OSPs are used, both will be connected to shore via independent 220 kV Offshore Export Cables. If one of these Offshore Export Cables goes out of service, a level of redundancy will be provided by MV (up to 72.5 kV) interconnector cables connecting the two OSPs. Such interconnection improves export power flexibility and will be made using MV (up to 72.5kV) cables similar to that used

for the inter-array cable system. The installation and burial of this cable will be the same as that described in Section 4.4.4.4.

4.4.4.4 Inter-Array Cables

90. Inter-array cabling used to connect turbines may be rated at up to 72.5 kV (MV) AC. The cables will be steel wire armoured and will have three electrical conductor cores varying in size up to 800 millimetres squared (mm^2) with cross-linked polyethylene (XLPE) insulation. Optical data cables for SCADA, control and protection will be included within the cable bundle (or alternatively may be laid separately alongside the main inter-array cables).

91. The inter-array cabling layout will be optimised to minimise losses and capital expenditure costs and as part of the final scheme design process. There will be up to 14 collector circuits (7 connecting to each OSP), connecting up to ten turbines each, dependent on the wind turbine mode layout; these will directly link to the OSP. This connection will, mostly likely, be made after the turbine foundation installation but before the turbine installation.

92. The total length of inter-array cabling will vary slightly depending upon the final turbine layout and ground conditions but will not exceed 140 km (for inter-array and interconnector cables combined).

93. Details of the inter-array cable design and burial parameters are summarised in Table 4.12.

Table 4.12: Summary of Inter-array cable design envelope parameters

Parameter	Maximum design envelope (or indicative range)
Number of cables	14 circuits (7 connecting to each OSP)
Total length of cabling (including interconnectors if required)	140 km
Design of array	10 turbines per collector circuit
Specification of cables	XLPE AC cable rated up to 72.5 kV Size ranges from 50 mm^2 to 800 mm^2
Burial method / scour protection	Likely ploughing/cutting/jetting or rock cover, options finalised when layout is confirmed.
Width of seabed affected (per cable)	Approximately 2 m direct impact width, 8 m width of zone of minor disturbance (approximately 10 m in total).
Burial depth	Target depth 1 to 1.5m. However likely to vary across site up to 3 m. Burial may not be possible in limited areas where bedrock outcrops at seabed level or in zones where thin sediment exists over the bedrock, in this instance protection will be used.

4.4.4.5 Installation of the Inter-Array Cables

94. Inter-array cables will be buried and protected where burial is not possible in order to:

- Prevent movement or exposure of cables over the lifetime of the Project due to seabed movement;
- Protect the cables from other activities such as fishing or anchor placement;
- Protect against the small risk of dropped objects; and
- Limit the potential effects on environmental receptors from the effects of heat and or induced magnetic fields caused by the cables.

95. Due to the relatively small diameter, greater inherent flexibility and shorter route lengths involved in inter-array cable installation, different approaches can be adopted for cable installation:

- Cables can be cut to length prior to the offshore installation phase;
- Uncut cable can be loaded into a vessel cable tank or carousel (with capacity up to 80 km of cable); or

- Shorter lengths can be spooled on to an installation reel or reels, which can then be lifted onto the installation vessel.

96. The inter-array cables will be buried where possible using cable ploughs (Illustration 4.16) and/or mechanical cutters as necessary. The cable plough uses a remotely operated adjustable steel cutting tool to achieve the required trench depth. In harder soils, a mechanical cutter with a hydraulically operated chain cutter can be used. A cable installation plan that will identify specific areas for the use of the plough and mechanical cutter tools will be prepared following the detailed geotechnical investigation and cable burial assessment.

Illustration 4.16: Cable plough (Source: Prysmian Group)

97. An installation rate of approximately 2 to 3 km per day on average depending on weather conditions and soil conditions is expected to be achieved.

98. The use of water jetting is considered unlikely to be viable due to the hard soils anticipated and the potential for very shallow rock outcropping; however, it may be used in some areas of the Wind Farm Area where conditions allow, as guided by the detailed geotechnical investigation and cable burial assessment.

99. It is currently expected that additional cable protection will be required over approximately 20% of the inter-array cable length, in locations where desired burial depths are difficult to achieve; such instances would occur where bedrock outcrops at seabed level or in zones where thin sediment exists over the bedrock.

100. Several materials can be used to provide additional protection to cables, which include:

- Durable crushed or original rock of defined size range;
- Artificial fronds or seaweed;
- Concrete ‘mattresses’; and
- Bags (high strength nylon fibre) of gravel, hardened sand-cement grout, or concrete (grout/concrete pre-filled and hardened onshore). The bag option may include a technique where the grout is introduced to the nylon fibre bag offshore through proprietary pipes (the bags being permeable to water but not to grout).

101. The amount of cable protection is dependent on the mobility of the seabed near the cables and the depth of burial achieved. The width of any cable protection that may be installed above the cable is expected to be approximately 2 m and the height of the cable protection is expected to be in the order of 0.5 m above the surrounding seabed level.

102. Cable protection material, where required, would be installed using a fall pipe vessel, a vessel equipped with a wire crane with grab or by rock dumping.

103. Either a single vessel or twin vessels as detailed below may be used to undertake the inter-array cable installation.

4.4.4.5.1 *Single Vessel Installation Process*

104. A single vessel may be used to both lay and bury the cable simultaneously. Support vessels will be used to manage the recommended safe passing distance around the inter-array cable installation works (refer to Section 4.5). The single vessel inter-array cable installation process may be summarised as follows:

- The cable laying vessel approaches the first structure and the cable end is over-boarded, transited to the structure, probably by ROV, and carefully pulled into the first J-tube and temporarily fixed in position at platform level ('hung off');
- The installation vessel then over-boards the plough or trenching unit, and cable loading takes place either on the vessel back deck or subsea;
- Simultaneous lay and burial of the cable then begins using the cable burial equipment;
- At the end of the cable where the next wind turbine is approached, the plough or trenching would cease and the vessel would transit past the wind turbine foundation leaving a length of cable exposed on the seabed; and
- Following recovery of the plough or trenching tool, an ROV would be used to recover the cable end which will then be pulled up through the J-tube.

105. The length of cable - approximately up to 100 m - left unburied at the approach to each turbine has to be protected. This can be done by any of the cable protection measures identified above in Section 4.4.4.5 or alternatively an ROV can mechanically cut a trench to accomplish burial of the cable in this area.

4.4.4.5.2 *Twin Vessel Installation Process*

106. Alternatively, two vessels can be used to complete the inter-array cable installation process - one to lay the cable and the other to bury it. In this scenario, the lay and bury activities occur in much the same way as described above, but cable burial takes place from a separate trenching vessel, either simultaneously or immediately after installation and cable hang off. Post-lay trenching is likely to be less well suited for ploughing operations and better suited to a mechanical trencher. It is possible that multiple vessels could be used to install the cables simultaneously.

4.4.4.5.3 Cable Crossings

107. Inter-array cable layout designs will seek to ensure that cable crossing is avoided; however, should this prove impractical, cable crossing protection measures will be necessary. No third-party cabling or pipelines have been identified within the Development Area. However, should a cable or pipeline crossing be required, the protection would consist of one or more of the scour protection materials identified in Section 4.4.4.5.

