7 *PROJECT DESCRIPTION*

7.1 *INTRODUCTION*

1. This Section provides a description of the Project, comprising the Wind Farm and OfTW. Onshore Transmission Works (OnTW) are required to connect the OfTW to the grid however these works are the subject of a planning application and a separate EIA and are not considered in this ES.

2. This Section contains the following elements:

- Site Description – provides a description of the site location and characteristics ;
- Definition of the Project – defines the scope of the project for EIA purposes and outlines the Rochdale Envelope Parameters used for technical assessments;
- Description of each principal component of the Wind Farm;
  - Wind Turbines – provides turbine specification, operational characteristics and proposed methods of installation;
  - OSPs – outlines purpose and likely specification of the platforms including substructures, foundations and method of installation;
  - Meteorological Masts – explains the purpose of the masts and provides details on likely specification, location and methods of installation;
  - Foundations and Substructures – explains purpose of foundations and substructures, outlines different types that may be used and details probable methods of construction and explains the zone of influence of these structures on the seabed;
  - Scour Protection – explains the need for scour protection and outlines the measures available to the Project;
  - Inter Array Cables – provides the range of specifications under consideration in terms of cable size and depth and details probable methods of installation and protection; and
  - Other Wind Farm Infrastructure – details the requirements for metocean buoys and Close Circuit Television (CCTV); likely location and method of installation.
- Offshore Transmission Works;
  - Provides details of the export cable including route corridor and specifications of the types of cables and protection that could be used.
- Construction Programme and Logistics;
- Operation and Maintenance; and
- Decommissioning.

3. This Section makes reference to the following:

- Annex 7A: Underwater Noise Modelling Technical Report.

4. A glossary of terms is provided at Appendix 7.1.

7.2 *SITE DESCRIPTION*

7.2.1 SITE LOCATION

5. The Project Boundary comprises the Wind Farm Site and the OfTW Corridor.

6. The Wind Farm Site is located approximately 25 km south south-east of Wick, Caithness located on the Smith Bank, a bathymetric high in the outer Moray Firth. The Wind Farm Site is, at its closest point, 13.5 km from the coastline (Figure 1.1).

7. The site is approximately 19 km in length and 9 km in width at the maximum extents of the site, covering an area of approximately 131.5 km^2.

8. The Beatrice oil and gas licence areas 11/30A and 12/26C are located to the south west of the Wind Farm Site, as shown on Figure 4.3. Beyond these, at a distance of approximately 11 km lie the two existing Beatrice demonstrator turbines. The proposed Moray Firth Round 3 Zone is located adjacent to the east of the Wind Farm Site. Full details of the oil and gas activities in the vicinity of the Project are provided in Section 30: Other Issues.

9. The OfTW corridor is approximately 65 km in length and varies between 575 m - 1.54 km in width running between the Wind Farm Site and the MHWS landfall point. It leaves the south of the Wind Farm Site and follows the northern boundary of the Moray Firth Round 3 Zone. At the point where it reaches the 3.7km 2 (NM) turbine exclusion zone enforced around the Beatrice A offshore platform (shown in Figure 1.2) the route turns south and exits the turbine exclusion zone passing through the Moray Firth Round 3 Zone Western Development Area (see Figure 4.2) towards the landfall at Portgordon on the Moray coastline. Note that the scope of this Application and ES ceases at MHWS.

7.2.2 GENERAL SITE CHARACTERISTICS

10. With the exception of the coastal stretch, the seabed in the Smith Bank has water depths varying between 38 m and 80 m. The Wind Farm Site has a minimum water depth of 38 m and a maximum of 68 m. There is a predominance of granular surface sediments across the Wind Farm Site, except in the shallowest parts of Smith Bank, where the underlying till is largely exposed with little sediment veneer. The surface sediments are typically medium sands (250 to 500 µm diameter) with little (i.e. less than 5%) or no measurable content of fines (less than 63 µm).

11. There are no known wrecks within the Wind Farm Site, nor are there any protected areas or designated sites.

12. The mean neap tidal range is 1.4 m, the mean spring tidal range is 2.8 m, and the maximum (astronomical) tidal range is 4 m. Peak tidal current speeds over Smith Bank are generally 0.25 metres per second (m/s) during mean neap tides and 0.50 m/s during mean spring tides.

13. The prevailing wind at the Wind Farm Site is from the south west.

14. The OfTW corridor lies within an area of water depths ranging up to 100 m. Despite this variation, the slopes are generally gentle.

7.3 DEFINITION OF THE PROJECT

15. Due to uncertainties associated with offshore construction it is not possible to define a detailed project design at this point in the development process.

16. Aspects of the Project that cannot be determined at this stage include:

- Model, dimensions and precise location of turbines;
- Foundation and substructure types;
- Lengths and layout of inter array cables;
- Extent of cable to be surface laid or buried;
- Transmission system i.e. Alternating Current (AC) or Direct Current (DC);
- Location of OSPs;
- Location of metocean equipment; and
- Location of meteorological masts.

17. In addition to these uncertainties, it is not possible to provide details of the construction techniques, vessels and methods that will be used during construction and ultimate decommissioning of the Project.

18. In order to ensure that this ES is sufficiently robust and has taken account of the worst case likely significant effects arising from the Project, a set of parameters has been developed.

19. These parameters are collectively referred to as the 'Rochdale Envelope', further details of which are provided in Section 3: Legislation and Consenting Requirements of this ES and are presented in Table 7.1 A-G Rochdale Envelope Parameters.

7.3.1 DEVELOPING THE ROCHDALE ENVELOPE

20. Extensive research has been undertaken in order to define the parameters of the Project. Alternatives that were considered at an earlier design stage but later discounted are summarised in Section 6: Site Selection and Consideration of Alternatives of this ES.

21. In respect of the Wind Farm the following known constraints were applied:

- The extent of the Wind Farm Site shown on Figure 1.2;
- The maximum onshore grid capacity of 1000 MW;
- Turbine minimum separation distances required for efficiency purposes i.e. minimum spacing of 6 x 6 rotor diameters (crosswind and downwind);
- Proximity to other infrastructure i.e. oil and gas, cables, Moray Firth Round 3 Zone;
- The requirement for up to three meteorological masts;
- The requirement for up to three metocean buoys; and
- The requirement for up to three OSPs.

22. The nature and route of the OfTW have been defined by the following known constraints:

- The extent of the OfTW Corridor width shown on Figure 1.2;
- Proximity to other infrastructure i.e. oil and gas, cables, Moray Firth Round 3 Zone;
- The requirement for up to three cable trenches; and
- The requirement for cable separation of approximately four times water depth.

23. Wind Farm and OfTW constraints have informed the development of the Rochdale Envelope.

24. The Rochdale Envelope provides details of the design parameters and number of of the following possible development components and construction techniques:

- Wind Turbines;
- OSPs;
- Meteorological Masts;
- Substructures and Foundations for all components;
- Inter array cables;
- Metocean equipment; and
- OfTW.

25. A detailed description of each of these components and associated construction methods is provided at Sections 7.4-7.12 and are generally structured as follows:

- Introduction;
- General Description;
- General Installation; and
- Vessels and Main Installation Activities.

26. Other pertinent details are included as required in relevant Sections.

27. Details of the likely number of vessels attending the construction site on a daily basis are provided at Table 7.6.

7.3.2 APPLICATION OF THE ROCHDALE ENVELOPE

28. The author of each technical assessment has been advised of the Rochdale Envelope parameters as set out in Table 7.1 A-G. Neither Scenario 1 nor Scenario 2 will represent the Final Build Plan however the findings of this ES will apply to the final design and the effects will be no worse than predicted.

29. Each ES Section describes which components and construction methods represent the worst case and provides an assessment of environmental effects based on that definition.

7.3.3 DEFINING THE DETAILED DESIGN

30. Following consent and final detailed design, a Final Build Plan will be provided to Marine Scotland for approval. The purpose of this submission will be to:

- Demonstrate compliance with any conditions attached to consents; and
- Ensure that the final design remains within the parameters of the Rochdale Envelope considered by this ES.

31. The assessments presented within this ES consider all construction, operation and decommissioning activities associated with the Wind Farm and OfTW during each phase of development.

Table 7.1A Rochdale Envelope Parameters (Turbines)

Wind Turbine			
Description of Component and Nature of Uncertainty	**Range of Components and Key Parameters**	**Scenario 1** **Utilising the anticipated smallest turbine available**	**Scenario 2** **Utilising the anticipated largest turbine available**
Three bladed horizontal axis wind turbine. **More than one turbine type may be used on site.** **These scenarios outline the largest and smallest turbines that would be utilised on site. The final turbine choice may lie within these extents. Each scenario also represents the maximum number of turbines of each size that would be installed. The final number of turbines may be less, but will not exceed those set out in Scenario 1 and Scenario 2.**	**Rated Generating Capacity per Turbine**	3.6 MW	7 MW
	Maximum number of turbines	277	142
	Maximum generating capacity of site	997.2 MW	994 MW
	Tip Height Range	132.6 – 140.6 m	190.4 – 198.4 m
	Hub Height Range	79 m – 87 m	107.9 m – 115.9 m
	Indicative Nacelle Dimensions (l x w x h)	13 m x 4 m x 4 m	26 m x 16 m x 12 m
	Blade Clearance above Lowest Astronomical Tide (LAT)	25.4 m – 33.4 m	25.4 m – 33.4 m
	Maximum Rotor Diameter	107.2 m	165 m
	Maximum Blade Swept Area	9025.7 m^2	21,382.5 m^2
	Revolutions per Minute Range	4.8 – 13	4.8 – 13
	Minimum Spacing	642 m	990 m

Table 7.1B Rochdale Envelope Parameters (Meteorological Masts)

Meteorological Masts			
Masts equivalent to turbine height mounted with meteorological monitoring equipment required to monitor wind conditions at the site. **Precise number of masts and mast locations undetermined.**	**Mast Type**	Lattice structure tower mast	
	Maximum Number of Masts	3	
	Minimum Number of Masts	1	
	Minimum Height above LAT	79 m	
	Maximum Height above LAT	115 m	
	Design	Lattice tower structure with equipment on booms at various heights including the top.	
	Power Source	Powered by either independent renewable source e.g. small solar panel or connected to wind farm distribution system by inter-array cables.	
	Available Substructure Types	Tubular Jacket	Monotower
	Available Foundation Types	Pin piles Suction piles	Gravity Base Monopile
	Location	Likely to be located on the outer edges of the Wind Farm.	

Table 7.1C Rochdale Envelope Parameters (Substructures)

Substructure			
Structure that connects the above sea level structure with the foundation. Will be used for turbines, meteorological masts and OSPs. **Substructure type not yet known.** **Dimensions of substructure types unknown.**	**Substructure Type**	Tubular Jacket	Monotower
	Design	Tubular steel lattice structure with up to 4 'legs'	Single cylindrical steel or concrete tube
	Dimensions	Unknown - will vary based on water depth and foundation type	Unknown - will vary based on water depth and foundation type
	Applications	Suitable for turbines, meteorological masts and OSPs	Suitable for turbines and meteorological masts
	Possible Foundation Types	Pin piles, suction piles or gravity bases for turbines, meteorological masts and OSPs	Conical gravity base with turbines. Conical gravity base or monopile for meteorological masts

Table 7.1D Rochdale Envelope Parameters (Foundations)

Foundations						
Element that fixes the substructure to the seabed. **Will be used for turbines, meteorological masts and Offshore Substation Platforms (OSPs).** **Foundation type unknown at present.**	**Foundation Type**	Pin Piles	Suction Piles	Gravity Base	Monopile
	Applications (Substructure)	Tubular Jacket	Tubular Jacket	Tubular Jacket Monotower	Monotower
	Applications (above sea level components)	Turbine, OSP and Meteorological Mast	Turbine, OSP and Meteorological Mast	Turbine, OSP and Meteorological Mast	Meteorological Mast
	Primary Materials	Steel	Steel	Concrete or steel	Steel
	Brief Description	Steel pins on each leg of Tubular Jacket driven into the seabed. Maximum blowforce of 2300 kJ. Vibropiling which is currently an untested technique may be used if feasible.	Upturned bucket style design on each leg of Tubular Jacket sunk into the seabed using vacuum pumps.	Cast structure that sits on flat sea bed and relies on the weight of the structure for stability.	Cylindrical tube driven into the seabed.
	Dimensions / Depth **(Dependent on number of piles and sea bed conditions)**	Each turbine pile up to 2.4 m diameter. Each OSP pile up to 3 m diameter. Approximately 20 m – 80 m in length.	Each pile 5 m – 15 m diameter. Approximately 8 m – 30 m penetration depth.	50 m – 65 m in diameter for turbines. 50 m – 100 m for OSPs. Sits on seabed.	Approximately 5 m diameter. Up to approximately 80 m in length

	Associated Operations		Seabed obstructions survey. Drilling operations. Piling operations. Cement grouting. Use of Jack up Vessel.	Seabed obstructions survey. Use of Jack up Vessel.	Seabed obstructions survey. Seabed preparation using jetting tool and dredging up to 5 m below starting seabed level. Ballasting operations. Use of Jack up Vessel.	Seabed obstructions survey. Piling. Grouting. Use of Jack up Vessel.
Dependent on final turbine and substructure selection. **Different combinations of turbine, substructure and foundation type will have different zones of influence.**	**Zone of Influence – Per Turbine**	**Maximum Footprint (areas of seabed in direct contact with structure)**	14 m^2	707 m^2	3,318 m^2	N/A
		Shadow (area of seabed over which structure is sited)	6,145 m^2	8,636 m^2	3,318 m^2	N/A
		Maximum Temporary Zone of Influence	9,272 m^2	17,449 m^2	20,867 m^2	N/A
		Maximum Permanent Zone of Influence	7,644 m^2	15,186 m^2	18,385 m^2	N/A

Table 7.1E Rochdale Envelope Parameters (Inter Array Cables)

<table>
<tr><th colspan="6">Inter Array Cables</th></tr>
<tr><td rowspan="15">Cables linking turbines and substations.

Current unknowns are; routing of cables; location in terms of being above or below the sea bed and protection measures required in either case. The length of cable required will be dictated by these issues.

