European Offshore Wind Deployment Centre

Environmental Statement

Chapter 3: Description of the Proposed Project

A project part-funded by the European Union under the European Economic Plan for Recovery in the field of Energy

3 DESCRIPTION OF THE PROPOSED PROJECT

3.1 Introduction

1 The European Offshore Wind Deployment Centre (EOWDC) is an innovative offshore wind turbine deployment facility proposed off the Aberdeenshire coast close to Blackdog.

2 The vision of the project is:

"To deploy new equipment, systems, processes, and initiate R&D to improve the competitiveness of offshore wind energy production, whilst generating environmentally sound, marketable electricity and to increase the supply chain capabilities in Scotland, the wider UK and Europe."

3 The EOWDC would include 11 three bladed wind turbines with a maximum power generation of up to 100 MW. It is more likely that the power generation would be around 84 MW which is based on the following assumption:

- 4 x 6 MW wind turbines
- 4 x 7.5 MW wind turbines
- 3 x 10 MW wind turbines

4 The wind turbines connected by inter-array cabling would export the electricity onshore to a new substation and then to the National Grid. Additional onshore facilities may include a deployment centre with a research and development centre.

5 This section of the Environmental Statement (ES) describes the details for the proposed offshore elements of the EOWDC, together with a description of the construction, operation, maintenance, decommissioning and their associated timescales.

6 Brief details of the onshore elements are also included for information only as the onshore elements would be included in a separate application as discussed in Chapter 1 Introduction. The exact construction process would depend upon the final details of the equipment to be installed, preferences of the construction contractor, availability of installation plant and, most notably, developments in technology in the near future. In addition, as many of the wind turbines and supporting equipment are still under development, only high level details and envelopes are available at present and are presented within this chapter.

7 The description provided here is based on current best practice, as employed recently on sites both in the UK and across Europe. Where possible, the impact of alternative foundation design or new technologies, practices, and their associated construction techniques are considered.

8 Should additional technologies or methodologies become available these would be considered against this Environmental Impact Assessment (EIA).

3.2 Objectives of the Development

9 As well as delivering renewable electricity to the National Grid, the EOWDC would encourage research, development, knowledge sharing, industry competition and competitiveness by allowing developers and supply chain companies to test a variety of products and applications, including reliability and capacity, in a real time offshore environment prior to commercial deployment. Environmental Management System

10 The successful contractors would need to take into account:

- the requirements of third parties
- the potential impacts and effects outlined in this ES
- the requirements for any mitigation measures and monitoring
- the results of site investigation surveys; and
- any conditions in the consents

11 The Contractors would be required to implement their own Environmental Management System (EMS). The contractors would produce detailed Method Statements and Risk Assessments covering construction activities, such as piling, in accordance with the requirements of this ES and any measures agreed with the statutory authorities. These Method Statements would be subject to approval by the design engineers and in accordance with the approved method statements and standards. Throughout the construction phase, contractors would be audited against their method statements and risk assessments, company policies (including this ES), and UK statutory health, safety and environmental requirements. Health and Safety Management

12 All construction activities shall comply with UK health and safety legislation, in particular the Construction (Design and Management) Regulations 2007, and be conducted in accordance with industry best practice as developed by the UK Health and Safety Executive and RenewableUK. Additionally, all contractors shall be required to comply with the Project's Health and Safety Policy and procedures.

3.3 Site Location and Physical Characteristics

3.3.1 Site Location

13 The EOWDC is located approximately 2.4 km from the coastline of Aberdeenshire at Blackdog. The total area of the wind turbine layout is approximately 4.3 km^2 which is situated within a 20 km^2 lease boundary awarded by The Crown Estate. Water depth on the wind turbine locations ranges from 20 m to 30 m below Lowest Astronomical Tide (LAT). Figure 3.1 shows The Crown Estate Lease Boundary. The wind turbine location coordinates are shown in Table 3.1 and The Crown Estate lease boundary coordinates are shown in Table 3.2.

14 The optimum site layout for offshore structures including the wind turbines is based on several conditions including:

- optimum wind capture
- ground geology conditions
- seabed obstructions including munitions and wrecks

- water depth
- foundation choice
- construction limitations
- scour potential
- operation and maintenance requirements
- electrical layout (array cables, etc.) and
- stakeholder considerations

15 It is proposed that the project may be constructed in two phases. The actual deployment of wind turbines is at this stage not known and the numbers deployed in 2013 and 2014 are variable but for the purposes of the EOWDC assessment, the following has been assumed for the phasing:

- 2013 - 4 wind turbines installed
- 2014 - 7 wind turbines installed

16 It should be noted that this is indicative (ie there could be six wind turbines installed in 2013 and five wind turbines installed in 2014) or all 11 wind turbines could potentially be installed in 2013. Each individual impact assessment has considered which is worst case, a phased deployment over two consecutive years or a full deployment within one phase.

3.3.2 Physical Characteristics

17 The EOWDC project would comprise of various components and construction activities as listed below:

- 11 wind turbines with a total rating of up to 100 MW
- potential for an Ocean Laboratory with meteorological mast (which would be subject to a separate application)
- foundations (gravity, monopile, tripod, suction caisson/bucket, jacket) and scour protection on seabed if required
- transition pieces including access ladders/fenders and landing platforms depending on the foundation
- marine lights/foghorns/or other buoys and markings to the requirements of the Northern Lighthouse Board, International Association of Marine Aids to Navigation and Lighthouses (IALA) and Marine Coastguard Agency (MCA)
- aviation lights to the requirements of Civil Aviation Authority (CAA)
- inter-array cables
- export cables to shore
- onshore cables
- miscellaneous cable joints/cable protection and cable/pipeline crossings
- temporary pre-assembly construction facilities onshore
- onshore substation
- boat landing (quay site in the harbour)
- operation and maintenance facilities depending on wind turbine selection

3.4 Site Layout

18 The wind turbine layout is illustrated in Figure 3.2. The figure shows the locations of wind turbines and an indicative position for the potential Ocean Laboratory.

19 The figure also illustrates the export cable corridor and inter-array cable options.

20 Table 3.1 lists the proposed wind turbine locations, however the exact position of the wind turbine may move slightly due to local seabed restrictions such as archaeology, seabed obstructions or pile refusal. It has been assumed that this move would be no more than 100 m. Figure 3.3 shows the indicative wind turbine spacing for the site.

TABLE 3.1
Wind Turbine Coordinates (UTM30N (WGS84 Datum))

Turbine ID	Easting (m)	Northing (m)
1	559820	6340967
2	559719	6341842
3	559619	6342717
4	560481	6341400
5	560374	6342325
6	560269	6343249
7	561224	6341887
8	561111	6342868
9	560999	6343849
10	561931	6343472
11	561811	6344515

21 The 22 year lease agreement with The Crown Estate includes an area of 20 km^2 and the installed nominal power must not exceed 100 MW. As this is a deployment centre to test first of run wind turbines there may be a requirement to change out the machines at an earlier date than the full potential operating life of the wind turbine.

Table 3.2
Coordinates of Crown Estate Lease Boundary (UTM30N (WGS84 Datum))

Lease Boundary Node (as shown on Figure 3.2)	Easting (m)	Northing (m)
1	559430	6345131
2	563485	6346152
3	561740	6340780
4	557684	6339759

22 Wind turbine technology is developing at a fast pace, so to ensure the project is adequately future proof, wind turbines in the range of 4 MW to 10 MW have been proposed for the purpose of this EIA, even though 10 MW is currently not available. With a maximum installed capacity of 100 MW, the project may contain a range of wind turbines ranging from 4 MW to 10 MW and the mix may also vary over time. Table 3.3 lists some maximum parameters of the 4 MW and 10 MW machines

TABLE 3.3 Wind Turbine Parameters		
Parameter	**4 MW**	**10 MW**
Maximum Height of Nacelle (above LAT)	100 m	120 m
Maximum Rotor Diameter	120 m	150 m
Maximum Tip Height (above LAT)	160 m	195 m

3.4.1 Construction Laydown Areas

23 At the port of shipping, during the construction period, space on the quay would be required for mounting and temporary storage of foundations, pre-assembly of the wind turbines, cables and other components of the project. It may be the case that several mobilisation ports may be utilised for different activities depending on vessel transits and restrictions. In addition, space at the quayside would be required for the vessels used for the establishment of the project (jack-up platforms, barges, tugs, cable vessels etc.) to anchor during downtime periods. Table 3.4 shows typical anticipated laydown areas associated with the construction of a typical wind farm.