4.4.4.5.4 *Post Burial*

108. Following the completion of burial activities, a further cable protection phase may be required to protect the cable transitions and any areas of cable exposure around the J-tubes. This cable protection will be installed using one of the processes outlined for foundation scour protection (see Section 4.4.1). The final decision concerning optimal burial methodologies will be made at a later date when further geotechnical investigations and a cable burial assessment have been carried out.

4.4.4.6 Offshore Export Cable

109. The Offshore Export Cable route selected was a balance of the shortest route possible between the OSP and the landfall, seabed conditions and environmental considerations. The Offshore Export Cable Corridor has been determined and surveyed, but the exact location of the Offshore Export Cable will be micro-sited based on a pre-cable lay survey.

110. The total length of installed Offshore Export Cable will be up to 86 km (two cables at 43 km each). The Offshore Export Cables will be laid within the Export Cable Corridor which will be a maximum width of 300 m (150 m either side of the Offshore Export Cable Corridor centre line). The Offshore Export Cables will be separated by a minimum spacing at sea of 70m, potentially extending to the edges of the 300m wide corridor in some areas, dependent on water depth. Towards the landfall at Thorntonloch, the cables will be closer. 220 kV HVAC 3-core insulated cable will be used.

111. The final design of the Offshore Export Cable system will be determined by results of geophysical and geotechnical surveys and the electrical design of the Project. Consideration will be given to minimising the number of cable joints, of both factory and offshore types, however it is currently anticipated that offshore joints will not be required. The parameters for the Offshore Export Cable are shown in Table 4.13.

Table 4.13 Offshore Export Cable design envelope parameters

Offshore Export Cable parameter	Maximum design envelope (or indicative range)
Number of cables	2
Total length of cabling	86 km
Length per cable	43 km
Specification of cables	220 kV (Um 245 kV) 3-phase AC XLPE insulated
Spacing between cables	Minimum 70 m / maximum 300 m (3x water depth but no less than 70 m)
Width of Offshore Export Cable Corridor	300 m (i.e. 150 m either side of Offshore Export Cable Corridor centre line)
Burial method / scour protection	Likely ploughing/cutting/jetting or rock cover, options finalised when layout is confirmed.
Width of seabed affected (per cable)	10 m (2m direct impact width in the centre of an up to 10m wide zone of minor disturbance from the plough skids).
Burial depth	Target depth 1 to 1.5m. However likely to vary across site up to 3 m. Burial may not be possible where bedrock outcrops at seabed level or in zones where thin sediment exists over the bedrock, in this instance protection will be used.

112. Offshore Export Cable characteristics vary depending upon cable manufacturer. An example of a typical 220 kV 3-core HVAC cable cross section is shown in Illustration 4.17. The cable typically comprises three copper conductors insulated by cross-linked polyethylene and an integral optical fibre cable (24 single mode fibres). Individual cables have an insulation screen, a lead alloy sheath and a polyethylene over sheath. The 3-core assembly is encased with a single layer steel wire armour covering and a final outer polypropylene sheath.

113. The fibre optic data cables may be included within the cable bundle for SCADA functions or alternatively separate fibre optic cables, laid in parallel with the power cables in the same cable trench may be installed.

Illustration 4.17 Illustrative export cable cross section

114. Currently, it is assumed that the Project will use subsea cables with aluminium conductors of up to 1,200 mm^2 and galvanized steel wire armouring to protect the cables. However, copper conductors may also be used.

4.4.4.7 Installation of the Offshore Export Cable

115. The cable installation methods to be adopted will be dependent on the ground conditions along the route, the final decision will be made following detailed geotechnical investigation and a burial assessment. Installation methods currently under consideration for the installation of the Offshore Export Cable include:

- Use of high-pressure pump/jets to cut trenches where sandy conditions exist. Having laid the cable, the trenches will close naturally without backfilling;
- Use of mechanical cutters or cable ploughs (as described above in Section 4.4.4.5 for the inter-array cables); and
- Laying of the cable on the seabed and covering with cable protection (protection methods as previously described for the inter-array cables - see Section 4.4.4.5) (where bedrock outcrops at seabed level or thin sediment layer is present over the bedrock).

116. The current intention is to bury the cable as far as is practicable along the entire Offshore Export Cable Corridor but the extent to which the cables will be buried will be dependent on the result of a detailed geotechnical survey and associated burial assessment process. In suitable seabed conditions, cables could be buried to a depth of up to 3 m, however, a target depth of 1 – 1.5 m is mor likely where seabed conditions allow. It is estimated that 15% of the Offshore Export Cable will require cable protection.

117. Subsea export cables are thicker and heavier than inter-array cables and land cables, and somewhat larger vessels are, therefore, typically required for installation. Illustration 4.18 depicts an example of a typical vessel commonly used for the installation of subsea export cables. The vessel has a mechanised cable turntable on deck to wind the cable on-board and to wind it off again. This vessel uses dynamic positioning and other navigational aids to maintain accurate cable laying.

Illustration 4.18: Cable lay vessel Giulio Verne (Source: Prysmian Group)

118. There are three common vessel arrangements used to install long distance cables:

- Lay and protect the cable from a single cable installation vessel (typically 2 to 3 km per day);
- Lay the cable using a cable installation vessel and protect the cable using a separate vessel, but with both vessels travelling together and working as a single unit to achieve a typical installation rate of 2 to 3 km per day; or
- Lay the cable using a cable installation vessel with a separate ship protecting the cable and both ships travelling independently. The cable installation ship could in this case travel much faster (15 to 20 km per day) and the protection vessel travelling at 2 to 3 km per day.

119. The Offshore Export Cable will need to be installed in varying water depths from the OSP to the landfall and in the intertidal zone. Based upon the water depths and nature of the seabed along the route, a dynamic positioning vessel is currently expected to offer the optimal operational flexibility across the range of cable installation operations necessary. Based upon the length and assumed weight of the cable, it is currently considered likely that each Offshore Export Cable would be laid in a single length without the requirement for a midline joint.

4.4.4.8 Installation of the Offshore Export Cable in the Intertidal Zone

120. The Offshore Export Cable landfall will be at Thorntonloch beach, to the south of Torness Power Station in East Lothian. At the landfall, the two Offshore Export Cables will be brought from the offshore cable-laying vessel, up the intertidal zone, to two adjacent transition pits located landward of MHWS – where the Onshore Export Cable and Offshore Export Cable will be connected. The transition pits and other work landward of MWHS fall under the OnTW planning permission. East Lothian Council granted planning permission for all onshore works in June 2013. For completeness, these works are described below although they are outwith the current applications for Section 36 consent and Marine Licenses.

121. This EIA assesses effects seaward of MHWS, with the EIA for the OnTW assessing effects from mean low water springs (MLWS) landward, however, information is provided below regarding works landward of MHWS for context.

122. Although a minimum spacing of between 70 and 300 m will separate the two Offshore Export Cables offshore, this will be reduced to a minimum of 10 m as the cables approach the landfall and the connection with the Onshore Export Cable. At landfall, the Offshore Export Cable will be housed in high-density polyethylene ducts installed under the beach.