There is a presumption in favour of burial or protection where feasible however the full extent of this is current unknown pending further technical studies.</td><td>Indicative Cross Sectional Area</td><td>185 mm^2</td><td colspan="2">400 mm^2</td><td>800 mm^2</td></tr>
<tr><td>Outer Diameter</td><td>113 mm^2</td><td colspan="2">129 mm^2</td><td>157 mm^2</td></tr>
<tr><td>Weight (kg / m)</td><td>21</td><td colspan="2">28.1</td><td>48.9</td></tr>
<tr><td>Possible Voltage Range</td><td colspan="4">33 – 66 Kv AC</td></tr>
<tr><td>Maximum Total Length of Cabling</td><td colspan="4">350 km</td></tr>
<tr><td>Maximum Length of Buried Cabling</td><td colspan="4">325 km</td></tr>
<tr><td>Minimum Length of Buried Cable</td><td colspan="4">0 km</td></tr>
<tr><td>Minimum Burial Depth</td><td colspan="4">On seabed surface</td></tr>
<tr><td>Maximum Burial Depth</td><td colspan="4">2.5 m</td></tr>
<tr><td>Minimum Zone of physical disturbance from trench</td><td colspan="4">1.5 m</td></tr>
<tr><td>Maximum Zone of physical disturbance from trench</td><td colspan="4">3 m</td></tr>
<tr><td>Cable Protection Measure Options</td><td>Concrete blanket / matressing</td><td>Rock Net/ gabion</td><td>Rock Placement</td><td>No Protection</td></tr>
<tr><td>Maximum extent of cable protection</td><td colspan="4">0.48 sq. km</td></tr>
<tr><td>Installation techniques for buried cables</td><td>Ploughing
Involves a blade cutting through the seabed and the cable laid behind. Plough will be pulled by either Surface vessel or Remote Operated Vehicle (ROV).</td><td colspan="2">Jetting
Involves the formation of trenches through the use of a water jet to displace sediment. The jet is usually attached to an ROV and is either free swimming, on ski-like skids or active tracks (e.g. caterpillar).</td><td>Trenching
Involves the excavation of a trench by a caterpillar tracked vehicle temporarily placing the excavated sediment adjacent to the trench.</td></tr>
</table>

Table 7.1F Rochdale Envelope Parameters (Offshore Substation Platforms)

Offshore Substation Platforms (OSPs)			
OSPs collect electricity from the turbines via Inter Array Cables and convert the voltage to a suitable current for export via the OfTW. **Number of OSPs, location, final design and dimensions, substructures and foundations unknown.**	**OSP Type**	AC Transmission	DCTransmission
	Maximum Number of OSPs	2 AC OSPs	2 AC OSPs and 1 DC OSP
	Maximum dimensions (l x w x h)	40 m x 40 m x 30 m	115 m x 55 m x 42 m
	Maximum Weight	2300 T	16000 T
	Maximum height from Lowest Astronomical Tide (LAT)	20 m	20 m
	Available Foundation Types	Pin Piles (excluding pre-driven piles) (3 m pin piles) Suction Piles	
	Available Substructure Type	Tubular Jacket	
	Access Facilities	Boat landing and helipad	

Table 7.1G Rochdale Envelope Parameters (Offshore Transmission Works)

Offshore Transmission Works (OfTW)				
The OfTW comprises cables transmitting electricity from the OSPs to the Substation element of the Onshore Transmission Works. **Transmission may be alternating current (AC) or direct current (DC).** **Number of cables and trenches.** **Routing of trenches.** **Cable protection measures.**	**Number of Cable Trenches**	Up to three cable trenches required on the seabed.		
	Maximum Width of Cable Trench	3 m		
	Maximum Depth of Cable Trench	2.5 m		
	Maximum Number of cables per trench	3		
	Maximum distance between trenches	Approximately four times water depth.		
	Maximum water depth along cable route corridor(s)	Approximately 100 m		
	Minimum water depth along cable route corridor(s)	38 m		
	Maximum slope of cable plough	15 degrees		
	Maximum slope of sea level in route corridor(s)	3 degrees		
	Installation techniques for installation	Ploughing	Jetting	Trenching
	Typical Dimensions of Drilling Equipment (l x w x h)	9 m x 4 m x 3.5 m	8 m x 4 m x 2.5 m	12.6 m x 10 m x 6.1 m
	Cable Protection Measure Options	Concrete blanket /matressing	Rock Net/gabion	
	Maximum length of cable protection (i.e. maximum length of surface laid cable)	45% of total cable length		
	Maximum extent of cable protection	0.26 sq. km.		
	Total duration of cable laying operations (based on three cables in each of three trenches)	Approximately 120 days		
	Total duration of cable protection measure installation operations (based on three cables in each of three trenches)	Approximately 120 days		

7.4 *WIND TURBINES*

7.4.1 INTRODUCTION

32. This Section provides a description of an offshore wind turbine providing details on colour scheme, oil and fluids to be used, rotational speed, material requirements and control functions and safety features of the turbines.

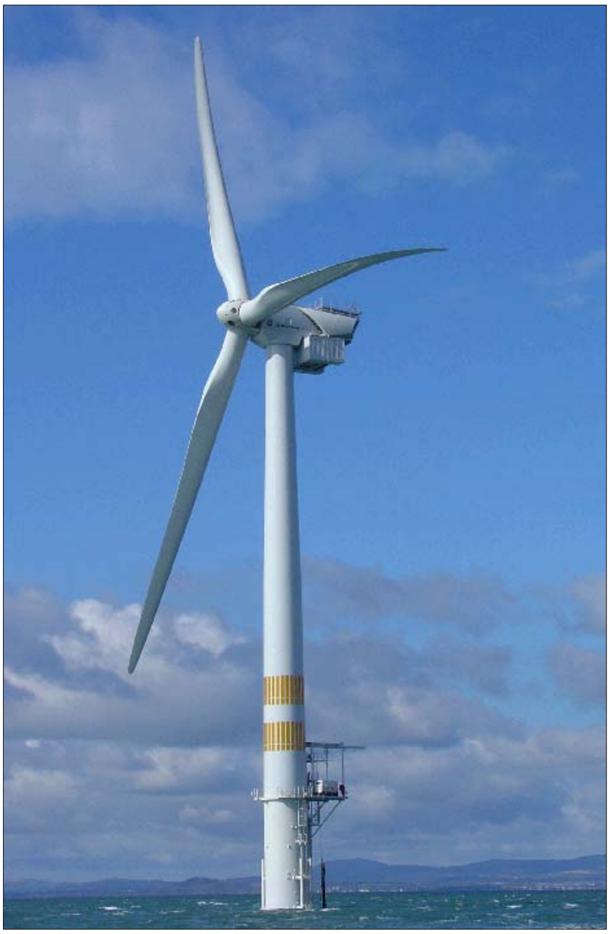
33. Conventional horizontal axis turbines will be used for the Project. These turbines comprise three main external components as follows.

- Rotor – comprised of the blades, hub, spinner and spinner bracket.
- Nacelle - housing the electrical generator, the control electronics and gearbox, adjustable speed drive or continuously variable transmission.
- Structural support - includes the tower and rotor yaw mechanism which allows the wind turbine rotor to turn against the wind.

34. The turbine will be mounted on top of a substructure which acts as a transition piece between the below sea level foundation and the tower of the turbine. Details of the substructures and foundations under consideration are provided at Section 7.7.

35. Plate 7.1 provides an illustration of the main external components of a turbine.

Plate 7.1 Typical Offshore Turbine



Source: Beatrice Offshore Windfarm Ltd

7.4.2 TURBINE SPECIFICATION AND DESIGN

36. The precise turbine model and number of turbines will not be known until the Final Build Plan is determined.

37. Table 7.1, Rochdale Envelope Parameters, provides the specification of the smallest and largest wind turbines that would be used alongside the maximum possible number of installed turbines in each case.

38. The various dimensions and technical specifications, such as rotation speed are provided in Table 7.1 and are not repeated here.

39. Irrespective of the choice of turbine it will conform to the following general design principles. The tower will be cylindrical in design; at its widest where it meets the substructure and tapers slightly as it reaches the nacelle at the top of the tower. The nacelle, housing all the generating equipment, will increase in size as larger capacity turbines are used, however this is also determined by the mechanical drive system.

40. The mechanical drive system can either have a gear box which significantly increases the speed of the wind-driven rotor or a direct drive generator which operates at the same speed as the rotor. Direct drive systems are usually larger and will result in a larger nacelle.

41. The turbines will be designed to operate unmanned and are expected to be available to produce electricity for around 85% of their lifetime. Each turbine will possess a heli-hoist platform on the top of the nacelle and the required boat landing facility at the foot of the tower to allow personnel access. These features are discussed in more detail in Section 7.4.3 below.

7.4.3 TURBINE ACCESS FACILITIES

42. The substructures will be equipped with either one or two boat landings and ladders, depending on the site metocean conditions and the operational and maintenance requirements. The boat landing(s) will be oriented such that the availability is optimised in respect to the local prevailing wind, tide, wave and current behaviour. An illustration of a typical boat landing and access is presented in Plate 7.2.

43. The turbines will be accessed primarily by marine vessels, however, a secondary means of access will be provided by helicopter. To facilitate this, the nacelle of the turbine will be fitted with a heli-hoist platform (typically a minimum of 4 m x 4 m) with associated markings and lighting. The turbine will be supplied with a turbine control system which can stall the turbine blades allowing helicopters to access.

Plate 7.2 Typical Turbine Boat Landing and Access Facility

Source: Beatrice Offshore Windfarm Ltd

7.4.4 COLOUR SCHEME

44. Turbine colour scheme requirements and other markings are set out by the International Association of Lighthouse Authorities (IALA), the Royal Yachting Association (RYA), the MCA and the CAA. All parts of the turbine from 18.9 m above LAT upwards are considered to be an obstruction to aviation and will be painted the standard colour for offshore wind turbines, a semi-matt pale grey colour RAL 7035. The tower and substructure of every turbine will be painted yellow colour RAL 1004 from the level of LAT up to 18.9 m, or up to the height of the navigation lights (whichever is greater) for observational or navigational purposes.

45. The turbines will incorporate turbine identification markings including, but not limited to, an identifier on the turbine tower, an identifier on the nacelle roof, contrast stripes on the blades and illuminated signage on the turbine tower. These requirements and guidelines are set by the MCA, RYA and IALA.

7.4.5 OIL AND FLUIDS

46. Pollution will be controlled and mitigated as far as possible at the design stage. For example, the turbine nacelle frame typically is designed and manufactured with a bund incorporated which can hold the full oil content of the gearbox in event of a complete failure. Dependent on the turbine type and size it will typically contain mineral lubricating and hydraulic oils for the gear box, hydraulics, pitch/yaw motor and transformer.

7.4.6 OPERATING AND ROTATION SPEED AND BLADE PITCH

47. It is expected that the turbine would operate in wind speeds of between 3 m/s and 35 m/s. This would equate to between 4.8 and 13 revolutions per minute (rpm). The pitch of the blade will be variable and it will be continuously positioned to the optimum angle based on prevailing wind conditions. This pitch control operation is also known as feathering.

7.4.7 GENERAL INSTALLATION

48. There are a range of options available for the erection of turbines ranging from each component being transported to site separately and erected piece by piece to the entire turbine being assembled on land then transported to site and erected by a jack-up vessel.

49. Within this spectrum, there are a range of other options that may be adopted such as tower and rotor (i.e. nacelle and blades) assembly onshore then tower and rotor being fitted to the substructure on-site.

50. The final decision regarding construction techniques will be made following the Final Build Plan and will take into account a range of economic and technical considerations.

7.4.8 VESSELS AND MAIN INSTALLATION ACTIVITIES

7.4.8.1 Individual Component Installation

51. The installation of components on an individual basis usually requires a jack-up vessel to ensure stability and to lift components in place and a transport vessel to bring parts from a quayside to site.

52. A nearby quayside facility location would allow delivery of turbine components from a manufacturer and then onward transport to the Wind Farm Site. This transfer of components could take place throughout the year. Either the jack-up vessel itself could transport the turbine components from the quayside to site, or the jack-up vessel stays at the site and a separate delivery barge or vessel takes turbine component from the quayside to the waiting jack-up vessel for assembly. It is also possible that components will be delivered direct from the supplier to the Wind Farm Site thus reducing the overall number of vessel movements.

7.4.8.2 Part Onshore Assembly

53. In the event that part assembly is undertaken onshore, components would be delivered to a nearby quayside facility with sufficient facilities to accommodate partial assembly.

54. Components would be part assembled and transported to site via suitable vessels. Installation would then be undertaken using lifting vessels to assemble component parts. This process is expected to take up to 24 hours per turbine.

7.4.8.3 Single Lift Installation

55. The Single Lift approach was first used during the installation of the Beatrice demonstrator project, therefore proving the feasibility of such an approach. Single lift operations can be undertaken from floating or jack-up vessels, although jack-up usage will take slightly longer. A number of specialist vessel concepts for single lift installation are also under development. An example of a single lift operation is illustrated in Plate 7.3.

Plate 7.3 Single Lift Activity undertaken by Heavy Lift Vessel

Source: Subsea7

56. The single lift method will require a large quayside facility for the delivery of the individual turbine components, their assembly, pre-commissioning and loading onto a vessel. Ideally this facility would be in the Moray Firth area as proximity to the Wind Farm Site reduces transport cost and weather risk. However, it could also be further afield in the UK or Europe. A single lift operation would take less than 12 hours to complete if a floating Heavy Lift Vessel (HLV) is used from delivery of turbine to the Wind Farm Site to turbine installation.

7.5 OFFSHORE SUBSTATION PLATFORMS (OSPS)

7.5.1 INTRODUCTION

57. The OSPs are required to collect the electricity from the turbines and transmit the power to shore at the most efficient voltage level and with the minimum number of transmission cables. There are a number of high level transmission designs which are

feasible for the Wind Farm which indicate that up to three OSPs may be required; two AC and one DC.

58. The location of each of the OSPs has yet to be determined therefore for assessment purposes each EIA specialist has considered the worst case based on their field of study. This approach ensures that wherever the OSPs are located the likely significant effects of the most sensitive locations have been identified and assessed in this ES.

59. The OSP locations will be determined once the size, type and number of turbines have been established and each potential location will be subject to a full geotechnical study prior to installation.

7.5.2 GENERAL DESCRIPTION

60. In addition to the main electrical equipment, each OSP will include electrical panels for control system, communication equipment, a workshop for small repairs, spare parts, emergency accommodation and welfare facilities and required safety equipment. There will also be an access system to allow personnel to maintain the OSPs. The facility may also require diesel generators and diesel tanks as a backup auxiliary power supply.

61. An illustration of a typical OSP is provided in Plate 7.4.

62. The OSP accommodation facilities will be for emergency use only. All waste will either be contained and recovered and disposed of onshore or collected in a macerator or treatment facility to be incorporated into the design to allow discharge of black water (i.e. water containing untreated effluent). The ability to discharge black water would greatly reduce site operational requirements and reduce the health and safety risks associated with the transfer of effluent to a collection vessel at sea. Removal of black water to shore would therefore involve additional vessel movements and additional visits by maintenance staff.

63. There will also be an integral drainage system within the OSP which will incorporate a drainage system with a sump and separator that will separate any contamination from rainwater run-off. Any contamination is stored ready for disposal and the clean water is then discharged overboard. There is an oil sensor in the discharge system which will trip the discharge valve shut ensuring that no waste is discharged to sea should the water contain an unacceptable level.

64. Any equipment on the OSP containing significant quantities of oil (e.g. transformers, diesel generator and tank, if required) will be bunded with an open steel bund which can hold 110% of the volume of the largest tank.

65. To maximise the safety and operational capability of helicopter use, facilities may be required to allow refuelling on the OSP. Should this be required, additional spill and fire protection systems will be incorporated into the OSP design and will be designed and built in compliance with relevant standards.

66. As with the turbine components the external colour scheme and marking requirements of the OSP will comply with the guidelines set by the MCA, RYA and IALA.