TABLE 3.4 Typical Laydown Areas	
Activity	**Construction Area (m^2)**
Storage of piles and assembly of transition pieces	100,000
Storage are for cable contractor (cable drums)	10,000
Pre-assembly of wind turbines	40,000 + offices and storehouse for components
Storage area for towers at paint shop	27,000
Storage area for bays at factory	27,000

3.5 Access Arrangements to the Site

3.5.1 During Construction

24 During the construction period, the crews/workers are most likely to reside in either onshore accommodation or accommodation on board the work vessel (depending on work hours and availability). If necessary, the daily transport between local port and the site would take place by transfer vessels.

3.5.2 During Operation

25 When operational, the wind turbines would be monitored remotely from an onshore operational/storage base. Service personnel would travel to the site as required for planned and unplanned maintenance work. The wind turbines would be accessed by transfer vessels. There would be at least one boat landing arrangement on the foundations. There are no plans to use helicopters for maintenance of the wind turbines, but the wind turbines may be equipped with a heli-hoist platform for possible future maintenance and Health and Safety activities.

3.5.3 Exclusion Zones

26 For health and safety reasons, exclusion zones would be sought during the construction operational and decommissioning phases. These are discussed further below.

3.5.3.1 During Construction

27 In the construction phase, advisory zones or safety (exclusion) zones of 500 m around the construction works would be sought to keep construction and non-construction vessels separate. These safety zones would be reviewed monthly and clearly marked using buoys. Notifications would be issued in accordance with statutory procedures. The vessels laying the cables to shore would have their own advisory or safety (exclusion) zone extending up to 500 m in addition to a 250 m safety zone either side of the cable corridor. There would be close liaison with port authorities and Maritime Coastguard Agency (MCA) particularly when working in close proximity to marked navigation channels and other anchorage areas. Where necessary guard vessels may also be employed should operations be phased/broken.

3.5.3.2 During Operation

28 It is thought likely operational safety (exclusion) zones would be sought for and should if granted take effect when construction exclusions finish. A navigational safety (exclusion) zone would then likely apply between 50 m and 100 m around each wind turbine foundation tower. The potential impact of these safety (exclusion) zones on navigational interest and fishing interest are discussed in Chapters 15 Shipping and Navigation and 21 Commercial Fisheries. Potential exclusion zones are shown in Figure 3.4.

3.6 Wind Turbines

29 The Applicant is proposing to install 11 three bladed horizontal axis wind turbines. As this is a deployment centre the exact models and types of wind turbine would only be chosen through assessment of wind turbines during detailed engineering and chosen on the basis of various selection criterias, including testing, operational and commercial aspects. The wind turbines may be replaced in the future life of the project to allow testing of newer wind turbines. An in-principle design of a wind turbine is shown in Plate 3.1. A mixture of wind turbines are expected on the site as these are pre-commercial deployments and therefore there are likely to be two to four of each type of wind turbine, not all 11 would be is the same.

Plate 3.1 3 MW Wind Turbines Installed at the Kentish Flats Offshore Wind Farm (Photographer Chris Laurens)

30 The wind turbines would likely begin generating electricity at 3 m/s hub height, achieving their maximum power output in winds greater than approximately 13-14 m/s hub height. They would continue generating up to wind speeds of 25 to 30 m/s where they would be designed to automatically shut down.

31 The blades would most likely be made of fibre-reinforced epoxy. The towers would be made in sections of tubular steel with an approximate diameter ranging from 5 m to 8.5 m at the foundations tapering to 3.5 to 5 m at the top.

32 On top of the tower the nacelle is placed containing among others the generator and controls.

33 The transformer would be placed in either the nacelle or in the tower. It transforms the electricity to minimise the loss through the cable to the substation.

3.6.1 Colour Scheme

34 Colour scheme of the turbine tower, nacelle and blades is likely to be light grey RAL 7035, white RAL 9010 or equivalent.

3.6.2 Dimensions and Airdraft

35 A schematic drawing of a wind turbine with maximum dimensions is shown in Figure 3.5. Minimum blade tip clearances of the wind turbines being considered for EOWDC is 22 m above MHWS.

3.6.3 Oils and Fluids

36 The wind turbine would contain the following approximate quantities of mineral lubricating and hydraulic oils:

- Gear box oil: Approximately 0–1,000 litres of mineral oil
- Hydraulic oil: Approximately 200–300 litres
- Yaw/pitch motor oil: Approximately 20 -100 litres
- Transformer oil: Approximately 0-3,000 litres
- Cooling fluids: Approximately 0-1,000 litres

37 The nacelle, tower and rotor would be constructed to accumulate any leaks from the construction and operation. Thereby leaks to the environment would be minimised.

3.6.4 Noise and Vibration from Operating Wind Turbines

38 Noise emissions from wind turbines could be separated into two categories: aerodynamic and mechanical noise. Aerodynamic noise occurs when the wind is passing the blades and mechanical noise is emitted from the engineering components of the wind turbine such as gearbox and generator. Although the larger wind turbines that are being considered for EOWDC site are not yet under production and therefore the noise characteristics have not been measured, the wind turbine manufacturers predict that the wind turbines would have a noise output of no greater than 110 dB(A) at hub height measured according to the IEC 61400-11 standard.

3.6.5 Installation of Wind Turbines

3.6.5.1 Base Case Method

39 The wind turbines are expected to be installed using an crane of suitable size located on a jack-up vessel. A jack-up vessel is a barge or ship that once in position lowers its legs onto the seabed and when the legs are sufficiently stable the vessel then jacks itself up out of the water. Jack-up vessels come in a range of specifications and can either be self propelled or require the assistance of tugs and anchor handling vessels to locate.

40 The wind turbines would be transported to site either on the jack-up vessel or to the jack-up on a barge or another jack-up. The installation crane lifts the wind turbine parts from the jack-up/barge onto the foundation, see Plate 3.2.

Plate 3.2 Jack Up Installation Barge at Ormonde Offshore Wind Farm

41 Experience has shown that it normally takes 24 hours to position the jack-up and erect a wind turbine requiring a total of 4–5 lifts per wind turbine to complete installation. Normal procedure would be that the bottom tower is mounted first followed by the top section. Following the top section the nacelle and the rotor/blades are mounted.

3.6.5.2 Alternative Methods

42 As part of the Deployment Centre aspect of the project, the Applicant would look for alternative methods for wind turbine installation. This may include installation of the wind turbine and foundation as a single operation or utilising dynamically positioned vessels rather than jack-up vessels.

43 Should alternative methods be utilised the impact on the marine environment would be the same or less than that described and evaluated above.

3.6.6 Material Requirement

44 Typical weights for EOWDC wind turbine (10 MW):

- rotor including blades: 120 tonnes fibreglass (three blades) and 150 tonnes steel
- nacelle: 70–600 tonnes mainly steel
- tower: 700 tonnes steel

3.6.7 Control Functions and Safety Features

45 All wind turbines would be designed to allow for the following safety features:

- manual yawing of the wind turbines shall be possible via the remote control
- remote parking of the wind turbines in an oriented stop, to allow for heli-hoist operation

3.6.8 Emergency Provisions

46 The wind turbines would be equipped with emergency provisions for personnel of the service team. The personnel of the service teams would be trained to work with these emergency provisions.

47 Emergency escape and access hatches to the wind turbine nacelle would be designed as far as practical to be capable of being opened from the outside in order to allow rescuers (eg helicopter winch-man) to gain access through the nacelle to the tower if personnel of the service team are unable to assist and when a sea-borne approach is not possible.

48 Ladders for access to the foundation platform for use in emergency or refuge would be placed in the optimum position taking into account the prevailing wind, wave and tidal conditions.

3.6.9 Wind Farm Marking and Lighting

49 All wind turbines would be marked with clearly visible unique identification characters. Characters would be visible from all sides of the wind turbine and would comply with requirement in MCA Marine Guidance Notice MGN 275 (M) (MGN 275) that they should be visible from at least 150 m from the structure and be permanently lit by down-lights to minimize light pollution. As an alternative to permanent down-lights the option of Light Emitting Diodes (LEDs) to mark the identification characters is included.

50 Logos and identification would be included on the offshore structures including Vattenfall, the European Union (EU) Flag and other manufacturer requirements.

51 The wind farm would be designed and constructed to satisfy the requirements of the Civil Aviation Authority (CAA) and the Northern Lighthouse Board (NLB) in respect of marking, lighting and fog horn specifications. The typical arrangement using the Navigation Risk Assessment layout (see Chapter 15) is shown in Figure 3.6. This arrangement would be adjusted in consultation with CAA and NLB, MCA and IALA.

52 The CAA has issued “Lighting of Wind Turbine Generators in United Kingdom Territorial Waters” in accordance with Annex A to 8AP/51/06/19 dated September 2003. The guidelines have been applied to the typical arrangement as follows.