4.4.4.8.1 Intertidal Zone Installation Method

123. The method of installation for intertidal works will be dependent on the ground conditions and the equipment used. Two potential options are currently being considered for installation, horizontal directional drilling (HDD) and open cut trenching. Both methods are described below.

Horizontal Directional Drilling (HDD)

124. HDD involves drilling a channel underground between two points, into which an electrical cable can be installed, without needing to excavate an open trench along the channel route (Illustration 4.19). To achieve this, an onshore drill rig commences drilling at the start of the underground channel (labelled here as the 'Rig Site'), toward the end of the channel (labelled here as the 'Pipe Site'). Using HDD, it estimated that the duration of cable installation works at the intertidal zone would be approximately 4 months.

125. The rig site will be located landward of MHWS behind Thorntonloch beach and will comprise a construction area of approximately 30 m long by 40 m wide which will contain a drill rig, an electrical generator, a water tanker, a mud recycling unit and a temporary site office. Drilling mud containing bentonite will be used to aid the drilling process and will use the output from the mud-recycling unit mixed with water for this purpose. The rig site will contain a receiving pit for the cable. This will be similar to a conventional manhole and will be approximately 2.5 m long by 1 m wide by 1 m deep.

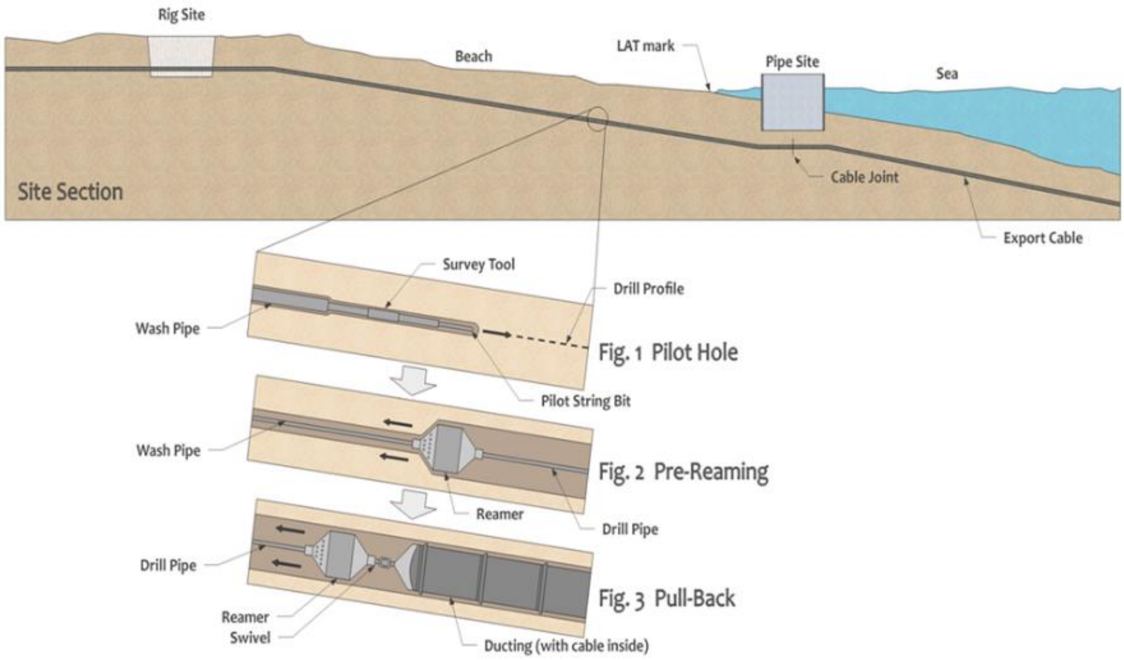
126. The pipe site would be located below (i.e. seaward of) MLWS on Thorntonloch beach and will comprise an area of up to 20 m long by 20 m wide. The precise location of the pipe site will be confirmed following the detailed design process and will be based on the geotechnical survey data that has been acquired for the intertidal zone. A jack-up platform equipped with an excavator could be used to carry out the works at this location. A circular/rectangular steel casing may be installed into the seabed to facilitate the excavation of a dry area within which a second receiving pit would be constructed. This would involve interlocking steel sheets being lifted in to place by an excavator. Here, the cable will emerge from the channel and, if required, be joined with the Offshore Export Cable. The cable will then be buried, the disturbed area reinstated and the casing removed.

127. The HDD drilling/cable installation process will comprise four stages as described below and illustrated in Illustration 4.19 below:

- A small diameter pilot hole will be drilled from the rig site to the pipe site, for the purpose of defining the path of the channel into which the cable is to be installed;
- A steel reamer will then be pulled back through the pilot hole from the pipe site to the rig site, enlarging the diameter of the hole as it progresses. This may need to be repeated a number of times, depending on the nature of the soil through which it passes, in order to enlarge the channel diameter sufficiently as to accommodate the electrical cable;
- The cable and the ducting within which it rests will then be attached to the reamer and pulled through the channel from the pipe site to the rig site, at which point it will be secured in place by means of precast concrete thrust blocks within the transition pit (or alternatively a smaller length of cable may be used with the ducting, which will then be connected to the remainder of the Offshore Export Cable and buried into the seabed); and
- The jack-up platform will be removed.

128. At the pipe site, the cable will be supplied by a cable installation vessel such that it can be drawn through the channel behind the reamer. This vessel will be required to remain a minimum distance from shore to ensure adequate water depth for operation. This distance is currently estimated to be up to approximately 1 km; however, this will be confirmed following the cable installation vessel selection and final route design process.

Illustration 4.19: Illustration of HDD process



Open Cut Trenching

129. Open cut trenching may be used as an alternative to HDD to install the Offshore Export Cable through the intertidal zone. The cables will be laid in PVC ducts (a tube that facilitates the passage of the cable and offers some protection). The required burial depth will be determined in detailed design and will include a burial risk assessment. It is currently anticipated that the burial depth to be in the order of 1 m below the current beach levels. Illustration 4.20 depicts a typical open trenching scenario.

130. Preparatory works along the intertidal zone will depend on the underlying geology. Excavators will be used to dig the necessary trenches. Should the sediment depth be insufficient, rock breakers or other mechanical cutting methods may be required to achieve the designed burial depth. Excavation will be achieved using an excavator mounted on a barge or jack-up platform in water depths up to approximately 5 m below LAT. In the deeper water beyond this point, cable burial into the bedrock can be handled by rock cutting or trenching using an ROV. The works corridor at landfall will be 30 m wide and will extend up to the onshore cable transition bays.

131. Cable ducts will be installed in the trenches from the transition pit and a temporary winch will be installed landward of MHWS for cable pull in.

132. Once the preparatory works are complete, the cable will be winched to shore from the cable-laying vessel and through the cable ducts to the onshore cable transition bays.

133. For installing cable ducts, recommended safe passing distances around the works could be required for up to circa 3 months depending on the extent of clay/bedrock excavation required with an additional minor exclusion period (estimated at 1 day) during the cable pull in. These are expected to be of the order of 50 m.