Plate 7.4 Indicative Offshore Substation Platform (OSP)

Source: Siemens T&D Ltd

7.5.3 LIKELY OSP DIMENSIONS

67. The OSP comprises two elements: the topside and the substructure. The topside will be approximately 16 m above LAT. Indicative dimensions of potential OSPs are provided in Table 7.2. As noted above, it is assumed that there will be up to three OSPs within the site, a maximum of two AC and one DC depending on whether the transmission system is AC or DC. The OSPs will consist of a single independent platform, but these could be installed in close proximity to one another and linked by a form of bridge for personnel to move from one to the other.

Table 7.2 Indicative OSP Dimensions

Parameter	AC OSP	DC Converter Station OSP
Max Length	40 m	115 m
Max Width	40 m	55 m
Max Height	30 m	42 m
Max Weight	2300 T	16000 T
Max Air Gap* (LAT)	20 m	20 m

* gap between LAT and the base of the platform.

7.5.4 LIKELY OSP ACCESS FACILITIES

68. At this stage of the Project it has been assumed that the OSP will be fitted with boat landing(s) for the turbines, and a helipad for personnel access. The helipad will be designed, signed and coloured to the required CAA standard.

7.5.5 GENERAL OSP INSTALLATION

69. The OSP will be mounted on top of a substructure which acts as a transition piece between the below sea level foundation and the platform of the OSP. Details of the substructures and foundations under consideration are provided at Section 7.7.

70. The OSP is likely to require a number of substructure and foundation components due to its size and weight. The duration of these installations will be as described in Section 7.7 for each substructure.

71. The topside will be transported to site by either a pontoon barge towed by two or more tugs or via a HLV which may be self propelled or towed. It may also be possible to lower the topside into the sea and tow by tug if it is buoyed. An HLV will be used to install the topside and any further large components to be added to it.

7.6 METEOROLOGICAL MASTS

7.6.1 INTRODUCTION

72. Meteorological masts are required to monitor real time weather conditions within the Wind Farm Site. These details are then correlated and compared to the turbine performance to ensure that the most efficient and effective operation is being implemented. It is proposed that a maximum of three permanent meteorological masts will be installed at the site.

7.6.2 GENERAL DESCRIPTION

73. The height of the meteorological masts will be equivalent to the turbine hub height. These structures are likely to consist of a foundation, substructure, transition piece and lattice style mast. It has not yet been determined where each of the meteorological masts will be located within the Wind Farm Site but it can be assumed that they will be on the outer edges. They will not be located in close proximity to each other.

74. The location of each of the meteorological masts has yet to be determined therefore for assessment purposes each EIA specialist has considered the worst case locations around the perimeter of the Wind Farm based on their field of study. This approach ensures that wherever the meteorological masts are located the likely significant effects of the most sensitive locations have been identified and assessed in this ES.

75. The meteorological mast is likely to consist of a lattice tower structure with instruments mounted on booms off this central tower. The top mounted instrument will be equivalent to the turbine hub height. The meteorological masts are most likely to be powered independently from the Wind Farm using renewable resources (e.g. solar panels) or alternatively, they may be connected to the Wind Farm distribution system. An indicative lattice style meteorological mast is shown in Plate 7.5.

7.6.3 GENERAL INSTALLATION

76. The meteorological mast will be mounted onto a substructure and foundation. Details of the substructures and foundations under consideration are provided at Section 7.7.

77. After the foundation and substructure have been installed the meteorological mast will be transported to site in a similar operation to that of a single lift turbine installation technique. Once the meteorological mast is lifted into position it will be welded or grouted on the top of the substructure. Aircraft and ship warning measuring and anemometry equipment will then be mounted.

78. It is expected that the installation of each of the meteorological masts, and its associated equipment, may take between five and twelve days to complete.

Plate 7.5 Typical Lattice Tower Meteorological Mast

Source: Beatrice Offshore Windfarm Ltd

7.7 *SUBSTRUCTURES AND FOUNDATIONS*

7.7.1 INTRODUCTION

79. The structure that connects the turbine, OSP or meteorological mast to the foundations is known as the substructure. The foundations are the engineered elements used to secure the substructures of turbines, OSPs or meteorological masts to the seabed. Preliminary studies have been undertaken by BOWL to assess the range of options available for the Wind Farm for each of these components. Further studies will be undertaken as part of the detailed design process to determine the final selection.

80. Those options considered viable are summarised in Table 7.1 which also indicates which substructures are compatible with which foundations and whether these are viable options for turbines, OSPs or meteorological masts at the site. Further detail on the two viable substructure options and four viable foundation options is provided at Sections 7.7.2-7.7.7.

81. At this stage in the Project it is not possible to be definitive regarding the structures that will be installed at the Wind Farm however in order to ensure the robustness of the ES, it has been necessary to provide technical assessors with sufficient information regarding the likely area over which foundation installation and operation may have an influence. To facilitate this, a judgement has been made as to the most likely foundation and substructure combinations to be used at the site. Section 7.8 provides details of the zone of influence of works associated with the installation and operation of these development components and this has been used to inform the technical assessments presented within this ES.

82. All foundation locations are likely to require some form of scour protection to avoid erosion from the sea. In order to avoid repetition, full details of possible protection measures are outlined at Section 7.9.

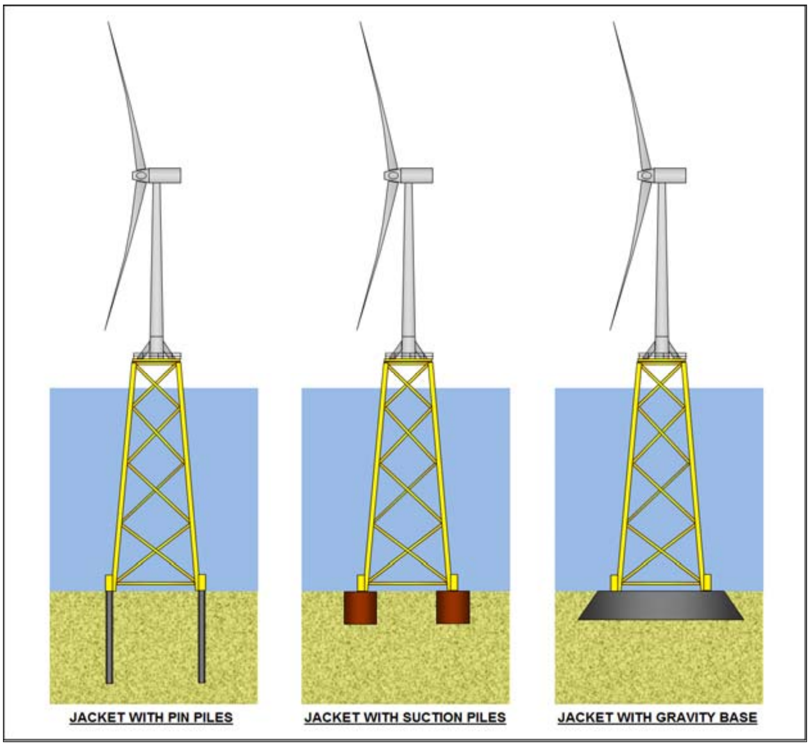
7.7.2 SUBSTRUCTURE OPTION 1: TUBULAR JACKET SUBSTRUCTURE

7.7.2.1 General Description

83. Tubular jacket designs can come in a number of shapes and sizes, for example they could have three legs or four, or could be tapered or straight to give a wider or narrower base. Tubular jacket substructures are of a typically lattice structure comprising the thick tubular steel sections (primary sections) which are braced by smaller tubular steel sections (secondary sections) to form a structural frame. They can be used with turbines, OSPs and meteorological masts.

84. Tubular jackets can be used with a range of foundation concepts. In the case of the Project, pin piles, suction piles and gravity bases are considered viable options. Examples of these are shown in Plate 7.6.

Plate 7.6 Tubular Jacket Substructure with Foundation Options



Source: J.P Kenny

85. The final choice of tubular jacket design will be determined on a range of factors including:

- Specific geological and seabed conditions;
- Final turbine, OSP and meteorological mast size; and
- Supply chain implications.

86. It may also be the case that because of these factors more than one substructure design is used throughout the site.

87. Due to the undulating seabed topography the water depths across the Wind Farm site vary between 38 m and 68 m. As a result the substructure components require to be tailored in height to suit specific water depths and a variety of heights of substructure will be utilised across the site.

7.7.2.2 General Installation

88. A tubular jacket is normally fully assembled at a quayside and loaded onto a large flat top pontoon barge, either vertically or on its side, for transport out to sea. The barge is towed out to sea and the tubular jacket is then lifted and lowered onto the foundation.

89. An alternative approach is to transport the tubular jacket to site via a suitable vessel with a crane that can lift the tubular jacket into position.

7.7.2.3 Vessels and Main Installation Activities

90. There are a number of installation vessels and techniques that may be employed to install tubular jacket substructures, the most likely of which would be for the component to be transported to the site on a pontoon barge, towed by a tug, as shown in Plate 7.7.

91. The crane of an installation vessel, such as a HLV or jack-up vessel, would then lift the tubular jacket off the pontoon barge and lower it into position on the seabed foundation. An alternative to a lift installation would be to adjust the ballast within the barge so that the barge lowers sufficiently into the water allowing the structure to slide off the barge and into the sea in a controlled manner. Where structures are not designed to be buoyant, temporary flotation will be provided on the structure to allow sufficient buoyancy for a controlled descent to the sea bed.

Plate 7.7 Tug Towing Lattice Jacket Substructure on Pontoon Barge

Source: Beatrice Offshore Windfarm Ltd

92. If the installation vessel is a jack-up vessel it will be secured in position at the turbine location by lowering its legs to the seabed. If a jack-up vessel is not used the HLV could be kept in position by either the use of a traditional anchored system or a Dynamic Positioning System (DPS), by using thrusters.

93. Typically this exercise would take approximately 1.5 days per foundation location in order to allow for moving and securing the installation vessel and installing the tubular jacket.

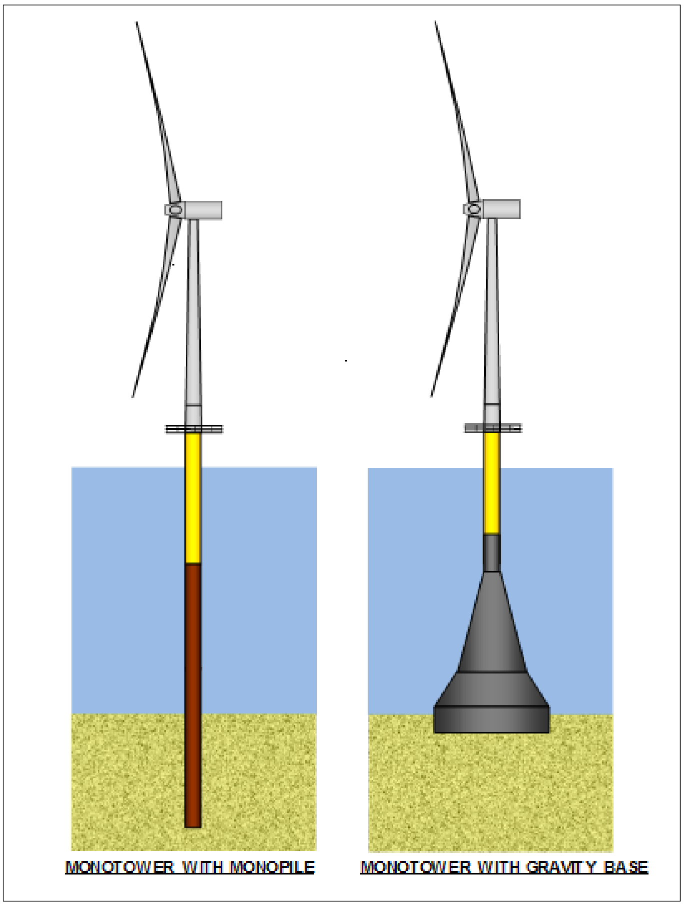
7.7.3 SUBSTRUCTURE OPTION 2: MONOTOWER SUBSTRUCTURE

7.7.3.1 General Description

94. A monotower substructure is a cylindrical steel or concrete tube which connects the above sea structure to the foundation. In respect of the Project a monotower substructure is suitable for use with turbines and meteorological masts but not suitable for use with OSPs. Monotower substructures have been used for the majority of offshore wind farms within the UK to date.

95. A monotower substructure can be used with either a gravity base (usually conical) or a monopile foundation (Plate 7.8). A conical gravity base may be used with a turbine or meteorological mast however the monopile foundation is only suitable for meteorological masts at this site.

Plate 7.8 Monotower with Foundation Options



Source: J. P. Kenny

7.7.3.2 General Installation

96. A monotower substructure is usually connected to a conical gravity base foundation at quayside and loaded onto a pontoon barge for transport out to sea. The barge is towed out to sea and the complete structure is then lifted and lowered onto the sea bed.

97. Where a monopile foundation is used, the monotower will be transported with no foundation attached and lowered onto a preinstalled monopile.

7.7.3.3 Vessels and Main Installation Activities

98. Irrespective of foundation type, the vessels required and installation monotower activities will be similar to those described for tubular jacket substructures at Section 7.7.2. Installation would generally take approximately 24 hours per foundation location in order to allow for moving and securing the installation vessel and installing the monotower.

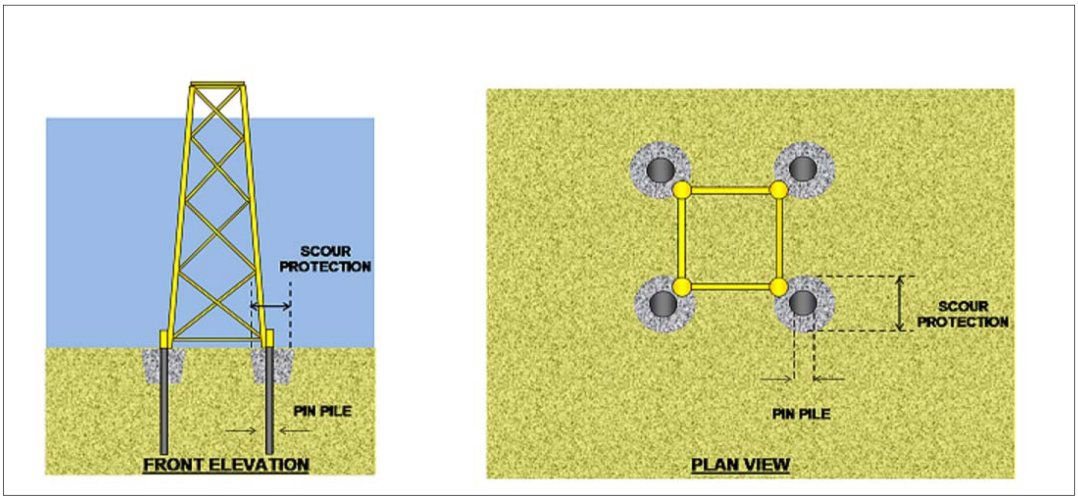
7.7.4 FOUNDATION OPTION 1 – PIN PILE FOUNDATIONS

7.7.4.1 General Description

99. A pin pile is a large steel peg which is driven into the seabed using a large piling hammer. It can be used with a tubular jacket substructure but not a monotower. Pin piles are suitable for use with turbines, meteorological masts and OSPs.