53 For aviation purposes, wind turbines would be marked with aviation lighting in line with the following:

- each wind turbine located at the corner would be fitted with aviation lighting
- in addition, aviation lighting would be installed along perimeter wind turbines so a maximum gap of 3.5 km between lighting

54 Lights would be fitted to be visible in all directions without interruption (the shadowing effect of passing blades is not considered to be an interruption in this context):

- the angle of the plane of peak intensity shall be elevated to between 3 and 4 degrees above the horizontal plane
- not more than 45 % or less than 20 % of the minimum permitted peak intensity shall be visible at the horizontal plane
- not more than 10 % of the minimum peak intensity shall be visible at a depression of 1.5 degrees or more below the horizontal plane

55 The navigational marking specifications for the typical arrangement would be agreed with the Northern Lighthouse Board (NLB). The Applicant proposes the following in accordance with IALA Recommendation 0-139 (see Figure 3.6):

- wind turbines foundations and towers would be painted yellow from highest astronomical tide (HAT) to 12 m above Highest Astronomical Tide (HAT)
- the wind turbines in the periphery of the wind farm would be marked with yellow flashing lights and potential fog horns as shown in Figure 3.6
- navigation lights would only be installed at the correct elevation on outer boundary wind turbines
- an uninterruptible power supply would be installed

3.7 Foundations

56 This section is applicable for all offshore wind farm structures requiring foundations including:

- wind turbines
- potential Ocean Laboratory including meteorological mast

3.7.1 Foundation Concepts

57 Foundation selection for an offshore wind farm development is generally influenced by the following factors:

- type of wind turbine/hub height that would be mounted onto the foundation
- wind turbine dynamic loads
- wind turbine access and maintenance requirements
- Mean Sea Level (MSL) and variations in water depth due to tide and meteorological conditions
- dynamic wind and wave loading especially with respect to fatigue
- extent of local scour and global seabed movements ie seabed stability
- soil conditions on which foundation would bear including drivability/drill ability

- transportation/logistics
- material costs/manufacturing costs and limits
- installation limits with respect to crane capacities, piling, drilling equipment, etc
- cable entry to foundation base

58 The Front End Engineering Design (FEED) studies and tendering process would establish, within the limits of this EIA, which types of foundations are the most cost effective and innovative for the EOWDC project. The following foundation concepts may be considered:

- gravity foundation
- monopile in steel
- steel tripod or piled concrete tripod
- jacket structure
- suction bucket

59 As part of this process, the installation of the foundation and the equipment requirements would also be considered. In addition, wind turbine and foundation manufacturers would also be involved to ensure all optimisation and innovation is considered.

60 There is likely to be a mix of foundations deployed on the site ie not all 11 foundations would be of one type, ie there would not be 11 monopiles installed on the proposed EOWDC site.

3.7.1.1 Gravity Foundation

61 The gravity foundation concept is typically installed in water depths from 0 to 30 m. Most are concrete based but steel based concepts are being developed. A concrete gravity foundation may be manufactured completely from reinforced concrete or a mixture of concrete and steel sections to provide an optimised design.

62 The gravity foundation is constructed such that the base structure has sufficient ballast and surface area to stay in place even at extremely high loading, ie a 50 or 100 year storm.

63 The concept can have slightly different designs in terms of shape and structure ie could be circular in plan or square. The concept and requirements may contain sufficient weight in the design itself for operation or ballast may be added once the structure is located in place. Ballast may be sand, stone or seawater.

64 Dimensions of the gravity base foundation are likely to vary across the site depending mainly on wind turbine size and water depth and seabed geology.

65 Future detailed geophysical and geotechnical investigations would determine locations where the seabed conditions are suitable for gravity foundations. The gravity foundation may be equipped with a 0.5 to 2 m high steel skirt penetrating into the seabed below the bottom plate. This skirt would protect the foundation against scour in the period until scour-protection is in place, if required.

Dimensions

66 The gravity foundation with hollow shaft for a typical wind turbine has the following dimensions as presented in Diagram 3.1:

- maximum outer shaft diameter: 6.5 m
- shaft wall thickness: 0.6 m
- base plate diameter: 20 – 40 m
- base plate thickness: 3 – 9 m
- weight (dry): 2,500 – 9,000 tonne

Manufacturing and Transportation

67 The foundations would be pre-manufactured onshore. Either directly on barges in a harbour, on the quayside or in the case of a towed foundation within a slipway. For the purposes of the ES the fabrication of gravity foundations could be either overseas or in the UK. If manufactured in the UK then the consideration would be given to the provision of a temporary concrete casting facility at a local port with adequate space, draft and facilities (Dundee, Aberdeen or Invergordon).

68 The gravity bases would be shipped directly to the offshore site.

Material Requirement

69 Amounts of material per concrete gravity foundation:

- concrete: 2,000–8,000 tonnes
- steel-reinforcement: 200–1,000 tonnes
- ballast: 0–4,000 m^3 based on sand
- stones for scour protection: up to 2,000 m^3

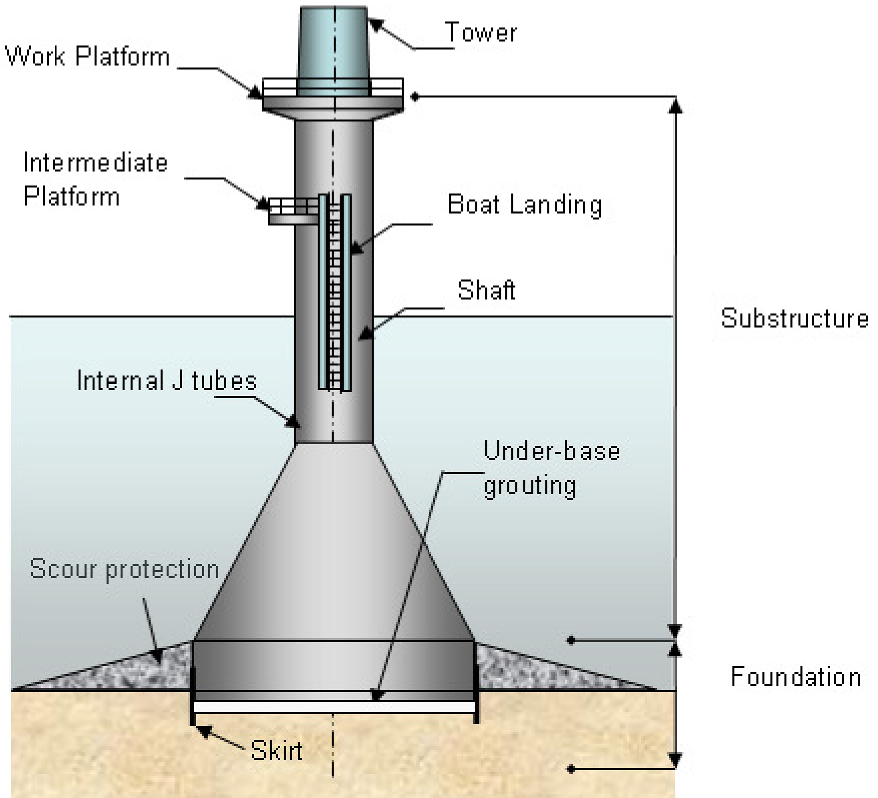

Diagram 3.1 Gravity Base Foundation (Courtesy of GL Garrad Hassan)

3.7.1.2 <u>Steel Monopile</u>

70 In the UK and most other countries (except Denmark) the steel monopile is the most common foundation type used for offshore wind turbines mainly due to suitable ground conditions for the monopile installation.

71 Usually steel monopiles are driven into the seabed from a jack-up barge using a hydraulic hammer which is available in various capacities for either operation above or below the water surface.

72 An alternative installation method includes drilling to assist piling operations (‘drive, drill and drive’). Drilling may be applied where ground conditions make driving more difficult.

73 The ability to fully drive piles to a required depth may be limited in the EOWDC site by:

- layers of consolidated glacial material
- Old Devonian sandstone at 25-35 m depth below seabed

74 The drive, drill and drive methodology has been used successfully at other wind farm sites with soil conditions similar to EOWDC. The basic steps of the drive, drill and drive methodology includes:

- driving the monopile down to the obstruction layer
- drill out pile internals (diameter of drill is approx 10–20 % less than internal of monopile) to final pile depth
- drive monopile to final depth

Dimensions

75 Example dimensions of the steel monopile foundations for the EOWDC are given below and the arrangement is shown in Diagram 3.2:

- outer shaft diameter: 4 – 8.5 m
- shaft wall thickness: 0.06 – 0.15 m
- overall length: 50-75 m
- seabed penetration: 30 m +
- weight (dry): 300–1500 tonnes depending on depth

Manufacturing and Transportation

76 The foundations are pre-fabricated onshore. Steel plates are delivered from steel mills to fabricators who roll and weld the plates together into a monopile structure. Once fabricated the monopiles are transported to site either directly or through an interim port.