Illustration 4.20: Open cut trenching beach excavations – tracked excavators and barge-mounted excavators (Source ETA Ltd)

4.4.4.8.2 *Construction of Transition Pits*

134. The transition pits will consist of an underground structure and will house the joints that link the multi-core Offshore Export Cable with the single core Onshore Export Cable. Each circuit may have its own transition pit; located adjacent to each other with up to 5 m separation. Alternatively, both circuits could be accommodated in a single pit.

135. Each transition pit will be within a below ground excavated trench with reinforced concrete sides and base. The dimensions are likely to be approximately 10 m length by 4 m width by 3 m depth. A concrete cover will be placed over the top of the pit for protection and land above will be reinstated to its previous condition. A manhole cover may be incorporated to provide permanent access.

136. The transition pits will be excavated by a mechanical excavator after which a concrete chamber will be installed. The concrete chamber will either be constructed on site or will be brought in prefabricated. A small container will be temporarily placed on top of the transition pit to allow a clean, secure and weatherproof working environment during cable jointing. A generator will be required to provide power supplies during jointing operations and a temporary security fence and lighting will be constructed to enclose and secure the transition pits during construction.

137. An access track will need to be made to the transition pit location during construction. It is anticipated that access will be made via the Onshore Cable Corridor haul road, requiring the use of a temporary bridge across Thornton Burn.

138. Once the transition pit has been established, the Offshore Export Cable will be winched into place as part of the Offshore Export Cable installation process. A joint is then made to join the Offshore Export Cable to the Onshore Export Cable.

4.4.5 Ancillary Equipment

4.4.5.1 J-Tubes

139. A J-tube is the conduit for the inter-array cables to travel from the seabed to the work platform on the wind turbines and the OSP(s). J-tubes will be attached to the foundations as part of the onshore fabrication works. The inter-array cables within the J-tubes have to be protected where they emerge

at the base of the foundation. Where necessary, cable protection in the form of, for example, durable mattresses pre-filled with stone, will be used to protect the cable between the base of the foundation and the point of burial. Further details on such cable protection measures are provided in Section 4.7.1.4.

4.4.5.2 Access Facilities

140. A boat landing, ladders, hoists and fenders will be located on the foundation to allow safe access to the wind turbine / OSP(s) for maintenance and operation. These facilities will be constructed and installed on the structure during the fabrication of the foundation at the onshore fabrication yard.

4.4.5.3 Transition Piece

141. Dependent upon the nature of the foundation, a means of connecting wind turbine towers to the foundation is required. Hence, a transition piece, which has standard tower attachments, typically bolted flanges on one end and a foundation specific arrangement on the other, is used.

4.4.5.4 Colour Scheme and Navigational Markings

142. The turbines and associated support structures will be marked according to the requirements of the Northern Lighthouse Board (NLB). Consultation is ongoing but the colour of the turbine tower, nacelle and blades is likely to be light grey RAL 7035. The transition piece and tower will be yellow above LAT to an agreed height above highest astronomical tide (HAT).

143. As for the turbines, the OSP(s) will be marked according to the requirements of the NLB. Navigation markings may be allocated solely to a number of wind turbines in the field.

4.4.5.5 Aviation Lighting

144. The legal requirement for offshore wind turbine aviation lighting is stipulated in Article 223 of the Air Navigation Order 2016 (reproduced in CAP393 Air Navigation: The Order and the Regulations), with other documents providing further policy information and guidance. It is noted that the Air Navigation Order only requires medium intensity red lighting to be fitted to turbines on the periphery of a group of turbines subject to approval by the Civil Aviation Authority (CAA). Additional requirements relate to the requirement for lighting and marking relating to the use of helicopter landing facilities on turbines and also for the purposes of assisting Search and Rescue (SAR) operations.

145. Aviation lighting for the final layout design will be agreed with the CAA (and in relation to SAR operations with the Marine Coastguard Agency (MCA)).

146. Three types of lighting are mandatory on wind turbines: medium intensity red lights, low intensity green lights, and low intensity red lights. In addition, low intensity infrared (i.e. invisible to the eye) lighting may be requested.

4.4.5.6 Diesel Generators

147. In the event that the grid connection works are late, then completion and ‘cold’ commissioning works can instead be performed using diesel generators in combination with dehumidifiers and ’soft starters’ all to work with and be governed by the wind turbine controller. These diesel generators, with a fuel tank capacity of 1,000 l, will be housed in offshore-certified double-skin containers (akin to standard shipping containers) that will be mounted on the wind turbine platforms. The generators will also serve to provide back up in the event of a grid outage.

4.5 Safety Zones

148. NnGOWL will apply to the Scottish Ministers for a notice declaring safety zones around construction activities and in the vicinity of offshore structures thereafter under specific scenarios. The safety zone notice will be applied for under Section 95 of the Energy Act 2004 in accordance with Schedule 16 of the Energy Act 2004 and the Electricity (Offshore Generating Stations) (Safety Zones) (Application Procedures and Control of Access) Regulations 2007.

149. The safety zones during the construction period will have a radius of 500 m from the outer edge of the proposed turbine and OSP locations during periods when installation vessels are in operation. The safety zone will reduce to a radius of 50 m if there is no installation vessel operation in the location and/or there are no personnel on the offshore structure. This would also apply to locations where piles have been installed but jackets have not yet been attached. The safety zones will limit all non-project vessels from entering the safety zones.

150. From time to time during the construction programme and in consultation with the regulators, NNGOWL may issue Notices to Mariners (NtM) suggesting recommended safe passing distances in addition to that covered by the safety zone notice to accommodate installation vessels with larger anchor spreads. NtM will also be issued suggesting recommended safe passing distances in respect of the Offshore Export Cable and inter-array cable installation works. This is to protect both the construction vessels and other vessels using the surrounding area.

151. During the operational phase, NnGOWL may apply for a safety zone of 50 m radius around the turbines and OSP(s). This will be considered in discussion with the MCA. An alternative would be to issue Notices to Mariners (NtM) suggesting recommended safe passing distances around the operational turbines and the OSP(s) to protect both the operational turbines, routine turbine maintenance vessel and technicians and other vessels using the Wind Farm Area or surrounding area.

152. In the event of major maintenance works, NnGOWL will apply for a notice declaring safety zones around the location where the maintenance work is taking place. The safety zone would have a radius of 500 m from the outer edge of the proposed wind turbine location / OSP during periods when major maintenance vessels (such as, for example, jack-up vessels required for major component repairs or replacements) are in operation.