100. Each tubular jacket substructure will require at least one pin pile at each corner to fix it to the seabed. The pin piles will vary in size depending on a number of factors, such as the type of structure they are used for, seabed conditions and structural loading of the turbine. Pin piles will range in diameter from 2.4 m for the turbines and meteorological masts to 3 m for the OSPs diameter and between 20 m to 80 m in length. An illustration of a tubular jacket substructure and pin pile combination is provided in Plate 7.9.

Plate 7.9 Pin Pile Foundation Elevation and Plan



Source: J. P. Kenny

7.7.4.2 General Installation

101. The seabed will be assessed prior to pin pile installation to ensure that no visible obstructions are present that would prevent the installation operation. This will typically involve a sonar sidescan or multibeam survey to identify any near surface archaeology, boulders or any other obstructions. Survey vessels with suitable equipment and technicians will be required to complete the offshore survey. No further seabed preparations will generally be required.

102. The pin piles will be delivered to site on a suitable vessel and moved into position. They are then driven by a piling hammer which is operated from an installation vessel.

103. In the event that the seabed and underlying geological conditions resulted in difficulties with piling operations, drilling may be required to facilitate installation.

104. It is also possible that vibropiling could be used to install pin piles if conditions allow. This technique can be used in easily penetrable geological conditions and involves using a vibrodriver to install pin piles by high frequency vibration rather than hammering. It is not yet clear whether conditions at the Wind Farm Site are suitable for this installation method and further work is being undertaken to assess the feasibility

7.7.4.3 Vessels and Main Installation Activities

105. Pin piles will most likely to be delivered to site on pontoon barges towed by a tug or on an installation vessel equipped with piling hammer. The installation vessel will be either a jack up vessel (as shown in Plate 7.10) or a floating vessel.

Plate 7.10 Typical Jack up Construction Vessel

Source: Beatrice Offshore Windfarm Ltd

106. On arrival at the site, piles will be lifted from the delivery vessel, using the installation vessel's crane, upended to the vertical position and then lowered to the seabed in preparation for piling.

107. There are two primary installation options available:

- The pin piles would be forced into the seabed through sleeves on the substructure once it is in position and then driven/hammered to the required depth to secure the component in place. This approach is common within the oil and gas industry; and

- The pin piles would be driven into the seabed through a reusable template and the substructure placed over the pre-driven piles.

108. The use of pre-driven piles has the advantage of breaking the installation schedule dependency between supply of pin piles and substructures, allowing more efficient installation. It is also a less weather sensitive method and can be carried out throughout the year with a suitable vessel.

109. The process of driving one pile will take up to five hours. This is however subject to weather which may result in longer driving durations and ground conditions which may result in shorter pile driving durations.

7.7.4.4 Drilling of Pin Piles

110. It is anticipated that at some locations in cases where pin piles cannot easily be hammered, e.g. where the seabed and geological conditions are particularly onerous, drilling into the seabed may be required to assist the piling operations.

111. There are a number of other tasks required to support the main drilling exercise, such as the control of drilling fluids and the injection of grout to control drill spoil which will extend the duration of the operation beyond that of basic piling activities.

112. Drilling fluids are used to lubricate the drill as it penetrates the seabed and the fluid will be biodegradable and non-toxic, and is likely to consist of water-based mud.

7.7.4.5 Grouting of Pin Piles

113. Cement grouting operations will usually be required for each pin pile following installation. Grout will usually be injected through tubes in the legs of the tubular jacket substructure into the small space between each pin pile and pile sleeve.

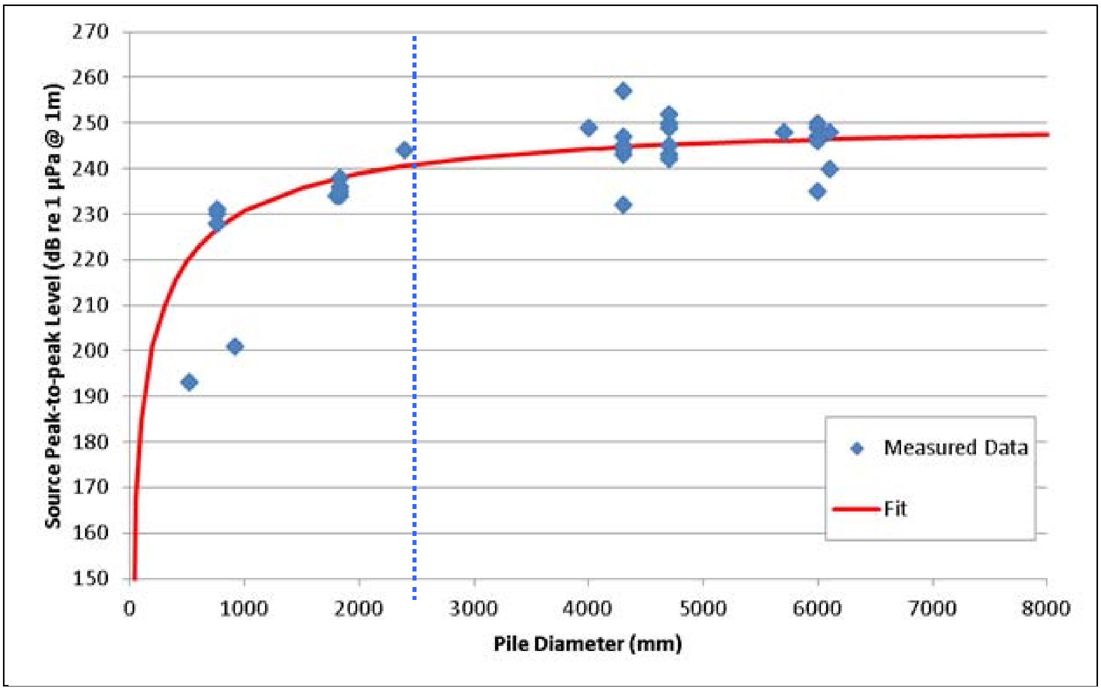
114. It is anticipated that due to the quantity of grout required, cement for grouting will most likely be stored in bulk pressurised silos on the installation vessel or construction support vessel. Fresh water for mixing the grout would also be stored on this vessel.

7.7.4.6 Noise Emissions from Piling Activities

115. Piling operations will generate underwater noise which has the potential to affect a range of sensitive receptors considered later in this ES. The diameter and length of pile, size of piling hammer and ground conditions will dictate the energy required to drive the pile and the duration of operations which in turn will dictate the noise emissions of the operation. Predicted noise from piling operations is provided at Annex 7A of this ES.

116. The size of the pile and the associated hammer relates directly to its noise emission when being struck during installation. With other factors such as the pile driving energy being equal, noise emissions will increase as the size (i.e. diameter and/or length) of pile increases. The graph in Plate 7.11 shows the best fit curve of noise emission data for pile sizes versus the 'source level' of noise. The source level is the noise level calculated at 1 metre from the pile when it is struck. The dotted line is located at 2.4 m which is the anticipated diameter of piles associated with turbine installation.

Plate 7.11 Predicted Noise Levels for Varying Pile Diameters



Source: Subacoustech

117. Plate 7.11 illustrates that a larger pile will therefore lead to a higher level of noise to be transmitted to the surroundings, which will propagate through the sea and seabed.

118. For the purposes of the EIA a range of potential piling activities were modelled. These comprised consideration of a 5 m diameter monopile (for the meteorological masts), a 3 m diameter pin pile (for OSP installation) and a 2.4 m diameter pin pile that would be used for turbine installation. Based on these options, a worst case of a 2.4 m diameter pin pile (assumed to be used for the installation of 277 turbines) has been modelled, at two blow force energies (1800 kJ and 2300 kJ). The vertical dotted line on Plate 7.11 shoes that a 2.4 metre pile will have a source level of approximately 245 decibel (dB) re. 1 µPa peak-to-peak.

119. It is anticipated that the 2300 kJ blow force would only be required where firmer seabed materials are encountered, most likely in the east of the site and that a blow force energy of 1800 kJ will be sufficient throughout the rest of the site. It has been assumed that each pin pile could warrant up to 16,000 hammer strikes to drive it to the required depth dependent on pile size and ground conditions.

120. It should be noted that the noise modelling also included a ‘soft start and ramp up’ approach which aims to reduce the effects of underwater noise.

121. Piling operations may take an average of approximately five hours of pile driving per pin pile and it is possible that two separate piling activities may take place simultaneously.

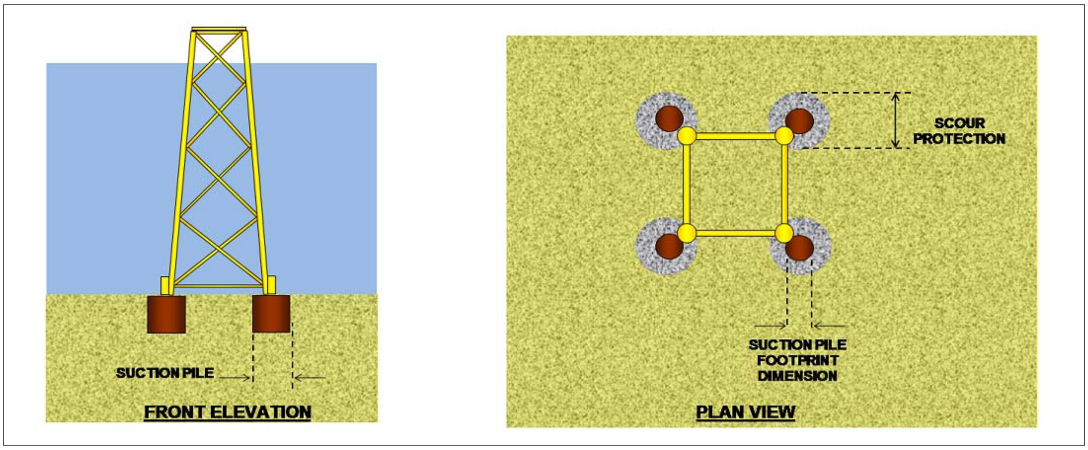
7.7.5 FOUNDATION OPTION 2: SUCTION PILE FOUNDATION

7.7.5.1 General Description

122. A suction pile foundation is an upturned bucket style design that when sunk begins to penetrate the seabed. It is then forced further into the seabed by vacuum pumps in order to secure the suction pile in place. Suction piles are suitable for use with tubular jacket substructures and can be used with turbines, meteorological masts and OSPs.

123. Each tubular jacket substructure would require at least one suction pile at each corner to fix it to the seabed. The pile diameters will range from 5 m to 15 m and will have penetration depths of 8 m to 30 m depending on seabed conditions and structural loading. Plate 7.12 illustrates a typical suction pile foundation with a tubular jacket substructure.

Plate 7.12 Suction Pile Foundation Elevation and Plan



Source: J. P. Kenny

7.7.5.2 General Installation

124. The seabed will be assessed as described in Section 7.7.4.2 prior to suction pile installation. Further to this initial seabed survey, no further seabed preparations are generally required.

125. Suction piles would usually be assembled and attached to the substructure at a quayside. The entire structure will be delivered to site and lowered to the seabed as shown in Plate 7.12. A vacuum pump system would then be utilised to create suction within the pile forcing it to further penetrate the seabed and secure the pile in place.

7.7.5.3 Vessels and Main Installation Activities

126. Suction piles are generally attached to the substructure at the quayside and the substructures delivered as described at Section 7.7.2.3.

127. Installation would most likely take place via HLV and would require a crane with sufficient capacity to lift an assembled substructure and suction pile in place.

128. The installation of suction piles and tubular jacket substructure will take approximately 24 hours from delivery to site to complete installation for each

installation. The penetration and suction operation using the vacuum pumps will typically take approximately eight hours during this period.

7.7.6 FOUNDATION OPTION 3 - GRAVITY BASE FOUNDATION

7.7.6.1 General Description

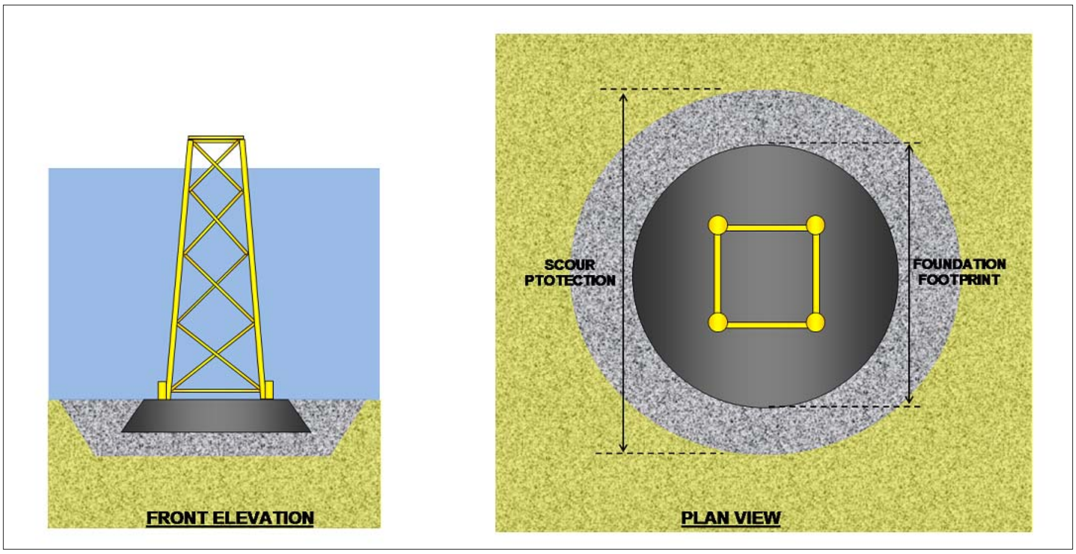
129. Gravity base foundations are structures cast from concrete or steel that sit on the seabed and rely on the weight of the structure to provide stability. These foundations can be used with either a tubular jacket or monotower substructure and are suitable for use with turbines, meteorological masts and OSPs.

130. The size of the gravity base is directly proportional to both the water depth at the point of installation and the weight of the structure to be mounted on top i.e. the turbine, meteorological mast or OSP. It is anticipated that the bases will be hollow and extra weight (or ballast) would need to be contained within the structure in the form of rock, sand or water.

131. The gravity base requires to be laid on a flat and level seabed in order to ensure even distribution of weight and to ensure that the structure is vertical; therefore multiple seabed operations may be required to achieve this prior to installation.

132. Gravity base foundations for the turbines are predicted to be between 30 m and 60 m in diameter. In respect of the OSP components the gravity bases are predicted to be between 50 m and 100 m in diameter. An illustration of a typical gravity base with tubular jacket substructure is provided at Plate 7.13 and a typical gravity base with a monotower substructure is provided at Plate 7.8.

Plate 7.13 Gravity Base Foundation Elevation and Plan



Source: J. P. Kenny

7.7.6.2 General Installation

133. The seabed will be assessed, as described in Section 7.7.4.2 prior to gravity base installation. Further to this initial seabed survey, these foundations will require seabed preparation in advance of installation to provide a level seabed.

134. Gravity bases will be manufactured onshore at a quayside. Whilst on the quayside the substructure may be attached to the gravity base so that both components are transported to site as one integrated structure. Alternatively, the gravity base may be transported to site on its own and the substructure attached once the foundation is in place.