77 An approximately 10 m long transition piece consisting of a piece of steel pile equipped with a flange in the top may be grouted on the outside of the top of the driven steel pile-fixing the top flange perfectly horizontal. Alternatively a heavy flange might be in place already during the driving sequence.

Material Requirement

78 Typical material amounts per foundation:

- steel: 300 – 1,000 tonnes
- concrete for fixing of transition piece: 25–100 tonnes
- gravel/rock for scour protection: 150–1,250 m^3

79 The volumes do not include for additional volumes of grout or concrete that may be used to secure the monopile in rock.

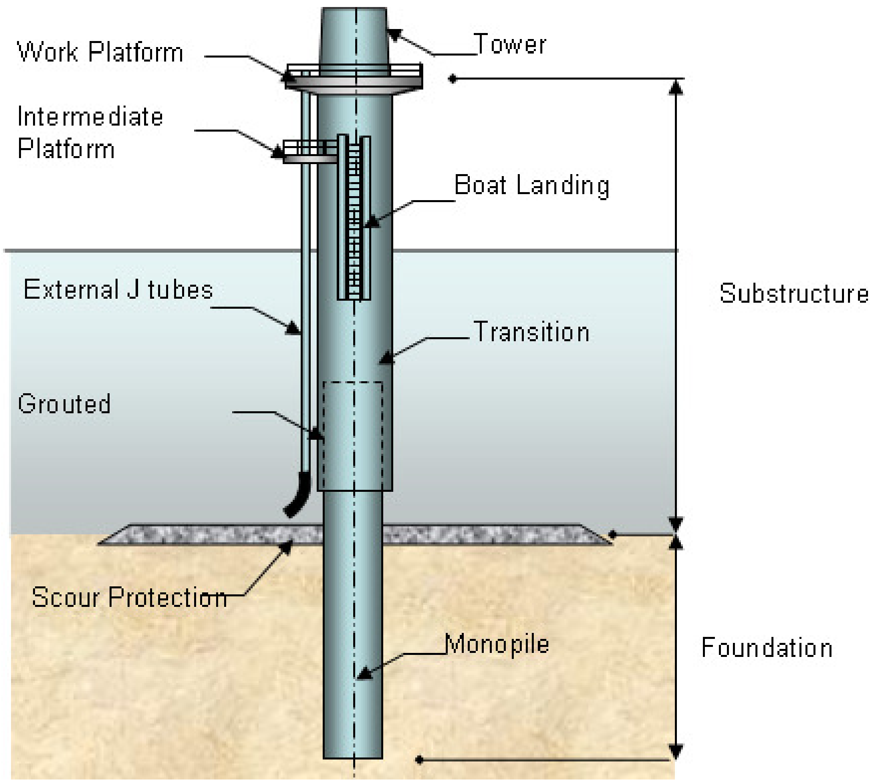

Diagram 3.2 Monopile Foundation (Courtesy of GL Garrad Hassan)

3.7.1.3 Steel Tripod / Piled Concrete Tripod

80 The steel tripod has been extensively used in the oil and gas industry for small, generally unmanned offshore platforms. The concept consists of a steel tube construction above seabed, and of three steel piles driven into the seabed.

81 The concept has only been used a few times for wind turbines, but may be an option for EOWDC for use in areas of greater water depths. Example dimensions are provided below and the arrangement is shown in Diagram 3.3:

- main shaft diameter: 5.5 m
- base footprint width: up to 25 m diameter
- seabed penetration (securing piles): 25 – 35 m
- securing pile diameter: 2.5 m
- overall height: 15 – 35 m (15 m above mean sea level)
- weight: 400 – 1,200 (excluding securing piles) tonnes
- number of piles: 3 (total up to 500 tonnes)

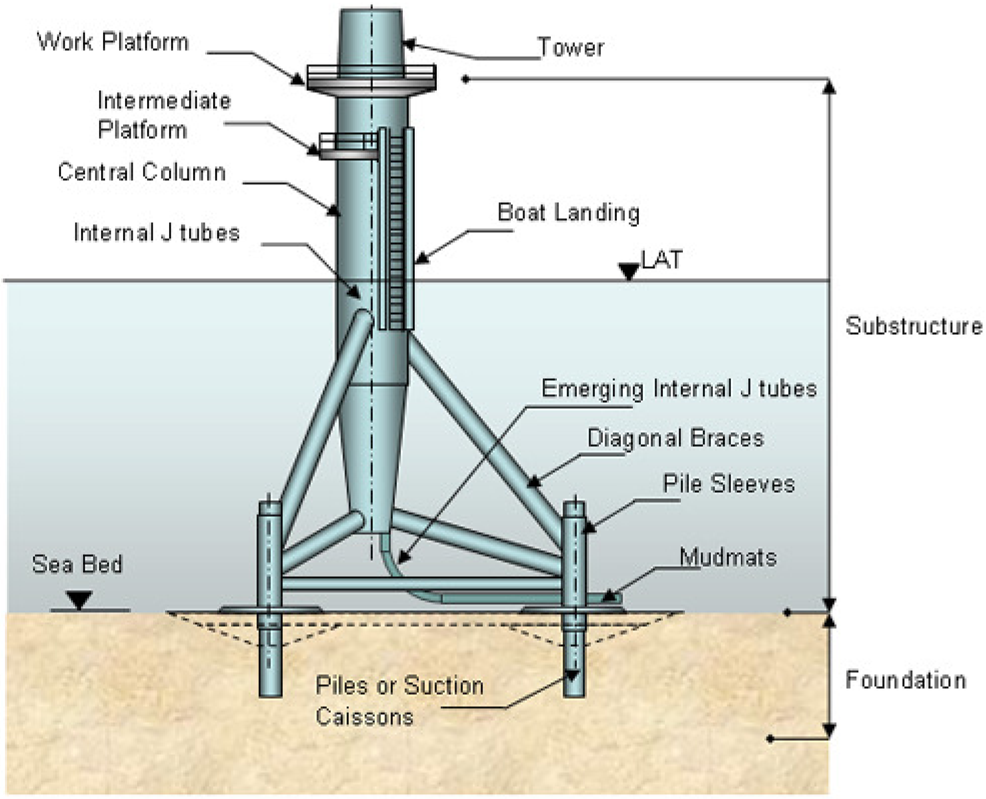

Diagram 3.3 Steel Tripod Foundation (Courtesy of GL Garrad Hassan)

Transportation

82 Transportation methods are similar to that of monopiles, including transporting out on barge and lifting off on-site by crane from a separate installation vessel. A disadvantage is that good weather conditions are required to allow pickup and transfer. Transportation directly on a jack-up or floating crane vessel is also possible.

Material Requirement

83 Typical amounts per foundation:

- steel: 400 – 1,200 tonnes
- concrete for fixing of transition piece: 25 – 100 tonnes
- grout for fixing of piles: 25 – 100 tonnes

Piled Concrete Tripod

84 The piled concrete tripod is a composite construction using steel piles and a concrete and steel construction above the seabed. An additional strength of the concept is a possibility to use the high stiffness of the concrete shaft to replace flexible steel-tower to heights up to 20 – 30 m above mean sea level. While the split of concrete and steel is not fixed a typical split would be steel piles, concrete base and a concrete shaft/tower. The parts are connected with grouted joints. Manufacturing, material requirement, seabed preparation, scour protection and installation methods for this option are similar to those of the gravity foundation.

3.7.1.4 Steel Jacket

85 The steel jacket has been extensively used in the oil and gas industry for small as well as large platforms. The concept consists of a steel tube construction above seabed, and of four steel piles driven into the seabed.