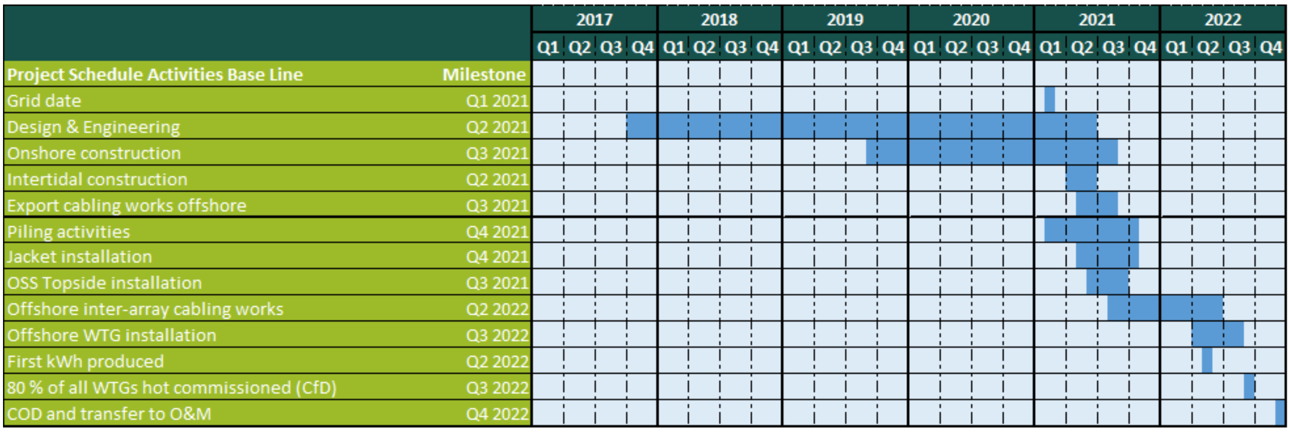
4.6 Construction Programme

153. The construction programme for the Project will be dependent on a number of factors, which include:

- Grid connection dates specified in the grid connection agreements with National Grid Electricity Transmission plc;
- The date that consents are granted; and
- The availability and lead times associated with procuring and installing the Project components.

154. An indicative Project construction schedule is shown in Illustration 4.21. This is based on consent being achieved in the fourth quarter (Q4) of 2018. The offshore construction activities are expected to start in 2020/21 and work will occur over approximately 2 to 3 years. Activities may not be continuous and the sequence of activities may change.

Illustration 4.21: Indicative construction programme



155. 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 programme.

156. The above durations for the major works are subject to change, which may arise, for example, from weather, site conditions, equipment lead times and supply programmes, detailed execution planning, sequential work requirements, plant availabilities and logistical issues.

4.7 Operation and Maintenance

157. The Project will be designed to operate with minimum day-to-day local intervention over its lifetime. Individual turbines will be monitored and controlled in the first instance using on-board microprocessor controls, faults can then be diagnosed and the turbine will shut down automatically if necessary. The SCADA system will transmit signals and commands to and from the Wind Farm to an onshore control room, to provide oversight and control.

158. Each turbine and the OSP control system will be linked to the onshore monitoring facilities via optical cables contained within the inter-array cables and Offshore Export Cable (or laid parallel to the inter-array and Offshore Export Cables).

159. Provision will be made to control the Offshore Wind Farm from a number of locations, which will be determined as part of the final project design, this may include:

- Onshore operations base;
- Operation and maintenance (O&M) offshore facility – e.g. Service Operations Vessel (SOV); and
- All wind turbines and the OSP(s) will have an internal emergency shutdown capability, which would automatically be triggered in the event of certain key component or system malfunctions.

4.7.1 O&M Requirements

4.7.1.1 Maintenance of Wind Turbine and OSP Foundations

160. Each foundation will be subject to routine inspections that will check the structural integrity of the foundation, ancillary equipment such as access ways and J-tubes, and the effectiveness of anti-corrosion measures in place. Marine growth may be removed in certain circumstances, particularly if near any access points, or if its loading effect on the foundation is considered excessive. In typical normal operating conditions, it is expected that up to two such inspection visits will be necessary per year per foundation.

161. Alternative approaches to prevention and removal of marine growth, including using semi-submersible scrubbers powered by waves (Illustration 4.22) are also being considered. In the event that marine

growth needs to be removed, conventional power washing using a high-speed water spray will typically be used. Subsea investigations and remedial works will be carried out by ROV or by divers as necessary.

Illustration 4.22: Marine growth prevention solutions (Source: FoundOcean Ltd)

4.7.1.2 Maintenance of the Wind Turbines

162. Maintenance can be categorised into different levels, as follows:

- **Local Resets** - frequent events where a maintenance crew does a local visual inspection. It is estimated that there will be up to 10 such visits per turbine per year.
- **First Line routine scheduled maintenance** - visits include changing out consumables and worn parts as part of a preventative maintenance regime. It is anticipated that two such visits per year per turbine will be required. Lubricants, hydraulic oils and any other hazardous liquids and materials will be disposed of through licensed recycling contractors onshore.
- **Second Line unscheduled maintenance** - to replace parts that have failed, where access is achieved using conventional workboats.
- **Third Line unscheduled maintenance** - to replace major components, requiring the use of a jack-up or similar large vessel on site. These major visits are typically infrequent and have a likelihood of occurrence of up to three times per annum across the full Wind Farm. Activities might involve disassembly and replacement of components, such as, for example, blades, gearboxes etc.

4.7.1.3 Maintenance of the OSP(s)

163. The OSP(s) will be subject to regular inspections and planned maintenance regimes. Emergency systems, circuit breakers and transformers will be checked regularly. Dissolved gas analysis and protection testing will be carried out on the transformers.

164. Control and protection equipment tends to have an operational life of between 15 and 20 years and may therefore require replacement within the lifetime of the Project. Transformers typically have useful life spans in excess of 20 to 25 years and may therefore also require replacement within the lifetime of the Project.

4.7.1.4 Maintenance of the Offshore Export Cable and Inter-Array Cables

165. The inter-array and Offshore Export Cables will be inspected regularly by use of a crew transfer vessel (CTV) mounted sonar or other suitable technology. The frequency of such inspections will be determined on a risk basis but will most probably be carried out during the summer months. Such operations will seek to check the integrity of the cable, cable burial and cable protection around J-tubes.

166. Should remedial action become necessary, a variety of measures may be viable, including additional rock dumping, mattressing, or the use of cable laying vessels with remote cable burial ROV to rebury the cable.

4.7.1.5 Resourcing the O&M Requirements

167. Careful consideration is being given to the nature of O&M for the Project. There are two options currently being considered: an offshore operations base and an onshore operations base.

168. A preferred solution has not been selected at this time. Both options are described in more detail in Sections 4.7.1.6 and 4.7.1.7.

4.7.1.6 Offshore Operations Base

169. An offshore operations base would be expected to include:

- Operations control centre;
- Accommodation quarters;
- Storage facility for spare parts;
- Workshop facilities;
- Medical centre;
- Walk-to-work system;
- Helideck or a wind zone (heli-hoisting area);
- Helicopter fueling facilities; and
- Workboats to convey maintenance crews within the Wind Farm Area.

170. A number of options are available to serve the purposes of an offshore operations base. A typical example is a SOV that incorporates the features above and moves around the site to transfer personnel using a specialised transfer system and position keeping system.

171. Maintenance crews would be deployed either directly from the SOV, or by smaller special purpose workboats, which can be recovered to the SOV using on-board cranes/davits.

172. A typical operational crew roster would probably contain the following disciplines:

- Turbine maintenance technicians;
- Marine traffic and works controllers;
- HVAC engineers and technicians;
- Offshore supervisory staff;
- Offshore technical staff; and
- Ship and work boat crew.