135. In any event, the gravity base will be delivered to site by a towed pontoon barge or a HLV. Alternatively, if the gravity base is designed to be self-floating it can be towed to site by a tug and lowered to the seabed by controlled ballasting which may take the form of flooding designed cavities within the structure or use of sand or granular rock.

136. Gravity bases may need additional ballast added once they are in place on the seabed. A further specialist vessel, such as a suction hopper dredger vessel, will be utilised for this to accurately place the ballast within the gravity base.

7.7.6.3 Vessels and Main Installation Activities

Seabed Preparation

137. Seabed preparation typically takes the form of sweeping the seabed with a jetting tool to remove sandwaves or similar sediment accumulations and/or rock placement to provide a level surface. The depth of dredging may be up to 5 m below the original seabed over the geographical extent of the gravity base.

138. Seabed preparation will result in increased suspended sediments which are detailed in Section 9: Wind Farm Physical Processes and Geomorphology.

139. Increased sediment will be addressed in one of two ways:

- Where minimal seabed preparation is required a jetting tool will be utilised and the seabed sediments will be suspended and will resettle within close proximity to the area of operation;
- Where more significant dredging is required specialist dredgers will remove the sediments and these will be disposed of at a licensed spoil site by a specialist dredging vessel. Site investigations (boreholes and lab tests etc.) will be carried out to determine the nature of the material and its suitability for disposal. A separate application will be made to Marine Scotland for a dredging licence, following more detailed studies.

140. A dredging vessel will recover sufficient dredged material to fill its cargo hold within one day. This activity will be repeated until the required seabed levelling is completed. Assuming dredging to a maximum depth of 5 m this activity could take up to two weeks for one specialist vessel to complete at a single foundation location.

141. Once sandwaves have been levelled there may be a further requirement for a layer of rock to be laid to complete the foundation preparations. To undertake this activity a fall pipe rock placement vessel which lowers rock in a controlled manner to the seabed will be used. Such a vessel may carry up to 24,000 tonnes of rock; this volume would likely be sufficient for foundation preparation for approximately four gravity base locations.

142. Seabed preparation activities will be monitored using ROVs.

Gravity Base Construction and Installation

143. Gravity foundations may be manufactured at a site onshore. The dimensions of the anticipated gravity base structures will require significant laydown areas to support the manufacture and assembly of the structures. Due to the potential difficulties in transporting large gravity bases onshore, manufacturing of gravity bases may be undertaken within dry docks at a port or by a slip forming which is carried out in the water which will allow the completed structures to be floated directly to site.

144. Gravity bases will be transported from a quayside to site either:

- On a pontoon barged towed by a tug;
- On an HLV; or
- In the case of floating/self buoyant foundations, towed by a tug

145. Foundations delivered to site via a Pontoon barge or HLV will be placed on the seabed by an HLV as shown in Plate 7.14. Methods for securing HLVs are outlined at Section 7.7.2.3. Foundations which have been designed to be floating/self buoyant will be sunk into position through a controlled ballasting exercise.

Plate 7.14 Typical Single Lift Operation of a Gravity Base and Monotower Combination

Source: Luc van Braekel

Ballasting

146. Ballast operations will be undertaken by a specialist vessel, such as a suction hopper dredger, which will accurately place the ballast within the gravity base. The volume or weight of the ballast will vary depending on the water depth and the size of the gravity base.

147. Ballast may take the form of rock, sourced from an onshore location, or sand from the seabed within the vicinity of the foundation location.

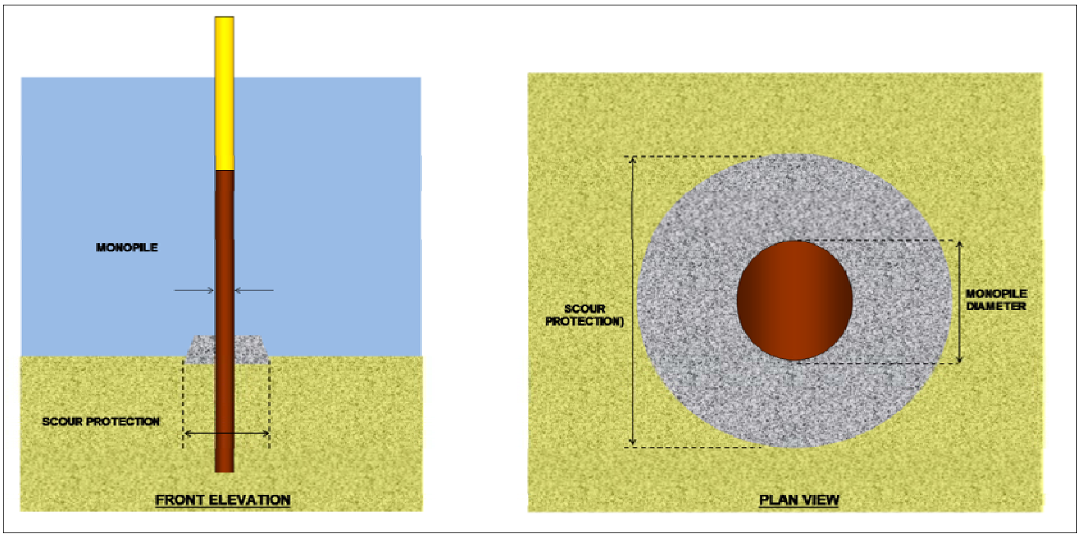
7.7.7 FOUNDATION OPTION 4: STEEL MONOPILE

7.7.7.1 General Description

148. A steel monopile is a large cylindrical steel tube which is hammered into the seabed. It can only be used with a monotower substructure and is only technically and economically viable for use with meteorological masts at this site.

149. Based on the anticipated seabed and geological conditions, it is considered that the likely maximum steel monopile diameters will be approximately 5 m. There will be up to three met masts, and therefore possibly three monopiles, within the site. An illustration of a typical monopile foundation with monotower is provided in Plate 7.15.

Plate 7.15 Steel Monopile Foundation and Monotower



Source: J. P. Kenny
Note: Potential engineering solution for the meteorological masts

7.7.7.2 General Installation

150. The seabed will be assessed, as described in Section 7.7.4.2 prior to monopile installation. Further to this initial seabed survey, no further seabed preparations are anticipated.

151. The installation techniques and vessels used for a monopile will be similar to that for pin piles outlined in Section 7.7.4.

7.7.7.3 Vessels and Main Installation Activities

152. The vessel and installation technique is similar to pin pile installation with the hydraulic or air operated pile driving hammer being attached to the steel monopile and then used to hammer the monopile to the required depth of penetration into the seabed.

153. This piling activity will generate underwater noise emissions. The predicted underwater noise levels generated by piling activities are indicated in the graph in Plate 7.11. The graph shows the best fit curve of data for different pile sizes versus the ‘source level’ of noise, the source level being the noise level calculated at 1 metre

from the pile when it is struck. It shows that a 5 metre pile will have a source level of approximately 245 dB re. 1 µPa peak-to-peak.

154. Using vessels similar to those outlined for pin pile installation and assuming that drilling and grouting are required it is estimated that on average it will take up to one day to install a single monopile, depending on the geology encountered.

155. The process of delivering and installing the foundation will be a maximum of approximately three days per monopile, subject to weather.

7.8 FOUNDATION AND SUBSTRUCTURE ZONES OF INFLUENCE

156. In order to ensure the ES presents a robust assessment of effects, the most likely combinations of foundation and substructure have been identified in order to allow the temporary and permanent impact on the seabed to be quantified.

157. The zone of influence of the relevant combinations is presented in Table 7.3. This exercise has been limited to turbine installation as it is considered that assuming the maximum number of turbines within the site will adequately represent the worst case scenario. As such, specific consideration of OSPs and meteorological masts has not been given.

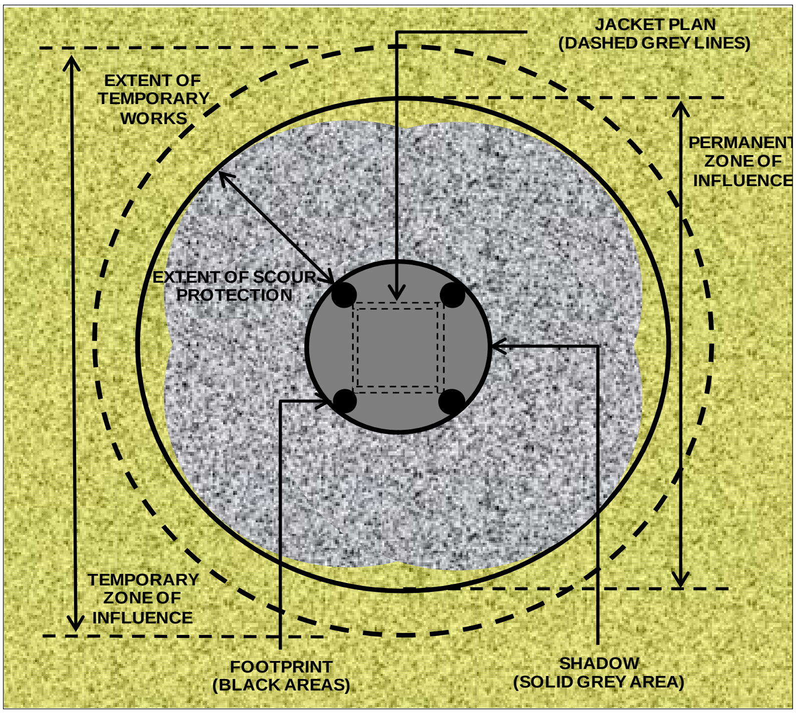
158. Table 7.3 presents the calculated area of seabed impact given the substructure and foundation combinations of the different turbine design options. It should be noted that these calculations relate to one single turbine installation and for assessment purposes these areas have been multiplied by the maximum number of turbines feasible.

159. For the purposes of assessment, the calculations within Table 7.3 assume that the size and type of substructures and foundations are constant across the site, relating to a scenario where an average water depth of 55 m is encountered.

160. The terms used in Table 7.3 and illustrated in Plate 7.16 are explained as follows:

- Footprint – The area of the foundation component which is in direct contact with the seabed. Determined by calculating the cross sectional area using the corresponding foundation (pin pile or suction pile, or gravity based) diameter.
- Shadow – The circular area beneath the foundation and substructure. Uses the maximum diagonal length of the foundation or substructure diameter, plus two diameters of any pile foundations. Assumes that suction piles are clear of the tubular jacket to further increase the 'shadow' area.
- Temporary Zone of Influence – This allows for an additional 5 m in all directions over the 'permanent' zone of influence. This results in an additional 10 m added to the permanent zone of influence diagonal length.
- Permanent Zone of Influence – The area calculated by adding the protection extent to either side of the structure's 'shadow' diagonal to account for the scour protection required in all directions around the pile. Scour protection is discussed in Section 7.9.

Plate 7.16 Foundation and Substructure Zones of Influence



Source: J. P. Kenny

161. Plate 7.16 illustrates that each installation may require a zone of scour protection. This protection is required to ensure the fine sands on the seabed do not shift over time and begin to expose or undermine the foundations of the turbine. Scour protection is discussed further in Section 7.9.

Table 7.3 Impact Area of Foundations and Substructures Per turbine

Combination			**Turbine Size**	
			3.6 MW	**7 MW**
Tubular Jacket & Pin Piles	Footprint	m^2	11	14
	Shadow	m^2	1621	6145
	Temporary zone of influence	m^2	3280	9272
	Permanent zone of influence	m^2	2344	7644
Tubular Jacket & Suction piles	Footprint	m^2	79	707
	Shadow	m^2	1997	8635
	Temporary zone of influence	m^2	4708	17449
	Permanent zone of influence	m^2	3571	15186
Tubular Jacket & Gravity Base	Footprint	m^2	1963	3318
	Shadow	m^2	1963	3318
	Temporary zone of influence	m^2	13685	20867
	Permanent zone of influence	m^2	11690	18358
Monotower & Gravity Base	Footprint	m^2	1963	3318

Combination			Turbine Size	
	Shadow	m^2	1963	3318
	Temporary zone of influence	m^2	13685	20867
	Permanent zone of influence	m^2	11690	18385

7.9 SCOUR PROTECTION

7.9.1 INTRODUCTION

162. Scour is the process where the seabed is eroded as a result of water movement and in the case of the Project, as a result of introducing new elements onto the seabed and changing water flows. Scour can occur around any structure placed on the seabed. It specifically occurs when the seabed particles around the structure are displaced by the action of the eddy currents which are generated close to the obstruction. Scour manifests itself by the formation of scour holes immediately around the obstruction and extending outwards.

163. The severity of scour depends on the wave and current velocities at the site, the type of sediment (sand is more likely to scour than clay due to its granular structure) and the size and shape of the obstruction. Section 9: Physical Processes and Geomorphology of this ES indicates that, given the water depth, seabed and geological characteristics, the effects of significant scour are limited to only a small proportion of the area of the Wind Farm Site.

7.9.2 SCOUR PROTECTION MEASURES

164. There are two options to allow for the fact that seabed erosion from scouring may occur, either:

- Allow for scour in the design; or
- Install scour protection.

165. Scour protection usually involves the placement of piles of rock boulders at a vulnerable seabed location. This is known as rock armour and it is usually laid upon another finer grade of rock known as the filter layer. Alternative solutions are to use the placement of gravel filter layers or geo-textile or concrete frond mattresses.

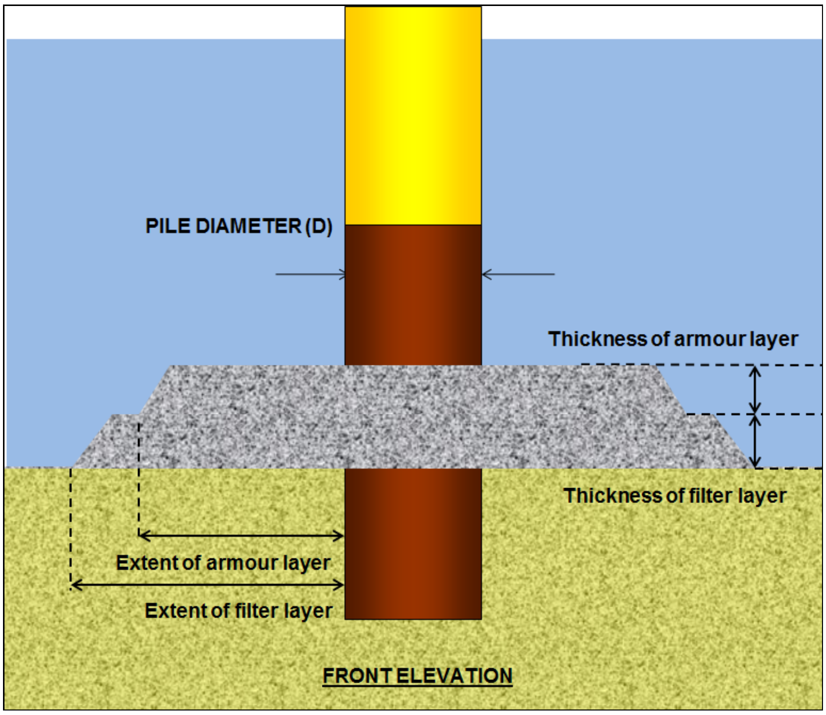
7.9.3 DIMENSIONS OF SCOUR PROTECTION

166. It is anticipated that some degree of scour protection will be required at all foundation locations. The required thickness and extent of the scour protection will depend upon whether pre-installed or post-installed protection is provided. Typical scour protection measures around a seabed installation are illustrated in Plate 7.17.