86 The concept has recently been used on the Ormonde Offshore Wind Farm, and may be an option for EOWDC. Example dimensions are provided below and the arrangement is shown in the Diagram 3.4:

- base footprint width: up to 25 m square
- seabed penetration (securing piles): 25 – 35 m
- securing pile diameter: up to 2.5 m
- overall height: 15–35 m (15 m above mean sea level)
- weight: 400–1200 (excluding securing piles) tonnes
- number of piles: 4 (total up to 600 tonnes)
- maximum width of structure above LAT: 21 m

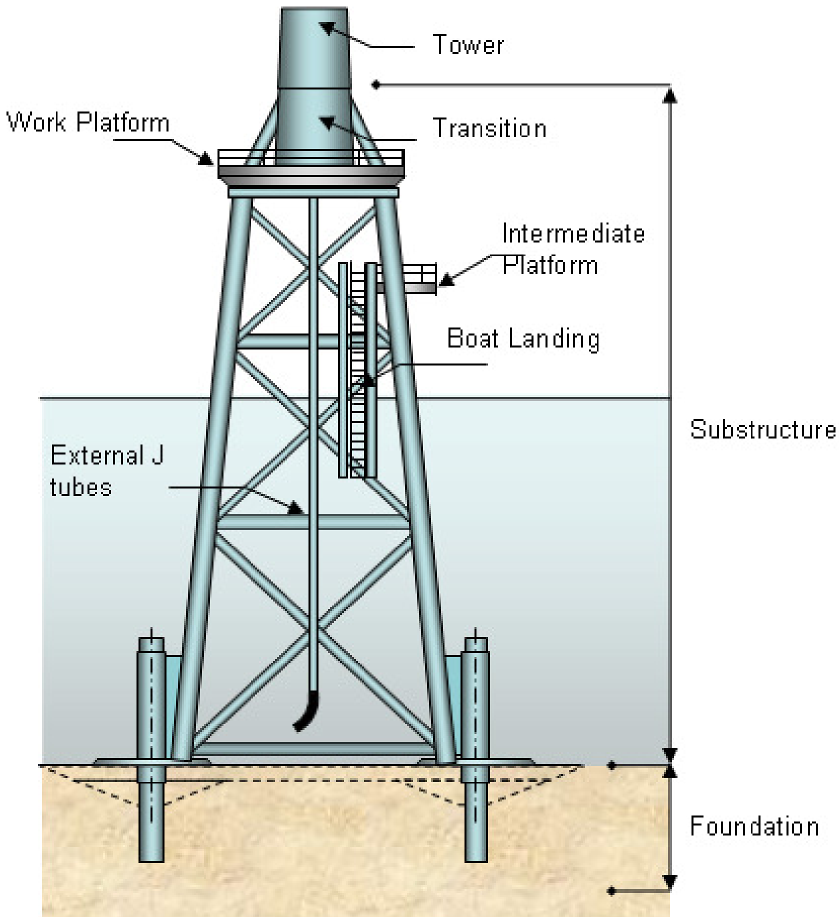

Diagram 3.4 Steel Tripod Foundation (Courtesy of GL Garrad Hassan)

Transportation

87 Transportation methods are similar to that of monopiles, including transporting out on barge and lifting off on site by crane from a separate installation vessel. An advantage of this method is that the installation vessel can remain on site. A disadvantage is that good weather conditions are required to allow pickup and transfer. Transportation directly on a jack-up or floating crane vessel is also possible.

Material Requirement

88 Typical amounts per foundation:

- steel: 400–1200 tonnes
- grout for fixing of piles: 25–100 tonnes

3.7.1.5 <u>Suction Caisson / Bucket</u>

89 The suction caisson/bucket foundation concept is typically installed in water depths from 20 – 50 m. The foundation is generally manufactured completely from steel.

90 The suction caisson is designed so a vacuum can be formed once in contact with the seabed which would then allow the pile to suck into and embed to the required depth. Overturning and gravity loads are resisted by a combination of skin friction around the skirt and to a lesser extent the bearing pressure on the top of the bucket.

91 The concept can have different designs parameters in terms of number of suction buckets and size and shape of buckets. This is a function of install ability and soil and load problems.

92 Dimensions of the suction caisson foundation are likely to vary across the site depending mainly on wind turbine size and water depth and seabed geology.

93 At the site of EOWDC future detailed geotechnical investigations would determine locations where the seabed conditions are suitable. Suction buckets are generally suitable for clay conditions without gravel or boulders and may have limited application at EOWDC, however they could provide a new concept that could be applicable to other sites in the UK.

Dimensions

94 Suction caisson foundations vary greatly depending on design and location and may be a shallow bucket of 20 m diameter or a cluster of deep cans penetrating 18 m deep.

- maximum outer shaft diameter: 6.5 m
- shaft wall thickness: 0.1 m
- maximum base diameter: 20 m
- penetration: up to 18 m
- weight (dry): 600–1,500 tonnes

Manufacturing and Transportation

95 The foundations would be pre-manufactured onshore in a similar manner to monopiles and tripods. For the purposes of the ES the fabrication of foundations could be either overseas or in the UK. If manufactured in the UK then consideration would be given to the provision adequate quayside draft and lifting at the manufacturing facility.

96 The foundations would be shipped directly to the offshore site.

3.7.2 Foundation Installation

3.7.2.1 Gravity Base

Soil Disposal

97 The worst case volume of sediment per gravity foundation has been calculated assuming preparation over a circle with a diameter of 40 m and down to a depth of 1 m.

98 The volume of sediment = $(40\ m/2)^2 * pi * 0.5\ m = 628\ m^3$ of sediment (sand) per gravity foundation.

Expected Noise levels

99 There is expected to be no major noise generation during the installation operations other than general noise from vessels, lifting operation and ballasting which would all be significantly less than monopile piling operations (see section 3.7.2.2).

Seabed Preparation

100 At the EOWDC site the seabed generally consists of sand overlying clay, with the thickness of the top layer of sand varying across the site. In some instances, some levelling or soil removal may be necessary across the base of the foundation. The amount of soil removal or replacement would be evaluated during detailed engineering, however it is expected to be less than the height of local sand waves which are up to 1 m in places. Levelling would be done by using either local sand or a gravel bed. Preparation of the seabed is expected to last 1 – 4 per foundation. It is expected that the seabed may be prepared for one foundation at a time immediately prior to foundation installation.

Installation

101 Installation is likely to be carried out from a floating vessel, either a shear-leg barge or a purpose made barge. The gravity based foundations may be floated using a tug prior to ballasting operations when at location.

Scour Protection

102 Subject to soil conditions a gravity foundation may require scour protection. The basic method of protection is use of gravel and possibly boulders at the periphery of the base plate. A 1 – 1.5 m thick layer of gravel 10 – 15 m extending from the outer edge of base plate perimeter is typical. This might be assisted by a skirt penetrating 0.5 – 2 m into the seabed in the periphery of the base, as presented in Diagram 3.1. Across the site, the seabed appears to be sand overlying clay of varying depths. If the sand is a sufficiently thin veneer, some small amount of scour of the overlying sand may be tolerated in the design.

3.7.2.2 Monopile

Seabed Preparation

103 Generally, seabed preparation is not required although some removal of obstructions may be required but is unlikely.

Installation

104 Monopiles could be transported to site by:

- sealing ends and floating out to the installation vessel
- transporting out on a transportation barge and lifted off on site by crane from a separate installation vessel
- transported out directly on crane vessel (either jack-up type or floating)

105 Once on site the piles are lifted up by a crane on the installation vessel and held in place until driven to final depth.

106 Pile driving of a single monopile could take from less than 2 hours to up to 24 hours if the geology and pilling operation proves to be difficult. It is estimated that on average it would take 4 – 6 hours to drive a single monopile. The overall installation time would however be longer as the pile must first be lifted, stabbed and the hammer located on top of the pile. The total length of operation may be up to 5 days as the worst case.

107 Generally installation of only one monopile at a time occurs as mobilising multiple vessels for a development the size of EOWDC would not be feasible.

Soil Disposal

108 Driving of monopiles is not expected to create any sediment spill of significance. However should ground conditions require some drilling this may cause sediment spill. Detailed assessment of this impact is detailed in the coastal processes study as presented in Chapter 8 Costal Processes.

109 The drilled hole would be slightly less than the inside diameter of the monopile but for the purpose of this description the outside diameter of the monopile would be used (slightly conservative assumption).

110 Total volume of sediment in this case would therefore be = $(8.5\ m/2)^2 * pi * 37m = 2,100\ m^3$ of sediment

111 The sediment that would be disturbed would consist of sand in the upper layers with clay and sandstone in the lower layers. The drilling activity, if required, could last from one day to five days depending on the ground conditions.

Expected Underwater Noise Levels during Installation of Monopiles

112 Pile driving using an impact hammer is potentially the greatest noise concern with this type of foundation system. High noise levels are produced by the repeated striking of the hammer to drive the pile to depth.

113 However as monopiles are the most common type of foundation system used for wind farms, the factors affecting the noise level are documented and the expected noise level at EOWDC has been assessed.

114 Factors that are affecting the noise levels include:

- seabed substrate
- bathymetry
- pile diameter
- piling equipment

115 No piles of 8.5 m diameter have previously been installed. An assessment of the underwater noise level produced by piling these monopiles has been made and is included as Appendix 3.1. Should noise mitigation measures be required, this would be addressed in the construction procedures.