173. Workboats associated with the SOV would probably be catamaran type vessels. The davit arrangements proposed would be capable of launching or recovering vessels and crew from the water on the lee side of the SOV even during relatively severe weather, due to the shelter afforded by the SOV.

174. The intention, however, would be for the majority of transfers to take place directly from the SOV to a wind turbine or OSP. Additionally, crew transfers and provisioning, and spare parts replenishment would take place on a fortnightly basis at port, further minimising risk to personnel during the transfer process.

4.7.1.7 Onshore Operations Base

175. The alternative to an offshore-based O&M approach is the use of a local port or harbour. The onshore operations base would ideally be situated within 50 km of the Wind Farm Area. A port / harbour facility, with capability for mooring the respective vessels would be necessary. Local offices, together

with storage facilities for spare parts and portside light duty craneage would also be required. In addition, it would be advantageous if the location had facilities for vessel maintenance.

176. In this scenario, technicians together with their tools and spares will be transferred from the O&M port or harbour to the respective wind turbine or OSP. There are a number of different vessels available that can be used for this purpose, including CTVs or large offshore supply vessels equipped with a 'walk-to-work' system. The best vessel will be chosen for the respective campaign to be undertaken and for regular corrective maintenance it is estimated that two or three CTVs will be operated from the onshore operations base supported by a helicopter based close to the facilities (see Section 4.7.1.8).

177. The CTVs will be capable of making the transit to shore as and when necessary in all but the most extreme conditions. They will most likely be dual hull for added stability and have purpose built access platforms to assist transits to and from offshore structures (Illustration 4.23). The vessels will be certified and be licensed to carry up to 14 persons (12 technicians, plus crew).

178. Methods for the transfer of maintenance personnel from CTVs to Wind Turbines and OSPs are continually being developed. It is likely that by the date of operation, effective systems will be commercially available. This factor may also have a significant impact on the O&M strategy selected.

Illustration 4.23 Example of CTV (Source: Windcat Workboats)

179. Major non-routine maintenance activities as described in Section 4.7.1.2 and Section 4.7.1.3 would likely involve the use of a jack-up vessel or similar large vessel. Such a vessel would not be based at the onshore operations base, but rather contracted as necessary from the market.

4.7.1.8 Helicopter Access

180. Under the onshore operations base scenario, helicopter transfers may also be used. The use of a helicopter is envisaged for troubleshooting, particularly when performing wind turbine resets and addressing minor defects, or to facilitate access by technicians at times when sea states do not permit access by the vessels described above.

181. Approximately 80 round trips to the Wind Farm Area are anticipated per annum for a small helicopter.

4.7.1.9 Repairs

4.7.1.9.1 Cable Repair or Replacements

182. The cable burial and protection measures are designed to avoid accidental cable damage from third parties. However, industry experience suggests that it is prudent to plan for less than five unexpected cable repairs. The process involved means that approximately 100 – 150 m of cable would be replaced on each occasion.

183. In the event that major repairs are necessary, it is envisaged that the following processes will be followed:

- Identify location of cable damage (this will use SCADA system);
- Mobilise cable repair vessel and use an ROV to Instigate cable de-burial and cutting of the cable at the damage location;
- Pull one end of the cable on board and remove the damaged section;
- Connect a repair section of cable with a cable joint prepared on the vessel;
- The jointed end of repaired section is over-boarded leaving the other end on the vessel;
- The cable repair vessel is moved and recovers the second end of the damaged cable (and removes the damaged section there). A second joint is made on the vessel; and
- The repaired cable loop on overboarded and the cable buried.

4.7.1.9.2 Turbine Nacelle or Blade Replacement

184. The turbine nacelle and blades are subject to type testing and certification, and therefore replacement is not expected. However, industry experience suggests that it is prudent to plan for accidental damage on up to 10% of the turbines.

185. In the event of a major turbine repair being required (e.g. gear box or blade replacement), the replacement elements will be delivered on a either a jack-up platform or a floating vessel with a crane. The characteristics of such a jack-up platform or floating vessel would be similar to those described in Table 4.5. The repair works would be completed from a single location (i.e. no moves required).

4.8 Decommissioning

186. A Decommissioning Programme (or Decommissioning Scheme) will be submitted to Scottish Ministers, for approval, prior to the commencement of construction in accordance with Section 62 of the Scotland Act 2016, which transfers the functions of the Energy Act 2004 (Section 105-114) where it relates to decommissioning of offshore renewable projects.

187. Prior to the commencement of any decommissioning works, the Decommissioning Programme will be reviewed and revised as required to take account of good industry practice at that time. The following sections set out the currently anticipated approach to the decommissioning process.

4.8.1 Decommissioning and Removal of Foundations

188. Current practice for offshore jacket installations is to cut pile foundations below the seabed level using either an abrasive water jet or a diamond wire cutter. The jacket is then raised to the surface and removed to a suitable onshore site for recycling. Removal of the entire embedded pile is currently considered impractical and is also considered likely to lead to unnecessary environmental impacts.

189. The following sequence of operations is likely to be followed during foundation decommissioning:

- Underwater inspection using ROV;
- Heavy lift anchoring points will be established and made good;
- Removal of any marine growth and or debris with the potential to impact later cutting activities;
- Establish lifting points for decommissioning vessel;
- Cut piles at circa 1 m below seabed level;
- Raise jacket to the surface for removal from site; and
- Seabed inspection and final clearance.

4.8.2 Decommissioning and Removal of Wind Turbines

190. Removal of wind turbines, either for replacement or for final decommissioning, is likely to be the reverse of the installation procedure. The sequence of activity is expected to be:

- Conduct inspection to identify any safety or operational hazards;
- Disconnect wind turbine from electrical and control networks;
- Removal and appropriate disposal of any hazardous liquids or materials;
- Mobilise decommissioning vessel or barge to site;
- Remove blades, rotor, nacelle and tower section in that order; and
- Transport components to designated recycling site onshore.

4.8.3 Decommissioning of Offshore Electrical Infrastructure

4.8.3.1 OSP(s)

191. The OSP(s) will be removed and processed for decommissioning after the operational lifetime of the Project. The following steps will be taken:

- De-energise and isolate the Wind Farm from the grid system;
- Marshal the appropriate lift vessels to the wind farm location;
- Cut or disconnect and remove cables from the OSP;
- Removal and proper processing of all hazardous substances and fluids such as oil from reservoirs;
- Transport the topside to shore, intact if possible. Otherwise, it may be necessary to deconstruct the topside into smaller modules to be transported; and
- Once onshore, the topside will be deconstructed. All components will be taken to the appropriate facility for processing for either reuse, recycling, or disposal.

192. Where possible, components will be removed from the Wind Farm Area intact and disassembly will take place onshore at an appropriate facility to minimise risks of spillage and to optimise safety.

193. Foundations will be removed in line with the procedures outlined in Section 4.8.1.

4.8.3.2 Inter-Array Cables

194. The current industry standard is to leave Inter-array cables in situ. However, as per foundations, best practice will be followed at the time of decommissioning.