167. Installation of scour protection can be undertaken using the following approaches.

- Static scour protection - the filter layer is placed prior to the installation of the foundation. The rock armour layer is installed once the structure is in place. In this approach the installation vessels required for scour protection would be required during the installation of each pile or foundation.
- Dynamic scour protection – the pile is driven or foundation laid and only after installation is scour protection installed at each location from the selected vessel.

Plate 7.17 Scour Protection Elements



Source: J. P. Kenny

168. The terms used in Plate 7.17 are defined below:

- Filter layer – This is likely to consist of a layer of finer grade rock or gravel; and,
- Armour layer – There are a number of solutions to provide this layer, the most likely being rock boulders. Rock nets/gabions could also be used for this layer, as illustrated in Plate 7.19.

169. For pre-installed scour protection, the required thickness of protection layers has been based on findings from recent research[1] and experience from Greater Gabbard Offshore Wind Farm. The extent of the filter layer has been assumed to extend beyond the armour layer. It is anticipated that protection for foundations will typically extend between 15 m up to 45 m from the structure. The range is wide as a result of the various foundation diameters currently under consideration for the Wind Farm.

170. If surface laid (i.e. not buried in a trench), the inter-array and OfTW cables could also cause scour and these elements too may need scour protection measures. The height and width of scour protection measures for these components is likely to be a minimum of 0.6 m high with a maximum area of 0.48 sq. km for the inter-array cables and 0.26 sq. km. for the OfTW. Details of the inter-array and OfTW cables are provided at Sections 7.10 and 7.12 respectively.

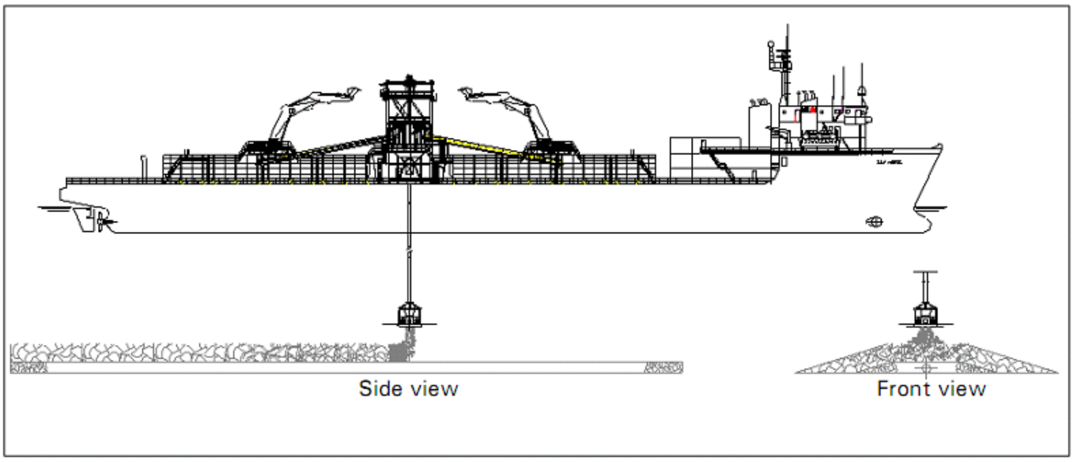
7.9.4 INSTALLATION OF SCOUR PROTECTION

171. Two approaches that are being considered and that have been assessed for placement of the filter and armour layers are as follows.

- Vessel with flexible pipe as shown in Plate 7.18. This technique is accurate, even in deep water.
- Side rock placement vessel, or barge, as shown in Plate 7.18. For a side stone-placement vessel the actual placement time is approximately 15 minutes (assumed 1000 tonnes). Given the deeper water at the Wind Farm Site this option would be less accurate.

172. A vessel with a flexible pipe carries up to 24,000 tonnes of rock, this quantity should be sufficient for foundation scour protection for at least two substructure locations.

Plate 7.18 Typical Rock Placement Vessel



Source: Bosacalis Offshore

7.10 INTER-ARRAY CABLES

7.10.1 GENERAL DESCRIPTION

173. The inter-array cables are the cables which connect the turbines to the OSPs and transport the generated electricity within the Wind Farm. This Section describes the likely size, voltage, configuration and installation techniques of the required cables. The OfTW export cable (i.e. the cable from the OSP to the connection with the onshore cable at the landfall) is discussed in Section 7.12.

174. The final technology and precise configuration of the inter-array cables will be determined following confirmation of turbine numbers and models, and when all constraints (e.g. seabed obstructions and installation requirements) are fully understood. The layout and length of inter-array cabling required will therefore depend on:

- Environmental constraints;
- Number of turbines;
- Turbine capacity (MW);
- Spacing between turbines;
- Number and location of OSPs; and

- Array voltage.

175. The maximum length of cable will be 350 km.

7.10.1.1 Cable Size and Voltage

176. It is likely that the inter-array voltage will be 33 kV AC, however it may be up to 66 kV. The cable will be a sea-armoured three core cable, usually with copper conductors and a fibre optic for communication purposes. Table 7.4 indicates the size and weight of three typical cables that are options for use. It is expected that the outer diameter of the cables will increase as the turbine size increases although a smaller size cable may be used for cables serving fewer turbines.

Table 7.4 Example of 33 kV Cable Sizes

Cross sectional area (mm^2)	Outer Diameter (mm)	Weight (kg/m)
185	113	21.0
400	129	28.1
800	157	48.9

7.10.1.2 Inter-Array Cable Layout and Positioning

177. Inter-Array cables may be surface laid, buried or protected. Cables will be buried or protected wherever feasible. However, due to the uncertainty regarding seabed and underlying geological conditions it is not possible to specify exactly what proportion of inter-array cables will be buried or protected at this stage in the development process however there will be a preference to bury or protect cables where feasible. The maximum extent of cable protection will be 0.5 km^2

178. Cables will be laid so as to best suit the turbine and OSP positions and as far as practicable to avoid cables crossing on the seabed. The arrangement will also be designed to allow for any planned construction, operation and maintenance activities.

179. Depending on the number of OSPs constructed, the number and spacing of turbines, and allowing for an element of contingency, the maximum total length of the inter-array cable will be approximately 350 km.

7.10.1.3 Cable Burial Depth

180. The depth of cable burial is determined principally by the need to protect against damage from certain fishing activities or vessel anchor impact. These risks may be considered relatively low in the inter-array cable zones however, there is evidence that certain fishing activities do take place within the boundaries of offshore wind farms within the UK. To protect the cables from these activities there will be a need to implement other protection systems other than burial at certain points in the cable network.

181. It is advantageous not to bury cables deeper than necessary thus reducing the risk of damage during installation, easing installation operations, and easing access to cable for any repair. However, cables have to be deep enough to minimise risk of damage from other identified and anticipated activities.

182. Sediment samples from the Wind Farm Site indicate that seabed conditions vary across the site and range from soft sand to pockets of very hard clay with fine sand layers. This will lead to variable cable burial depths and techniques across the site. For the purposes of assessment a maximum burial depth of 2.5 m has been assumed.

183. The appropriate burial depth for each cable on the site will be identified as part of the detailed design phase of the Project following more detailed studies.

7.10.1.4 Cable Protection Measures

184. Protection measures are required where cables are exposed. Cable protection is typically required at each end of the inter-array cables. At each end there is likely to be an exposed section of cable as it transitions from the trench to the cable entry point of the substructure for turbine or OSP. At these locations additional protection may be required. It is expected that the length of exposed cable sections may be up to 50 m at each end.

185. Typical cable protection solutions include covering the cable with:

- Concrete mattresses;
- Rock armour;
- Rock nets/gabions; or
- Rock placement.

186. Standard mattress dimensions are typically 6 m length by 3 m width. Based on this, the maximum area of protection throughout the site is expected to be 0.48 sq. km. In sandy areas, the mattresses may be fitted with fronds, which will attract sediment and create sediment build-up. The fronds would be to act as a sediment trap further increasing the ability of the mattress to provide scour protection.

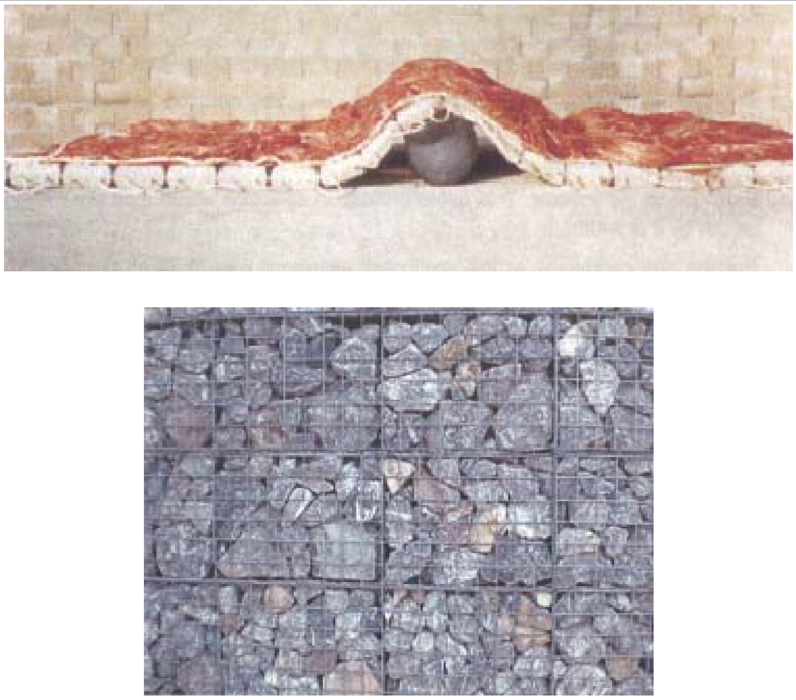
187. Alternative solutions such as the use of rock armour (layers of boulders) or rock nets /gabions (wire mesh nets filled with rocks) may also be considered. Cable protection with mattresses, rock armour or rock nets/gabions may be required to remediate surface or shallow burial depths where cable trenches are insufficiently deep due to seabed conditions. Rock placement (or rock dump) which is used as scour protection, may also be used for cable protection. Plate 7.19 illustrates a typical concrete mattress and a rock net/gabion solution.

7.10.2 GENERAL INSTALLATION

188. A specialist cable laying vessel, designed to transport and deploy these cables, would be used to lay the inter-array cables. This vessel would be kept in the correct location during its operation by the use of a dynamic positioning control system. The cable would be wound onto a cable carousel and then once the vessel is positioned on site the cable would be unwound and laid on the seabed or in a prepared trench. Where the cable is to be buried a specialist tool, or alternatively a specialist ROV, would be deployed from the cable vessel to create the trench into which the cable would be laid.

189. If there is a requirement to protect the inter-array cabling this would be undertaken by another specialist vessel that would protect at the required locations.

Plate 7.19 Typical Concrete Blanket/Mattress and a Rock Net/Gabion



7.10.3 VESSELS AND MAIN INSTALLATION ACTIVITIES

190. Cables will be delivered to site by a cable laying vessel (Plate 7.20).

Plate 7.20 Cable Laying Vessel

Source: Subsea 7

191. There are a number of installation techniques available to bury the inter-array cables, namely:

- Ploughing;
- Jetting; and

- Trenching.

192. These techniques are discussed further in the following Sections. The final choice of technique will be made as part of the detailed design and when constraints such as geotechnical issues and water depths are fully understood.

7.10.3.1 Ploughing

193. Ploughing involves a blade which cuts through the seabed with the cable being laid behind and is the most likely of techniques to be employed at the Wind Farm site. Ploughs are generally pulled directly by a surface vessel, or they can be mounted onto a self propelled caterpillar tracked ROV which runs along the seabed. Pull forces to move the plough through the seabed can be significant e.g. of the order of 200 tonnes.

194. Cable ploughs are usually deployed to both make the trench and then simultaneously lay the cable into the trench. The trench width and the disturbed area would be on average 3 m wide. Once the plough has pushed the cable into position at the base of the cut trench the plough continues and backfills the trench to provide immediate burial. Some ploughs are fitted with jet assist options and/or hydraulic chain cutters to work through patches of harder seabed conditions.

195. Ploughing is the most efficient burial method in most ground conditions however steep seabed slopes may undermine the stability of the equipment. If they are towed from the surface, rather than using an ROV, ploughs are less manoeuvrable and this places limitations on their accuracy and also the ability to re-plough a trench should this be required. Plate 7.21 provides an image of a typical cable plough.

Plate 7.21 Typical Cable Plough

Source: Subsea 7

7.10.3.2 Jetting

196. Jetting involves directing water jets towards the seabed to displace the seabed sediment. The water jets are usually deployed from jetting arms beneath a ROV that

can either be free-swimming, based on ski-like skids or on active tracks similar to a caterpillar vehicle.

197. During the formation of the trench the displaced sediment is forced into suspension and then resettles. The jetting process is controlled to ensure sediment is not displaced too far and is available to fall back into the trench for immediate burial through settling.

198. Jetting tools have been used successfully at offshore wind farm projects in the UK. Plate 7.22 illustrates a typical jetting trencher. A key benefit of a jetting tool is that it is able to operate close to existing structures and it is also possible to use jetting tools for any corrective trenching, if required.

Plate 7.22 Typical Jet Trencher

Source: Canyon Offshore

7.10.3.3 Trenching

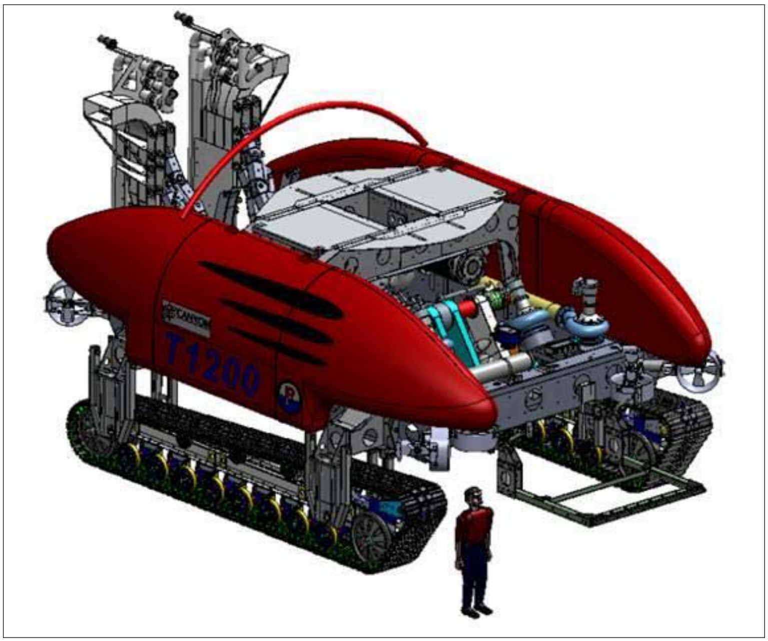
199. Trenching involves the excavation of a trench whilst temporarily placing the excavated sediment adjacent to the trench. The cable would then be laid and the displaced sediment used to back-fill the trench, covering the cable. This is most commonly used where the cable has to be installed through an area of harder seabed composition. This technique is least favoured for the Wind Farm Site and would only be used in exceptional circumstances where firmer seabed conditions dictate.