3.7.2.3 Steel Tripod/ Piled Concrete Tripod

Steel Tripod Soil Disposal

116 Generally, no seabed preparation would be required for the tripod structure other than levelling to position the mud mats. Worst case seabed preparation would involve sediment removal for drilled piles.

117 Volume of sediment = 2.5 m x 2.5 m x Pi/4 x 3 x 35m = 515 m^3 per tripod foundation.

Piled Concrete Tripod Soil Disposal

118 Soil disposal and seabed preparation for a piled concrete tripod is expected to be similar to steel tripod. It is therefore referred to the soil disposal section for steel tripod for sediment volumes.

Expected Noise levels

119 The noise levels during installation of a piled steel or concrete tripod foundation is expected to be less than for monopile installation due to the decrease in pile diameter and therefore piling force which has been found to result in lower levels of underwater sound, however the number of piles increases to three (Nedwell, et al. 2007).

3.7.2.4 Jacket

Installation

120 At site the jacket structure is lifted into position by the installation vessel crane. The jacket is then fixed to the seabed by driving piles through the feet by use of hydraulic hammer. An alternative would be to install a guide frame and pre-install the piles prior to jacket installation. Once driven the piles are fixed to the piled sockets by grouting or swaging. Prior to lifting the jacket into position, seabed preparation may be required to ensure the jacket is level prior to piling. The jacket would be temporarily supported on mudmats prior to piling.

Soil Disposal

121 Generally, no seabed preparation would be required for the tripod structure other than levelling to position the mud mats. Worst case seabed preparation would involve sediment removal for drilled piles.

122 Volume of sediment = 2.5 m x 2.5 m x Pi/4 x 4 x 35mm = 687 m^3 per foundation.

Expected Noise Levels

123 The noise levels during installation of a steel jacket foundation are likely to be less than that for monopile installation due to the decrease in pile diameter and therefore piling force required.

3.7.2.5 Suction Caisson/ Bucket

Seabed Preparation

124 It is not anticipated any seabed preparation would be necessary.

Installation

125 Installation is likely to be carried out from a floating vessel, either a shear-leg barge or a purpose made barge. Floating to site of the suction caisson foundations with tug control may also be an option with ballasting operations when in place.

Scour Protection

126 Subject to soil conditions the foundation may require scour protection. The basic method of protection is use of gravel and possibly boulders at the periphery of the base plate. A 1 – 1.5 m thick layer of gravel 10 – 15 m extending from the outer edge of base plate perimeter is typical.

Expected Noise Levels

127 The noise level during installation of a suction pile type foundation is expected to be small in comparison to monopile installation and likely to be comparable to gravity based installation with the principal noise sources being the installation vessels.

128 There is expected to be no major noise generation during the installation operations other than general noise from vessels, lifting operation and subsea pumping.

3.7.3 Levelling of the Foundation

129 Transition pieces could be used to connect the wind turbine tower to the foundation. The transition piece provides a means to adjusting non-verticality tolerances of installed foundations, and makes the pile design very simple, basically only a straight tube, with only minor attachments for fixing of anodes or cable ducts.

130 There have been a number of issues with failure of grouting of transition pieces. An aim of this project would be to investigate and possibly trial alternative connection and levelling methods. Alternative methods may include use of a jacking mechanism on the platform or foundation to level the connection flange for wind turbine installation.

131 Some types of foundation, such as suction caisson could be levelled by controlling the level of seabed penetration.

132 A second alternative to using a transition piece is the use of a flange welded directly onto the monopile. Welding *in-situ* requires that the upper piece of around 1 m is cut off the monopile after hammering.

133 Specific flange geometry is required to optimise the flow of the shock waves from the hammer impact through the pil*e.* Any inclination of the pile has to be compensated by shim plates or an inclined adapter piece. This option has the potential of a reduction of offshore vessel time as well as saving on grout curing time. However, damage of the flange or high fatigue of the flange is a risk.

134 The transition piece, which does not undergo significant loading during installation, could be fully equipped with all electrical or electronic components prior to installation.

135 Traditionally, the transition piece is joined to the pile with a radial connection of high performance grout. The tower itself is mounted on an internal L-flange on top of the transition piece however alternatives would also be investigated.

3.7.4 Scour Protection

136 There are two main design options to address seabed erosion, either allow for scour in the design or install scour protection such as rock dumping.

137 The amount of local scour around a monopile without scour protection is expected to be less than 2 times the monopile diameter. Allowance for scour in the design would lead to increases in penetration depths and potentially wall thickness of monopiles, and therefore additional fabrication and handling weights both leading to increases in the cost.

138 For other foundation designs such as gravity based, skirts may be added around the perimeter of the foundation to penetrate the seabed and provide a hard barrier for undermining of the foundation.

139 Scour protection of loose rock, rough gravel or mats around the base of the pile to a diameter of 2 – 3 times the pile is the most likely solution, though the choice of solution can only be made after detailed design of foundation, taking into account a range of aspects including soil data, tidal, depth of water, foundation option, maintenance strategy, cost of options.

140 Installation may involve a specialised rock placement vessel. Once the vessel has positioned itself alongside the specified rock dump location the hydraulically operated dozer blades pushes the rock material over the ships side or bags with boulders are lifted into location. Alternatively rock is transported to site by barge where it is then grabbed and dropped onto location by excavating bucket (either positioned on same barge or separate installation vessel). The final option involves mats being transported to site on the installation vessel, whereby they are picked up and lowered onto location around the base of the foundation.

3.7.5 Sediment Spill during Installation

141 Table 3.5 summarises the sediment volumes that may be excavated or released during the installation process. The sediment can either be cast-aside or disposed on a licensed disposal ground. Disposal licenses would be applied for from Marine Scotland as appropriate prior to any disposal activities taking place. For the sediment spill modelling it is considered a worst case assumption that the sediment is cast-aside next to the foundations.

TABLE 3.5 Sediment Spill during Installation			
Foundation Type	**Volume of Sediment**	**Sediment Composition**	**Comments**
Gravity Base	628 m^3	Sand/some glacial till possible	Assumes average 0.5 m excavation of 40 m diameter circle
Monopile Driven	Negligible	N/A	-
Monopile Drilled	2,100 m^3	Sand/some glacial till/some sandstone	Assumes average inner pile diameter of 8.5 and length if 37 m.
Tripod	Negligible	N/A	Assumes driven piles
Suction Caisson/Bucket	Negligible	N/A	Assumes driven piles

3.7.6 J-tubes

142 The j-tubes hold and protect the cables to and from the structure. They could be attached to the inside or outside the foundation structure. If the j-tubes are run on the inside they would penetrate the structure near the seabed. If run on the outside the j-tubes would be supported on a number of supports connected to the main structure. The j-tubes could be made of steel or thick walled plastic type tubes.

3.7.7 Corrosion Protection

143 In the aggressive offshore environment, steel foundations have to be protected against the corrosion. In principle there are several options - Surface protection in the form of painting and /or metallic coating. Treatment of the surface is particularly relevant for the part of the structure above water and in the splash zone. Another alternative include an allowance for corrosion (designing the structure with sufficient steel to allow waste due to corrosion).

144 Below the splash zone (permanently submerged structure) corrosion protection would be administered by paint and cathodic protection. This may be in the form of an impressed current system or anodes which corrode in preference to the structure.

3.8 Meteorological Masts

145 One anemometer mast may be required for EOWDC to monitor wind over the project life, however this could be integrated with the Ocean Laboratory which would be the subject of a separate planning application.

146 A potential location is shown on Figure 3.2.

147 The combined Ocean Laboratory and anemometer mast would consist of a platform mounted on a foundation, which depending on the loading would be smaller than wind turbine foundations, but follow a similar design. The platform, located approximately 20 m from LAT may be up to 20 m square and house various measuring, survey and research apparatus. Should an anemometer mast be required, the mast would be installed on the platform and extend to the hub height of the largest wind turbine. The Ocean

Laboratory may be powered by a separate cable from shore or by diesel and electrical generators located on the platform.

148 The combined Ocean Laboratory and anemometer mast would include all required navigation and aviation warning requirements in accordance with other aspects of the project.