195. If cable removal is required, this will typically be done using a water jetting or grapnel tool. The cable will be lifted at both ends and spooled onto a cable drum. Typically, the cable can be recycled after recovery.

196. Any cables that are cut during removal of the wind turbines or OSP(s) will be removed and reused, recycled and/or disposed of appropriately.

4.8.3.3 Offshore Export Cable

197. The Offshore Export Cables will be removed if necessary in a similar manner to that described for the inter-array cabling (Section 4.8.3.2).

4.8.3.4 Transition Pit(s)

198. Similar to the remainder of the Onshore Export Cable, it is likely that the transition pit(s) will be left in situ, as removal will result in significant disturbance to the local environment. Contingency plans will be developed to ensure that appropriate actions are taken should the transition pit be disturbed or exposed following decommissioning of the Project.

4.8.4 Repowering

199. The Crown Estate Scotland (CES) lease for the Development Area is for 50 years and this EIA assesses the Project over that lifetime. If, during that time, repowering is considered necessary, that would require a new consent application and a new EIA. The Application and the Project EIA therefore do not include for repowering.

4.9 The Forth and Tay Offshore Wind Farms

200. There are currently several major offshore wind farm development sites in the Firth of Forth and Tay – Inch Cape, Seagreen and the Project (Figure 4-4). The original consents for these projects, issued by Scottish Ministers in 2014, were subject to lengthy Judicial Review proceedings. In parallel with the judicial review proceedings, both Inch Cape and Seagreen submitted requests for scoping opinions, accompanied by Scoping Reports, seeking an opinion on the matters to be addressed in an EIA Report to accompany new consent applications. It is the current understanding that these new applications are likely to be submitted to Scottish Ministers in the coming months. Based on information provided by the developers of each project and the information set out in the respective Scoping Reports and Scoping Opinions, NnGOWL understands that these applications will be for revised project design envelopes (when compared to the originally consented projects).

201. Table 4.14 summarises the key changes to the design parameters for the Inch Cape and Seagreen revised consent applications when compared to the parameters set out in the existing consents.

Table 4.14 Summary of changes between original and revised project design envelopes – Inch Cape and Seagreen phase 1 (based on the summary provided in the respective scoping opinions issued by the Scottish Ministers and additional information provided by Inch Cape

Parameter	Inch Cape		Seagreen	
	2014 Consent	Proposed Application	2014 Consent (Alpha and Bravo Combined)	Proposed Application – Phase 1
Maximum number of turbines	110	Up to 72	150	120
Maximum turbine capacity	-	-	7 MW	15 MW
Minimum blade clearance (above LAT)	27 m	30.5 m	29.8 m	29.8 m
Maximum Hub Height (above LAT)	129 m	176 m	126 m	140 m
Maximum blade tip height (above LAT)	215 m	291 m	209.7 m	280 m
Maximum rotor diameter	172 m	250 m	167 m	220 m
Minimum separation between turbines	820 m	1,278 m	835 m	1,000 m
Jacket piling:				
Maximum drilling/piling events (based on four piles per turbine)	852	288	600	480[2]

[2] The Scoping Report for Seagreen Phase 1 stated that monopile foundations were being considered. No design information is available for monopile foundations, therefore, only jacket foundations are considered throughout this EIA Report.

Parameter	Inch Cape		Seagreen	
	2014 Consent	Proposed Application	2014 Consent (Alpha and Bravo Combined)	Proposed Application – Phase 1
Maximum piling hammer energy	1,200 kJ	2,400 kJ	1500 kJ	2300 kJ

4.10 Summary of the Neart na Gaoithe Design Envelope – Key Parameters

Table 4.15 Table of Project Specifications

Parameter	Design envelope (maximum or indicative range unless otherwise stated)
Project	
Wind Farm Area	105 km^2
Offshore Export Cable Corridor width	300 m
Offshore Export Cable length	43 km
Distance from shore to closest point of Wind Farm Area	Approximately 15.5 km
Project output	450 MW
Number of wind turbines	54
Number of OSPs	2
Number of met masts	1
Wind Turbine Foundations	
Jacket type	Steel lattice
Jacket leg spacing at seabed level	35 m x 35 m
Details of seabed preparation	Clearance of any debris found A seabed template with up to 6 legs will sit temporarily on the seabed during pile installation for the OSP foundations.
Foundation pile diameter	3.5 m
Number of piles per foundation	6
Foundation bed penetration depth (piling)	50 m
Piling installation method	▪ Driven only piling; ▪ Drive-drill-drive; or ▪ Drill only.
Indicative Foundation installation overall duration (per foundation)	Pile Driving (6-21 hours for up to 6 piles) Pile Drilling (62-180 hours for up to 6 piles) This includes time for setting up and changing equipment between piling locations. Jacket installation (12-24 hours). Concurrent piling activities: pile driving or pile drilling at two locations concurrently (either on same vessel or on an independent vessel).
Weight of jacket	1,000 tonnes
Diameter of main jacket tubulars	3m
Seabed occupied by jacket leg (piles and scour protection)	300 m^2 per leg for four-legged jacket. 108 m^2 per leg for a six-legged jacket.

<table>
<tr><th colspan="2">Parameter</th><th colspan="2">Design envelope (maximum or indicative range unless otherwise stated)</th></tr>
<tr><th colspan="4">Pile Installation</th></tr>
<tr><td colspan="2">Soft start duration</td><td colspan="2">30 min</td></tr>
<tr><td colspan="2">Applied hammer energy during soft start</td><td colspan="2">360 Kilojoules (kJ)
(20% of max energy for an IHC 1800 hammer)</td></tr>
<tr><td colspan="2">Driving duration at maximum energy</td><td colspan="2">up to 180 min</td></tr>
<tr><td colspan="2">Applied hammer energy at maximum energy</td><td colspan="2">1,635 kJ
(approx. 90% of max energy for an IHC 1800 hammer)</td></tr>
<tr><th colspan="4">Installation Vessel</th></tr>
<tr><th>Vessel Type</th><th>Vessel parameter</th><th>Minimum design envelope</th><th>Maximum design envelope</th></tr>
<tr><td rowspan="4">Jack up Vessel</td><td>Jack-up moves per foundation installation</td><td>1 (pile installation)
1 (jacket installation)</td><td>3 (pile installation)
1 (jacket installation)</td></tr>
<tr><td>Leg spacing of jack-up</td><td>50 m x 50 m</td><td>100 m x 100 m</td></tr>
<tr><td>Number of spud cans</td><td>4</td><td>8</td></tr>
<tr><td>Spud can footing area (per vessel)</td><td>1 m^2 (leg area without spud can)</td><td>106 m^2</td></tr>
<tr><td rowspan="2">Floating Vessel</td><td>Number of anchors</td><td>0 (position on Dynamic Positioning (DP) only)</td><td>8</td></tr>
<tr><td>Anchor mooring length</td><td>200 m</td><td>1,200 m</td></tr>
<tr><th colspan="4">Wind Turbines</th></tr>
<tr><td colspan="2">Number of turbines</td><td colspan="2">54</td></tr>
<tr><td colspan="2">Rotor tip height (above LAT)</td><td colspan="2">208 m</td></tr>
<tr><td colspan="2">Rotor diameter</td><td colspan="2">167 m</td></tr>
<tr><td colspan="2">Hub height (above LAT)</td><td colspan="2">126 m</td></tr>
<tr><td colspan="2">Minimum air gap clearance to blade tip (above LAT)</td><td colspan="2">35 m</td></tr>
<tr><td colspan="2">Height of platform</td><td colspan="2">21 m</td></tr>
<tr><td colspan="2">Minimum wind turbine spacing (approximate)</td><td colspan="2">800 m</td></tr>
<tr><th colspan="4">Wind Turbine Oil or Fluid</th></tr>
<tr><td colspan="2">Grease</td><td colspan="2">250 litres (l)</td></tr>
<tr><td colspan="2">Hydraulic oil</td><td colspan="2">600 l</td></tr>
<tr><td colspan="2">Gear oil</td><td colspan="2">2,100 l</td></tr>
<tr><td colspan="2">Transformer silicon / ester oil</td><td colspan="2">3500 kilograms (kg)</td></tr>
<tr><th colspan="4">Met Mast</th></tr>
<tr><td colspan="2">Number of met masts</td><td colspan="2">1</td></tr>
<tr><td colspan="2">Height (above LAT)</td><td colspan="2">140 m</td></tr>
<tr><td colspan="2">Jacket leg spacing</td><td colspan="2">35m x 35 m</td></tr>
<tr><td colspan="2">Foundation pile diameter</td><td colspan="2">3.5 m</td></tr>
<tr><td colspan="2">Foundation material</td><td colspan="2">Steel (jacket and piles)</td></tr>
<tr><td colspan="2">Pile depth below sea-bed</td><td colspan="2">50 m</td></tr>
</table>