7.10.3.4 Trench Widths

200. The trench width, and its zone of influence, can vary depending on the burial method selected and the ground conditions, but are generally not less than 1.5 m. A study by the Department for Business & Regulatory Reform concluded that the limits of environmental impact from trenching occur over long and narrow corridors with a maximum width of up to 3 m. Given the information on seabed conditions and the trenching techniques available it is considered the minimum and maximum trench widths are likely to be as follows:

- Minimum trench width - 1.5 m; and
- Maximum - 3.0 m.

Plate 7.23 Typical Trencher



Source: Beatrice Offshore Windfarm Ltd

7.10.4 TIMING AND DURATION OF CABLE INSTALLATION

201. The inter-array cable lay operation will most likely take place after a defined area of the Wind Farm has had foundations installed. It is possible that cable laying could be undertaken after the installation of pre-driven piles (if used) and before installation of the substructures at these locations.

202. It is estimated that on average each turbine array cable will take approximately one day of vessel time to lay and trench. The installation rate will be heavily dependent upon weather conditions, technique adopted and seabed conditions.

7.11 OTHER ANCILLARY WIND FARM FEATURES

7.11.1 METOCEAN BUOYS

203. Up to three metocean buoys will be anchored to the seabed within the site to gather data on the wave and tidal regime throughout the lifetime of the Project. The location of these buoys is not yet determined. All required lighting and markings will be adhered to and the locations of the equipment will be publicised through the appropriate notification procedures.

7.11.2 CLOSED CIRCUIT TELEVISION (CCTV) AND RADAR MONITORING

204. CCTV may be installed to enable coverage of the Wind Farm Site from key locations, either on the turbine structures or the OSPs. The CCTV will be adjustable for day/night conditions (infrared cameras may also be specified) and allow operators to identify vessel names from a distance to facilitate radio communications.

205. It is also possible to install radar, either as an extension of existing port Vessel Traffic Service (VTS) systems or as stand alone systems. Once the Wind Farm layout has

been determined an assessment shall be made on the suitability of current radar technology to enhance coverage for the Wind Farm.

7.12 OFFSHORE TRANSMISSION WORKS

7.12.1 INTRODUCTION

206. The OfTW comprises up to three export power cable trenches between the Wind Farm and the landfall point. The final number of export cable circuits will depend on the final Wind Farm design, the cable will either be a high voltage direct current (HVDC) or high voltage alternating current (HVAC). The cables will run parallel, to each other, and be installed with a separation distance (between cables) of approximately four times water depth.

207. The cables will transmit the power produced by the Wind Farm to the shore, where the OnTW will then continue to a new substation where the generated electricity will be distributed to an existing substation and into the grid.

7.12.2 OFFSHORE TRANSMISSION WORKS

208. The OfTW comprises the cables used to connect the OSPs with the OnTW (which form part of a separate application) at a landfall point near Portgordon.

209. The corridor within which the OfTW will be located is shown on Figure 1.2. The corridor is approximately 65 km in length and will accommodate up to three cable bundles laid in separate trenches. The trenches will be spaced at a nominal distance of four times the water depth apart (e.g. 160 m at a depth of 40 m). The cables will be encased in extruded cross linked polyethylene (XLPE), insulated and wire armoured for erosion protection. It is likely that the export cables will also allow for data to be transferred from the Wind Farm to the mainland using optical fibres.

7.12.3 GENERAL INSTALLATION

210. This Section describes the three possible cable installation methods that may be utilised for the OfTW cable. The cable installation techniques under consideration are the same as those detailed at Section 7.10.3 in respect of the Inter-Array cables:

- Ploughing;
- Jetting; and
- Trenching.

211. The final choice of technique will be made as part of the detailed design and when constraints such as geotechnical issues are fully understood.

212. External protection of the cable is typically provided by trenching. A 'V' shaped trench is generally cut in the seabed with the cable laid to the base of the trench. Indicative trench dimensions are up to 3 m wide and up to 2.5 m deep with the aim of achieving minimum depths of at least depths of 0.6 m.

213. In addition to these standard techniques provision for directional drilling has been made in respect of the parts of the OfTW which are located under the Spey Bay SSSI and details of this are provided at Section 7.12.7.

7.12.4 INSTALLATION OPTIONS

7.12.4.1 Cable Laying by Ploughing

214. Cable laying by ploughing is described at Section 7.10.3.1

215. Trench widths and the disturbed area will be approximately 3 m wide and approximately 2.5 m deep with the trench formed, the cable product is then placed on the base of the trench. A zone of influence of approximately 12 m^2 per linear metre is generated by the cable plough. Cable ploughs can be operated in a simultaneous or post lay[2] mode.

7.12.4.2 Cable Laying by Jetting

216. Cable laying by jetting is described at Section 7.10.3.2

217. This process leads to a large displacement of seabed sediment into the water column. A zone of influence of approximately 12 m^2 per linear metre, as stated for the cable plough, would also be expected for jet trenching tools.

7.12.4.3 Cable Laying by Trenching

218. Cable laying by trenching is described at 7.10.3.3. Generally, trenches created by cutting tools are narrower and on the basis of a narrower trench the footprint may be reduced to approximately 11 m^2 per linear metre. These trenching tools can be operated in simultaneous or post lay and burial modes.

7.12.5 CABLE PROTECTION

219. Where cable additional protection is required due to insufficient trench depth, or where existing infrastructure, cables or pipelines have obstructed trenching, remediation measures may be necessary to provide protection to the cable. As with the protection measures described for the inter-array cables this protection could be in the form of rock armour or concrete.

220. Seabed obstructions such as boulders and overlying cobbles and gravelly soils can present difficulties when trenching such that it may not be feasible. As a consequence, it is anticipated that up to 0.26 km^2 of cable protection may be required.

221. Rock armour placement has been extensively used in the North Sea for cable/pipeline protection. A rock berm is created. The rock berm dimensions can be sized to accommodate the risk of damage to commercial fishing equipment and the rock can be graded to suit seabed current conditions.

222. Typically, a rock berm will have a 1:3 slope (vertical to horizontal) with a crest width of 1 m and a height of 0.5 m above seabed. It is anticipated that a typical volume of 2 m^3 per linear metre will be utilised.

223. The concrete mattressing method has also been widely used in the North Sea, particularly near platform approaches. Typically, an installation vessel crane lowers

[2] Post Lay - Cable laid on the seabed and trenched subsequently.

and places the mattress on the seabed. Mattresses are likely to have lower seabed stability than rock berms from prevailing seabed currents.

7.12.6 CABLE SEPARATION DISTANCE

224. There will be a requirement to construct up to three cable trenches in parallel with one another along the entire cable route. Cables must be laid with a separation distance so that, in the event of a fault, repairs can be carried out without risk of damaging the adjacent cables. It is anticipated that a nominal spacing of approximately four times the water depth would be utilised.

7.12.7 SITE SPECIFIC CONSTRUCTION CONSIDERATIONS

7.12.7.1 Directional Drilling

225. A Horizontal Directional Drill (HDD) duct will be constructed to allow the cables to be installed under the Spey Bay SSSI without disruption to the designated features of the site. To install a HDD duct a shaft will be excavated to a predefined depth and a casing (pre-cast concrete or sheet piling) installed to provide stability to the excavated shaft. Cable entry ducts will then be installed within the shaft to allow the cables to be pulled from the cable laying vessel. Horizontal drilling techniques will then be employed to drill under the SSSI. The cable will then typically be fed through with the use of a land-based winch to pull the cables ashore through the duct from the shallow water lay barge.

226. It is possible that one HDD duct will be required for each of the three cable bundles, however it may be feasible to feed three cable bundles through one duct. Typical dimensions of the onshore shaft will be in the region of 5 m diameter by 10 m deep.

7.12.7.2 Offshore to Onshore Transition

227. An onshore transition pit will be used to join the multi-core export cabling to single core onshore cables. This aspect of the development does not form part of this EIA and will be subject to a separate EIA and consent.

7.12.8 VESSELS AND MAIN INSTALLATION ACTIVITIES

228. Cable laying vessels are typically dynamically positioned (DP) vessels which are restricted to water depths of greater than 15 m LAT. They are typically 100m in length. These vessels would undertake all cable laying and trenching activity. In the nearshore a cable lay barge would be used.

7.13 CONSTRUCTION PROGRAMME AND LOGISTICS

7.13.1 INTRODUCTION

229. This Section outlines the indicative programme and logistics associated with constructing the Wind Farm and the OfTW.

7.13.2 CONSTRUCTION PROGRAMME

230. It is anticipated that the construction and installation works for the Wind Farm will take place over a maximum five year period. The earliest start date for construction is considered to be 2014 with the current programme based on a target of first phased

electricity generation in April 2016. The working assumptions used for this five year programme are shown in Table 7.5.

Table 7.5 Indicative Construction Programme

Construction Activity	2014				2015				2016				2017				2018			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Pre-installation seabed investigations		■	■	■																
Installation of foundations			■	■	■	■	■	■	■	■	■	■								
Installation of inter-array cables						■	■	■	■	■	■	■	■	■	■	■	■			
Installation of substructures					■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Installation of wind turbines /OSPs									■	■	■	■	■	■	■	■	■	■	■	
Offshore Transmission Works						■	■	■	■											
First electricity production and export										■										

231. Table 7.5 assumes an ideal single phase programme for a scheme of up to 1,000 MW. therefore it is essential that a deliverable project programme is afforded sufficient flexibility beyond this to accommodate unforeseen events, including but not limited to:

- Variations in ground conditions;
- Critical logistics and supply chain constraints or delays;
- Delays or acceleration to arrival, or failures of specialist equipment; and
- Construction activities will take place all year round, 24 hours a day, seven days a week although dependent on weather conditions.

232. It is anticipated that the OfTW will take approximately nine months to construct. Each cable will be laid as a non-stop activity from one end to the other and installation works will be undertaken 24 hours a day. Both the OfTW and OnTW require to be installed to allow electricity to be transported to the grid.

7.13.3 CONSTRUCTION LOGISTICS

233. The use of vessels during construction is outlined in Sections 7.4 - 7.12. Table 7.6 provides an indication of the likely number of vessels to be working on the Wind Farm Site and OfTW Corridor in any one day and further information is contained in Table 7.6.

Table 7.6 Indicative Construction Vessel Movements

Vessel type	Maximum number of vessels simultaneously on-site	Number of movements between port and site per day (per vessel)
Turbine and OSP Construction		
Guard vessel	3	Likely to be based offshore with 24 hour working regular shuttle to port for shift change.
Survey vessel	3	Depends on the survey task. Likely to return to port every 12 hours.
Dredge vessel (for gravity base)	3	Likely to be based offshore with 24 hour working.
Split hopper barge	Up to 2 barges per dredger	Likely to be based offshore with 24 hour working.
Rock placement vessel (for gravity base, one vessel will hold enough rock for up to four installations)	3	Approximately one visit per week.
Diving Support Vessel / remotely operated vehicle support vessel	1	Likely to be based offshore with 24 hour working.
Installation vessel (HLV, jack up barge, crane vessel, anchored semi submersible crane vessel)	3	Unlikely to require more than one port visit per week.
Construction vessel or Anchor Handling Tug for positioning and grouting	3	An offshore specified light construction vessel may only need to return to port once a fortnight. If it is a tug then it would probably return to port daily.
Jack up rig for installation of turbine	2	Assuming it carries up to six turbines per round trip, the vessel would require approximately one port visit a week.
Transport of turbines - barge towed by up to two tugs	1 barge on site at one time	Anticipated to require no more than one port visit every 3-4 days.
Transport of foundations - barge towed by up to two tugs	1 barge on site at one time	Anticipated to require no more than one port visit every 3-4 days.
Transport of substructures - barge towed by up to two tugs	1 barge on site at one time	Anticipated to require no more than one port visit every 3-4 days.
Crew transfer vessel	20	Up to two trips between port and site per day per vessel.
Inter Array Cable		
Cable lay vessel	1	Unlikely to require more than one port visit per week.
Construction vessel for pull in operations	1	Unlikely to require more than one port visit per day.
Offshore Transmission Works		

Vessel type	Maximum number of vessels simultaneously on-site	Number of movements between port and site per day (per vessel)
Cable laying vessel	1	Three trips to port to pick up cable reel.
Rock placement vessel	1	Approximately one visit per week.

7.13.4 SAFETY ZONES DURING CONSTRUCTION

234. During all marine operations a relevant safety zone will be applied for the construction, commissioning and operational phases of the Project. The safety zones will be applied for and implemented in compliance with the Energy Act 2004 and the Electricity (Offshore Generating Stations) (Safety Zones) (Applications Procedures and Control of Access) Regulations 2007.

235. The purpose of such safety zones will be to manage the interaction between vessels associated with both the Wind Farm and other users/developments in order to protect life, property and the environment. The fundamental principle is that vessels will be kept at a safe distance from construction, commissioning and operational activities related to the Wind Farm in order to avoid collisions.

236. Temporary safety zones will be marked with a navigation buoy at each corner of the zone. The zone will be subject to a Notice to Mariners' as a temporary construction site and off limits to third parties. The zones will be advertised using the proper channels and liaison will take place prior to implementation with the relevant local sea users and bodies, including the port authorities.

237. Where necessary along the OfTW Corridor, guard boats or standby boats will be employed to guard specific points. A vessel will also be nominated to monitor the safety zones and guard against any infringements.

238. A 500 m (the maximum permissible under international law) safety zone will be in place around each turbine during construction, major maintenance, possible extension and decommissioning. A Control Centre, part of the necessary O&M facilities, will have an Automatic Identification System (AIS), radar coverage, and CCTV coverage, which will identify vessels with AIS facilities entering into the safety zone during construction and commissioning activities. This will be in addition to visual observations by personnel on Wind Farm vessels or guard vessels working within and around the Wind Farm Site and OfTW Corridor. Any vessel identified or observed to stray in to the safety zone will be contacted by a designated member of the crew of the Wind Farm or guard.

239. Marine navigational marking, including lights and marks on significant and intermediate peripheral structures will be provided in accordance with NLB requirements, which will comply with IALA Recommendation 0-139 (the Marking of Offshore Wind Farms) and the requirements of MCA MGN 371, see Section 7.14.3 below.

240. Appropriate site management procedures, method statements and tool box talks will also be utilised throughout the construction phase to ensure all necessary

environmental measures are undertaken according to the Project's Construction Management Plan.

7.14 OPERATIONAL REQUIREMENTS

7.14.1 INTRODUCTION

241. The Wind Farm will be designed to operate under minimum supervisory input, however all operation and maintenance (O&M) activities will require year round access i.e. 365 days per year, 24 hours per day. This Section describes the characteristics of the Wind Farm during the operational phase, namely:

- Safety zones; and
- Navigation and aviation markings and lighting.

242. The principal O&M activities are also discussed in more detail, specifically:

- Scheduled and unscheduled events; and
- Possible port and harbour facilities.