149 The source noise level of 90 dB(A) at 1 m distance for the diesel generator has been estimated.

150 Outline parameters for the Ocean Laboratory are shown in Table 3.6.

TABLE 3.6
Ocean Laboratory Parameters used in Cumulative Assessment

Maximum Height above LAT (m)	120 m
Platform size	20 m x 20 m
Height of platform above LAT	18-20 m
Depth of Platform	Maximum 4 m including containers and ancillary equipment
Foundation Type/Size	As wind turbines
Maximum Noise Output at source	90dBA at 1m (Diesel generators)

3.9 Cables

3.9.1 Introduction

151 The wind turbines would be electrically connected by inter-array cables. Indicative options for the layout of the inter-array cables are shown on Figure 3.7. The final positions of the cables would be determined once the wind turbine types and locations are finalised and following the detailed site investigation which would establish in more detail the positions of any seabed obstructions that would need to be avoided. It is likely that the final inter-array cable layout would be a mix of more than one of the options presented in Figure 3.7 determined by slot allocation for the wind turbines.

152 It is expected there may be up to four export cables installed on the site. The export cables would collect the power from the wind turbines on the west or south edge of the site and export it to shore. It is expected that the maximum power would be in the region of 35 MW per cable with a 33 kV operating voltage.

153 Subject to further detailed electrical engineering studies, the array and export cables are likely to be 33 kV three-core cables with optical fibres incorporated for communications. Three-core designs are better than single-core designs in the marine environment as losses in the cable armour wires, and a resulting derating of the cables, are considerably less along with a single installation and therefore less disturbance. The external magnetic and secondary electric fields outside three-core designs of cables are also considerably less than those for single-core cables. Single-core subsea cable designs have not been considered within this ES.

154 Assuming the use of currently available models, each wind turbine would generate electricity at 690 V or higher and would have its own transformer

and switchgear within the tower or nacelle to step-up the voltage to the inter-array and export cable circuits collection voltage of likely 33 kV.

155 The total length of inter-array and export cable would be approximately 39 km. This is based on the following:

- up to 13 km for the inter-array cables
- up to 26 km for the export cables (1 x 5 km, 1 x 6 km, 1 x 7 km, 1 x 8 km)

156 This actual lengths would be depndent on the number of wind turbines and the electrical design employed.

3.9.2 Cable Protection

157 Cables would be buried in the seabed to a sufficient depth, which would be determined by a burial protection study. In determining the burial depth, consideration must be given to potential threats such as fishing gear and small anchors (larger anchors are excluded by an exclusion zone) and seabed movement. Consideration would also be taken of long-term seabed movement. Based on the surveys undertaken, seabed mobility would be restricted to the top layer of sand. Typical burial depths would be in the range of 0.6 m – 3 m.

158 It is possible that the export cables could cross redundant telecom lines. As the cables are redundant, permission may be provided to cut through the cables prior to installation. A second crossing philosophy would be to provide a surface crossing of the cables. In this case, the EOWDC cables would be laid on the seabed and protected on the exposed section by concrete mattresses.

3.9.3 Cables Design

159 The inter-array and export cables are likely to use a voltage of 33 kV and be a sea-armoured three-core cable, with copper conductors. A typical cable is shown in Plate 3.3. Table 3.6 shows the size and weight of three typical cables and it is expected that up to 800 mm^2 cable would be used for the export cable. A smaller size may be used for cables serving fewer turbines and for inter-array cables. The cables may also contain a fibre optic, for communication purposes.

TABLE 3.6
Example of 33 kV Cable Sizes

Conductor cross section	**Diameter**	**Weight in air**	**Weight in sea water**
120 mm^2	110	18 kg m^{-1}	10 kg m^{-1}
240 mm^2	120	24 kg m^{-1}	14 kg m^{-1}
300 mm^2	125	28 kg m^{-1}	16 kg m^{-1}
400 mm^2	130 mm	32 kg m^{-1}	20 kg m^{-1}
500 mm^2	150 mm	36 kg m^{-1}	22 kg m^{-1}
630 mm^2	160 mm	42 kg m^{-1}	24 kg m^{-1}
800 mm^2	170mm	52 kg m^{-1}	30 kg m^{-1}

Plate 3.3 Cut Away Image Showing a Typical Undersea Cable (Courtesy of DUCO)

Table 3.7 **Typical Cable Corridor**			
Section	**Water Depth**	**Approx Corridor Width**	**Temp Construction Corridor**
Landfall	5 m	10 – 150 m	650 m
Approach to wind turbines	15 m	150 – 1,000 m	1,500 m
Inter-array Cables	15 – 30 m	10 m	510 m

3.9.4 Cable Landfall

160 There are potentially up to four cables to make landfall along the coastline. The landfall location has not been confirmed at present as is subject to many factors including detailed investigation of potential routes, substation locations and consideration of the potential environmental impacts of the chosen location.

161 It is understood that the shoreline is similar throughout the corridor location, therefore the proposed methods may be employed at any location. Methods under consideration include:

- horizontal directional drilling (HDD)
- dredged cofferdam
- plough pulled off the beach

162 It should be noted that only the works that are below Mean High Water Mark are assessed in this ES.

3.9.4.1 Horizontal Directional Drilling

163 Horizontal directional drilling may offer a solution with lower environmental impacts to the intertidal area, however is more suited to harder seabed materials and may have a limited application on the EOWDC. Softer seabed materials may require the use of drilling muds to support the hole on a temporary basis.

164 The hole would be drilled from behind the dune area under the tidal zone to exit the seabed a suitable distance from the shore. Each hole would be supported either temporarily with drilling mud or a steel liner to allow the cable to be pulled through.

3.9.4.2 Dredged Cofferdam

165 An alternative solution is to provide an open trench temporarily supported by coffer dams in which the cables are laid. This solution involves removing soils to the required burial depth over a width of approximately 10 m between high water mark and location where subsea trenching can commence. The trenching walls would be supported by sheet pile driven into the beach and seabed, which would also keep the trench dry for work.

166 Following completion, the beach would be reinstated with original materials.

167 This method could require removal of 12,000 m^2 of material for a 400 m long excavation which would be locally stored and reinstated after cable installation.

3.9.4.3 Plough Pulled off the Beach

168 The third solution generally utilised for single cables is to pull the plough up the beach beyond the high water mark and then commence trenching of the cable down the beach using a vessel to pull the plough over the cable into the sea. For this project, this operation would need to be repeated three up to four times.

169 As the chosen method depend on many factors including soil conditions, number of cables and availability of equipment and access, this would be assessed further during detailed engineering and procurement phases.

3.9.5 Onshore Cabling (Information Only)

170 Should the substation not be located behind the cable landfall, onshore cabling would be required to connect the cable jointing bays to the onshore electrical substation. The trench per circuit is approximately 0.75 m wide by 1.2 m deep, with 2 m distance between circuits. Therefore a maximum cable route width of 12 m would be appropriate for four circuits.

3.9.6 Cable Jointing (Information Only)

171 The offshore cables would be jointed to the onshore cables inside pre-cast concrete enclosures located close to the landing area. This would be behind the beach if required and would therefore form part of the onshore planning

application. Each of the four sunken enclosures, one for each export cable, is approximately 7 m long x 2 m wide and 1.5 m deep, with the top surface below ground level. Following installation, these enclosures would be covered with a layer of topsoil. Access to these enclosures would only be required during the operations phase of the wind farm for emergency purposes and they do not need be maintained.

3.10 Substation (Information only)

172 The proposed onshore substation location has not been finalised and is expected to be in one of three locations between Blackdog and the Aberdeen Exhibition and Conference Centre in land that is designated for industrial development or future development. Details are included for information only but would be subject to a separate planning application.

173 In addition the substation location would also include the following facilities:

- site control room
- office and amenities
- facilities relating to the development centre, which may include additional office and training facilities and a permanent exhibition
- possible energy storage and or Flexible Alternating Current Transmission Systems(FACTS) devices

3.10.1 Transmission Cables (Information Only)

174 The transmission infrastructure to the National Grid network would be part of the scope of work undertaken by Scottish and Southern Energy (SSE) and National Grid and therefore does not form part of this EIA.

3.11 Construction

3.11.1 Offshore Construction

3.11.1.1 Introduction

175 This section presents an overview of the proposed methods of construction for the project. While as much care as possible has been taken to explore and document the most suitable construction methods, it must be noted that construction contractors have not been appointed and the Applicant would also look towards innovative methods for construction which may be more efficient or cost effective. Options for this may include:

- use of larger vessels which would require less trips
- use of smaller vessels / different vessels suited for the specific water depths at different parts of the site
- installation of wind turbine and foundation in one operation

176 As such, this should be considered provisional and would be updated for each phase prior to construction.

3.11.1.2 Access to Site

177 Construction in the marine environment is potentially hazardous, and in the interests of safe working the project should be permitted to take advantage of as much construction time in favourable conditions as is possible. Construction activity is expected to continue, subject to site weather conditions, for 24 hours per day until construction is complete and may take place at all times of the year.