<table>
<tr><th>Parameter</th><th colspan="2">Design envelope (maximum or indicative range unless otherwise stated)</th></tr>
<tr><td>Met mast safety features</td><td colspan="2">Fog Detector – VF-500 Visibility Sensor: Uses forward scatter sensor technology to measure visibility in all weather conditions. The visibility sensor acts as the on/off switch for the foghorn.
2 nautical mile (NM) fog horn: Automatically broadcasts (when required by the fog detector) a 360o beam of sound to a pre-selected code audible for 2 NM. Sound Signal: Morse.</td></tr>
<tr><th colspan="3">Offshore Substation Platforms (OSPs)</th></tr>
<tr><td>Number of OSPs</td><td colspan="2">2</td></tr>
<tr><td>Height of topside (above LAT)</td><td colspan="2">21 m</td></tr>
<tr><td>Height to top of crane / helicopter pad (above LAT)</td><td colspan="2">60 m (above LAT)</td></tr>
<tr><td>Length x width of topside</td><td colspan="2">40 m x 40 m</td></tr>
<tr><td>Weight of topside</td><td colspan="2">1,000 - 3,500 tonnes</td></tr>
<tr><th colspan="3">OSP Major Plant (two OSP scenario)</th></tr>
<tr><th>Plant item</th><th>Quantity</th><th>Features</th></tr>
<tr><td>Transformer</td><td>One large transformer and up to 2 small auxiliary transformers on each of the two OSPs.</td><td>Oil filled transformer complete with oil bunding designed to capture any leakages. NB. gas-insulated (using sulphur hexafluoride (SF_6)) and dry auxiliary transformers are also being considered, which would not require oil.</td></tr>
<tr><td>Transformer cooler</td><td>To be determined during detailed design of the transformer.</td><td>Contained within ventilated (louvres on external wall), perimeter enclosure</td></tr>
<tr><td>Medium voltage switchgear</td><td>One 33 kV switchboard with a minimum of 11 circuit breakers on each OSP.</td><td>Modular, gas insulated switchgear (up to 72.5 kV)</td></tr>
<tr><td>220 kV breakers</td><td>One on each OSP</td><td>Modular, gas insulated unit. Number depending on final design of protection system</td></tr>
<tr><th colspan="3">OSP Foundations</th></tr>
<tr><td>Jacket type</td><td colspan="2">Steel lattice</td></tr>
<tr><td>Jacket leg spacing at seabed level</td><td colspan="2">60 m x 60 m</td></tr>
<tr><td>Details of seabed preparation</td><td colspan="2">Clearance of any debris found.
A seabed template with up to 8 legs will sit temporarily on the seabed during pile installation for the turbine foundations.</td></tr>
<tr><td>Pile diameter</td><td colspan="2">3.5 m</td></tr>
<tr><td>Number of piles per foundation</td><td colspan="2">8</td></tr>
<tr><td>Pile penetration depth</td><td colspan="2">50 m</td></tr>
<tr><td>Pile installation method</td><td colspan="2">Drive only, drive-drill-drive or drill only</td></tr>
<tr><td>Indicative foundation installation duration (per foundation)</td><td colspan="2">Pile Driving (maximum of 21 hours for up to 8 piles)
Pile Drilling (maximum of 180 hours for up to 8 piles)
This includes time for setting up and changing equipment between piling locations.
Jacket installation (maximum of 24 hours).</td></tr>
<tr><td>Weight of jacket</td><td colspan="2">2,500 tonnes</td></tr>
<tr><td>Diameter of main jacket tubulars</td><td colspan="2">3 m</td></tr>
</table>

Parameter	Design envelope (maximum or indicative range unless otherwise stated)
Seabed occupied by jacket leg (piles and scour protection)	300 m^2 per leg
Inter-array and Interconnector Cables	
Number of cables	14 circuits (7 connecting to each OSP)
Total length of cabling (including interconnectors if required)	140 km
Design of array	10 turbines per collector circuit
Specification of cables	XLPE AC cable rated up to 72.5 kV Size ranges from 50 mm^2 to 800 mm^2
Burial method / scour protection	Likely ploughing/cutting/jetting or rock cover, options finalised when layout is confirmed.
Width of seabed affected (per cable)	Approximately 2 m direct impact width, 8 m width of zone of minor disturbance (approximately 10 m in total).
Burial depth	Target depth 1 to 1.5m. However likely to vary across site up to 3 m. Burial may not be possible in limited areas where bedrock outcrops at seabed level or in zones where thin sediment exists over the bedrock, in this instance protection will be used.
Offshore Export Cables	
Number of cables	2
Total length of cabling	86 km
Length per cable	43 km
Specification of cables	220 kV (Um 245 kV) 3-phase AC XLPE insulated
Spacing between cables	Minimum 70 m / maximum 300 m (3x water depth but no less than 70 m)
Width of Offshore Export Cable Corridor	300 m (i.e. 150 m either side of Offshore Export Cable Corridor centre line)
Burial method / scour protection	Likely ploughing/cutting/jetting or rock cover, options finalised when layout is confirmed.
Width of seabed affected (per cable)	10 m (2m direct impact width in the centre of an up to 10m wide zone of minor disturbance from the plough skids).
Burial depth	Target depth 1 to 1.5m. However likely to vary across site up to 3 m. Burial may not be possible where bedrock outcrops at seabed level or in zones where thin sediment exists over the bedrock, in this instance protection will be used.