7.14.2 SAFETY ZONES DURING OPERATION

243. It is likely, although to be confirmed, that BOWL will apply for an operational safety zone of 50 m around each structure in accordance with the relevant guidance from DECC. During maintenance operations this would be extended to 500 m (the maximum permissible under international law) around the relevant structures. Once the Wind Farm is in use AIS and CCTV from an onshore Control Centre, will be in place to monitor vessel movements within the Wind Farm.

7.14.3 NAVIGATION AND AVIATION MARKINGS AND LIGHTING

244. Turbines and OSPs will incorporate the identification markings, safety markings and signage as specified in requirements and guidelines set by the MCA, RYA and IALA. These requirements are summarised below.

245. These bodies, along with the CAA, also dictate the requirements and recommendations for vessel and aircraft safety and navigational lighting of offshore structures. Their requirements will be embedded into the final design of the Wind Farm.

7.14.3.1 Turbine Markings

246. There will be Unique Identification Characters (UIC) including numbering on turbine towers and nacelle roofs. Turbines will have high contrast markings (dots or stripes) placed at 10 metre intervals on both sides of the blades to provide search and rescue helicopter pilots with a hover-reference point.

247. Turbine access areas, nacelle roofs and landing platforms will also be fitted with clearly marked safe areas, railings, hand holds and/or strong points for the securing of safety harnesses.

248. The UICs on the turbine tower will be clearly readable in all directions under normal conditions of visibility and all known tidal conditions by an observer at sea level (6.9 m above LAT). The UIC will be visible from a distance of 500 feet (150 m) in all directions as well as from above for aviation purposes.

249. The UIC, where practicable, will be displayed in black letters or numbers 1 m in height on a yellow background. However, precise dimensions will be determined by the height of lights and necessary range of visibility of the identification numbers. The UICs will each be illuminated by a low-intensity light controlled from the site Control Centre and activated as required.

7.14.3.2 Turbine Obstruction Lighting

250. Obstruction lighting is to be fitted on offshore turbines with a height of 60 m or more above the highest astronomical tide. At least one medium intensity steady red light (2,000 candela) should be positioned as close as possible to the top of the fixed structure with a requirement for some downward spillage of light. Where four or more wind turbines are located together in the same group, with the permission of the CAA, only those on the periphery of the group need to be fitted with obstruction lighting.

251. For any structure with potential to conduct heli-hoist operations the following requirements will be met. The red light positioned for navigational purposes will be visible from all angles of azimuth and have a minimum intensity of 50 candelas for angles of elevation between 0 and 15 degrees, and a minimum intensity of 200 candelas between 5 and 8 degrees, but will not be visible below the level of the winching area platform.

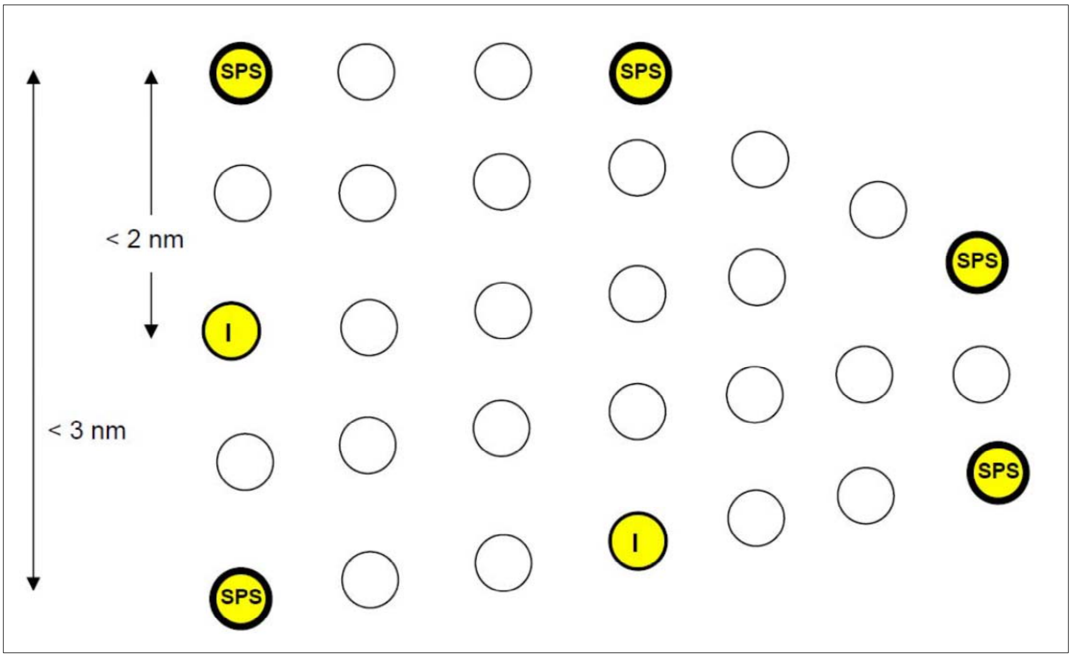
7.14.3.3 Perimeter and Route Lighting

252. In consultation with the relevant stakeholders, the precise location of buoys or beacons will be agreed and will be placed to mark the perimeter of a group of structures, or to mark routes/channels through a group of structures.

253. At least one light will be visible upon approaching the structure from any direction. The light will be placed not less than 9.4 m above LAT and not more than 33.4 m above LAT. The vertical distribution of the projected beam will be such that the light will be visible from the immediate vicinity of the structure to the maximum luminous range of the light. The lighting will have a minimum effective intensity of 1400 candelas.

254. A Significant Peripheral Structure (SPS) is the corner or other significant point on the periphery of a wind farm and an Intermediate Structure (I) is on the periphery of a wind farm. A theoretical illustration is provided on Plate 7.24 where each circle denotes a turbine.

Plate 7.24 IALA Lighting Requirements - Significant Peripheral Structures (SPSs) and Intermediate Structures(I)



255. Both SPSs and Is will be synchronised to display an IALA special mark characteristic, yellow flashing lights every five seconds with a range of not less than five nautical miles. The lights will be operated in unison with a flashing character according to Morse letter "U" and with a maximum period of 15 seconds. The intermediate structures will have a yellow flash character with a range of not less than two nautical miles. The lights will be visible from all directions in the horizontal plane and have an availability of no less than 99%.

7.14.3.4 Heli-hoist Platform Lighting

256. Heli-hoist platforms will be illuminated during transfer of personnel. A green light will be located in the safety zone to indicate that the turbine blades and nacelle are secured in position prior to helicopter hoist operations commencing. This would be capable of being operated both remotely, and from the heli-hoist platform itself.

257. The green light will have a minimum intensity of 16 candelas and a maximum intensity of 60 candelas for all angles of azimuth and for all angles of elevation from 0 to 90 degrees but will not be visible below the level of the winching area platform. The lighting will be visible from a minimum distance of 150 m in all directions and from above.

7.14.3.5 Turbine Boat Landing Lighting

258. Boat landings will be illuminated during personnel transfers. The lighting will be such that during a transfer the boat landing will be visible in all directions during hours of poor visibility and darkness.

7.14.3.6 Further Aids to Navigation

259. The Wind Farm will be marked with sound signals such as fog horns. These will be operated when the meteorological visibility is two nautical miles or less.

260. When required there will be rhythmic blasts corresponding to Morse letter "U" every 30 seconds with the minimum duration of the short blast being 0.75 seconds and covering a range of no less than two nautical miles.

261. Sound signals will be mounted at least 9.9 m above the level of the LAT but not higher than 18.9 m and not higher than the lowest point of the arc of the rotor blades.

7.14.4 SCHEDULED O&M EVENTS

262. Scheduled works on the turbines, OSPs, meteorological masts and inter-array cables will include annual or bi-annual maintenance, statutory inspection and routine inspection visits. Retrofitting and upgrading works may also take place when necessary. The scheduled works will normally be timetabled for the summer months, given the typically more settled weather and longer daylight hours. During this period the number of O&M personnel at site can be expected to peak.

263. The number of technicians for a project of this size is dependent on the number and type of turbines built. Based on the scenarios outlined in Table 7.1, the number of technicians which would be required for maintenance/repair operations would be 75 - 110 technicians.

264. The current technology of a turbine means it will require a major service every 12 months and gearbox oil changes every five years. Periodically large components such as gearboxes and blades may also need to be replaced. In this case a floating HLV or jack-up vessel, similar to that used for turbine installation, would be used to carry out the necessary works.

265. Access to each installation offshore will be by boat or helicopter with at least two service personnel being on each offshore structure at any one time for safety reasons. Daily transfers of personnel and materials from the O&M base to the Wind Farm would utilise a work boat i.e. a vessel carrying a maximum of 12 personnel, plus crew, and typically 18-20 m in length. It is anticipated that by the time of operation larger vessels for up to 30 personnel which are typically in excess of 24 m will be readily available.

266. In order to achieve the maintenance programme it is anticipated that O&M teams will be working simultaneously on several turbines at any one time (and potentially also on the OSPs). It is therefore expected that at least two crew vessels will be on-station within the Wind Farm Site when O&M work is being undertaken. A summary of likely planned vessel movements is presented in Table 7.7.

267. In addition to technicians employed for maintenance operations, a core Operations Team of approximately 35 personnel will be required based at an onshore O&M base to manage and support all aspects of Wind Farm operation.

268. In order to undertake monitoring and servicing of underwater Wind Farm components (foundations, scour protection, cables) it is likely that a combination of service vessels (crew vessels, dive vessels and ROVs) will be used to complete inspection of components.

Table 7.7 Indicative Scheduled O&M Vessel Movements

Scenario	Max	Min
Total number of offshore technicians	110	75
Number of service vessels required	8	5
Typical size of service vessels	20 m	20 m
Average number of vessel trips to site per day	5	3
Estimated number of vessel movements per annum	1760	-

7.14.5 UNSCHEDULED O&M ACTIVITIES

269. The turbines will require periodic visits in the event the turbine experiences a fault which cannot be reset remotely. These will happen from time to time but by their nature the frequency or timing of these are unknown. .

270. Unscheduled repair activities will range from attendance on location to deal with the resetting of false alarms to major repairs, e.g. the replacement of a turbine gearbox or blade.

271. Transport of the major turbine components for replacement will take place by sea, with the components typically being shipped directly from manufacturing bases directly to the Wind Farm Site. These manufacturing bases are likely to be based in Europe, however, it is expected over time replacement components will begin to be held in the UK ports.

272. In the event of a major component replacement there will be a need to use HLVs, pontoon barges and tugs in order to replace defective components such as generators, gearboxes and blades. Detailed planning of the remedial work and travelling time will be undertaken to keep transit as short as possible and maximise lifting operations and installation activities.

7.14.6 ANCHORAGE AREA FOR MOTHER VESSEL/SUPPORT VESSEL

273. During the operational phase it is likely that a support vessel may be required for planned and unplanned maintenance activities. Several pre-determined areas will be identified within the Wind Farm Site and marked as temporary anchorage areas to ensure a manoeuvring and mobilisation point is widely known by vessel crew. As detailed planning moves forward it is possible that a 'mother' vessel concept could be adopted whereby a larger vessel is semi-permanently positioned offshore and the day to day service activities are run from smaller 'daughter' craft from the mother vessel, saving transit time back and forth to a local port.

7.15 DECOMMISSIONING PLAN

274. An offshore decommissioning plan will be prepared in accordance with the requirements of the Energy Act 2011. However, a brief description is given on decommissioning activities in the following paragraphs.

275. It is likely that decommissioning activities will use similar vessels and require a similar number of movements as proposed for construction. Components of the Wind Farm that will be less straightforward to deconstruct and remove will relate to

the foundations. The following Sections indicate a possible decommissioning solution for each of the foundation types.

7.15.1 JACKET/TRIPOD/QUADRAPOD

276. Decommissioning of a jacket, tripod and quadrapod structure will largely be the reverse of the installation process. The substructure will be disconnected from the foundation and recovered to land for onshore disposal, reuse or recycling.

7.15.2 MONOPILE

277. Decommissioning of monopiles will involve either complete removal or cutting off the structure below sea level. Due to the depth of seabed penetration associated with the monopile it is likely that the latter option will be preferred. The specific decommissioning techniques will be determined at the time of decommissioning taking into account environmental, health and safety and economic factors and will be in accordance with the legislative framework in place at that time.

7.15.3 PIN PILES

278. Decommissioning of pin piles will involve either complete removal or cutting off the structure below sea level. Due to the depth of seabed penetration associated with the pin piles it is likely that the latter option will be preferred. The specific decommissioning techniques will be determined at the time of decommissioning taking into account environmental, health and safety and economic factors and will be in accordance with the legislative framework in place at that time.

7.15.4 SUCTION PILE

279. Decommissioning of a suction pile will largely be the reverse of the installation process. All feasible efforts will be made to remove the foundation completely. Subsea pumps will be used to remove the foundation out of the seabed. The suction pile will then be recovered and disposed, reused or recycled onshore.

7.15.5 CONCRETE GRAVITY BASE

280. In accordance with current legislation for the decommissioning of offshore structures, it is envisaged that all concrete structures must be fully recovered for onshore disposal, reuse or recycling. The process will largely be the reverse of the installation process with the ballast removed first and then the structure lifted out using a HLV. The gravel bedding underneath the gravity base structure will most likely be left in-situ as removal is likely to cause a greater disturbance than leaving in place.

7.15.6 CABLES AND SCOUR PROTECTION

281. Cables could be left in situ if that represents the most appropriate option taking into account environmental, health and safety and economic factors at the time of decommissioning. If they are required to be removed methods include pulling out of the seabed using a grapnel, jetting and pulling up the cable for disposal at an onshore recycling facility.

282. Subject to discussions with stakeholders and taking into account environmental, health and safety and economic factors it may be appropriate to leave scour protection in situ.

7.16 REFERENCES

283. BERR (Jan 2008) Review of Cabling Techniques and Environmental Effects Applicable to the Offshore Wind Farm Industry

284. DECC (2007) Guidance Notes - Applying for Safety Zones around Offshore Renewable Energy Installations.

285. Margheritini L. (2006) Scour Around Monopile Foundations for Offshore Wind Turbine in Presence of Steady and Tidal Currents, University of Aalborg

APPENDIX 7.1: GLOSSARY OF TERMS

Term	**Definition**
Turbine	This is the term used to describe the wind turbine, including its component parts; tower; nacelle; hub; and blades.
Installation vessel	This is a generic term used to describe the main vessel used for the main installation activities. This vessel would usually be either a jack-up vessel or HLV (see below).
Anchor handler tug (tug)	This is a smaller boat which would be used to tow floating components or structures out to site.
Pontoon barge	This is a flat floating platform used to transport large heavy components. It is usually towed by a tug.
Jack-up vessel	This vessel can take many forms but is essentially a large floating construction vessel which possesses the ability to jack itself up on legs once it is in position on site. The vessel will also likely possess a crane and can accommodate other installation equipment (e.g. pile driving hammer).
Heavy lift vessel (HLV)	This vessel can take many forms but is essentially a large floating construction vessel which possesses a large crane capable of lifting in excess of 1000 tonnes. It can be kept in place by either using traditional anchors, or dynamic positioning centred systems.
Work Boat	A vessel carrying a maximum of 12 personnel, plus crew, and typically 18-20 m in length. It is anticipated that by the time of operation larger vessels for up to 30 personnel which are typically in excess of 24 m will be readily available.

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