3.11.1.3 Safety Zones

178 The Applicant will request advisory safety zones or apply to the Secretary of State for Trade and Industry for a temporary offshore construction safety zone under Section 95 of the Energy Act 2004. The purpose of this zone is to protect the safety of project plant and personnel, and the safety of third parties during the construction and commissioning phases of the wind farm.

179 Although the stated safety zone encompasses the entire wind turbine area, the extent of the safety zone at any one time would be dependent on the locations of construction activity, and a rolling safety zone may therefore be proposed.

180 It is intended that third parties would be excluded from any safety zone during the construction period, and that the zone(s) would be marked in accordance with Trinity House Lighthouse Service recommendations. Regular Notice to Mariners would be issued as construction progresses.

181 For the export cables, an advisory safety zone would be implemented to the extent permitted by legislation and by the relevant regulatory authorities.

3.11.1.4 Construction Vessels

182 The types of construction vessels to be used would be selected post-consent, however the main types of vessels for each tasks are presented in Table 3.8.

TABLE 3.8 Likely Types of Construction Vessels		
Task Likely	**Type of Construction Vessel**	**Comments**
Pile Installation	Jack-up barge Dynamic Positioning (DP) vessel	Potential for support barge, tug(s) and work boats as support craft
Gravity Base Installation	Floating Barge (eg Shear Leg) DP vessel	Potential for support barge, tug(s) and work boats as support craft
Tripod	Floating Barge (eg Shear Leg) DP vessel	Potential for support barge, tug(s) and work boats as support craft
Wind Turbines	Jack-up barge	Such vessels now able to carry multiple units in one trip
Scour Protection	Construction barge or dedicated rock dumping vessel	
Cable Installation	Dedicated cable lay vessel (anchored barge or Dynamic Positioned vessel)	
Crew transfer, wind farm commissioning	Workboat	To conform to the MCA Workboat Code

183 The predicted number of movements (between port and the site) relating to the construction phase are shown in Table 3.9 and Table 3.10:

TABLE 3.9 Phase 1 Construction Vessel Movements		
Activity	**Frequency**	**Total Vessel Movements (approx)**
Pile Installation	One visit per two piles	2
Gravity Base Installation Crane barge on site at all times	One support barge visit per base	4
Wind Turbines	Two visit per turbines	8
Scour Protection	One visit per turbine	4
Cable Installation	One visit per five inter-connecting cables and one trip/export	5
Crew transfer, wind farm commissioning	Six visits per turbine	24
		TOTAL 45

TABLE 3.10 Phase 2 Construction Vessel Movements		
		Total Vessel Movements (approx)
Pile Installation	One visit per two piles	4
Gravity Base Installation Crane barge on site at all times	One support barge visit per base	7
Wind Turbines	Two visits per turbine	14
Scour Protection	One visit per turbine	7
Cable Installation	One visit per five inter-connecting cables	2
Commissioning	Six visits per turbine	42
		TOTAL 72

184 To optimise the construction programme, it is likely that installation of wind turbines, foundations and cables would be undertaken on the site at the same time, although not necessarily in the same part of the site. Therefore it is likely that 1 - 5 vessels (including support craft) may be on site at any one time.

3.11.1.5 *Lighting and Marking*

185 The construction area would be depicted on Admiralty Charts by the UK Hydrographic Office, and information pertaining to construction would be disseminated through the Notice to Mariners procedure together with regular communication with local and regional stakeholders.

186 The construction area and incomplete structures would be lit and marked in accordance with the protocol recommended by THLS.

3.11.1.6 *Construction Programme*

187 An indicative construction programme is presented below, based upon two construction seasons:

- Phase 1 2013
  - 4 x 6.5 MW wind turbines installed
- Phase 2 2014
  - 4 x 7.5 MW wind turbines installed
  - 3 x 10 MW wind turbines installed

188 To optimise the construction programme, it is likely that installation of wind turbines, foundations and cables would be undertaken on the site at the same time, although not necessarily in the same part of the site.

3.11.1.7 *Construction Management (Environmental)*

189 During construction (and decommissioning) some discharges to the atmosphere would arise from the marine vessels required to undertake these stages of the development.

190 There are no anticipated solid discharges into the marine environment during the construction phase.

191 A comprehensive Environmental Management System would be implemented prior to construction in consultation with statutory authorities, with a suite of complementary management plans corresponding to different aspects of the construction activity. The Environmental Management System would form a component part of the construction contract for the development. The documents, which would be tailored specifically to ensure compliance with the consent conditions for the project and current environmental best practice, include the following:

- Environmental Management System
- Environmental Management Plan including Commitments Register
- Monitoring Protocol (as per statutory consents)
- Incident Reporting and Non Conformance Procedure
- Emergency Response Plan

- Collision Risk Management Plan
- Marine Pollution Contingency Plan
- Dropped Objects and Materials Recovery Plan
- Archaeology Plan
- Noise, Dust and Vibration Management Plan
- Waste Management Plan
- Health and Safety Plan

3.11.1.8 Foundation Installation Vessels

192 The different types of foundations would be installed using different methodologies, however fall into the following main categories:

- float to location and ballast
- lift to location and ballast
- lift to location and secure to seabed

Float to Location and Ballast

193 This is restricted to gravity base foundations that could be towed to site by tugs and once in the final location, ballasted to secure to the seabed. Typically the foundation may require 2 - 3 tugs for the tow and positioning operation. Additional vessels (such as rockdumpers) may be necessary for the ballasting operations and scour protection. Seabed preparation may be required prior to installation.

Float to Location and Lift

194 This method could be utilised for some foundation types including monopiles. With this method the foundation would be towed to location by tugs (in the case of a monopile, the ends would be sealed). Once on location a crane vessel (either jack-up or Dynamically Positioned (DP) vessel) lifts the foundation and control location and orientation as the foundation approached the seabed.

195 For this installation method, 1 – 2 tugs would be utilised for the tow and the crane vessel for the lift operation. Additional vessels may be required for seabed preparation prior to installation and scour protection following installation.

Lift to Location and Secure on Seabed

196 Using this method, the foundations are transported to site utilising either a barge or the installation vessel. The foundation would generally be seafastened to the deck of the vessel. Once at location the seafastening would be removed and the foundation lifted to location and secured to the seabed by ballasting or pilling. This method would be suitable for all foundation types.

197 Additional vessels would also be required for seabed preparation prior to installation and scour protection after.

3.11.1.9 Wind Turbine Installation Vessels

198 Although offshore contractors have varying construction techniques, the installation of the wind turbines would likely require one or more jack-up barges, possibly one of the vessels currently in the market and/or a purpose-

built wind turbine installation vessel. Most of these large vessels stand on the seabed and create a stable lifting platform by lifting themselves out of the water. The area of seabed taken by the vessel feet varies between vessels and maybe up to 800 m^2 (in total), or with leg penetrations of up to 6 m to 8 m for leg designs reliant on leg wall friction (dependant on seabed properties). These holes would be left to in-fill naturally. Based on a worst case scenario and taking into account multiple operations (including barge jack-up for wind turbine and foundation installation), this could entail an area of impact of up to 4200 m^2 per wind turbine/ foundation. Alternatively, a DP vessel may be used for the installation work, which does not leave footprints. The wind turbine components would either be stored at an adjacent port and transported to site by support barge or the installation vessel itself, or transported directly from the manufacturer to the wind farm site by barge or by the installation vessel. The wind turbine would typically be installed using multiple lifts – the tower (1-2 lifts), nacelle (1 lift), hub/blades (1- 4 lifts). A support jack-up barge, support barge, tug, safety vessel and personnel transfer vessel may also be required.

200 It is expected that wind turbines would be installed on the foundation at a rate of one every one to two days.

201 As an alternative the project would investigate other options for innovative installation which would reduce the number of lifts, installation time and impact.

202 The works would be planned for 24 hours per day, with lighting of each barge or vessel (if using multiple barges) at night, and accommodation for crew on board.

3.11.1.10 Cable Installation

203 The installation of the inter-array and export cables is likely to be carried out by a specialist cable lay vessel, with the cables stored either on reels or a carousel designed to carry the necessary lengths and maintain the minimum bend radius.

204 The vessel is likely to be fully equipped with specialised cable lay equipment, including cable tensioners and a full survey suite to provide details of the final cable positions. The vessel would follow the cable route either through use of a four or eight point moving system or a fully DP (Dynamically Positioned) or a DP assisted operation. The vessel is likely to be specifically mobilised to undertake the work and would be selected for the ability to work in the shallow water and tidal conditions that prevail on site. A typical DP vessel is shown in Plate 3.4, however barge based vessels may also be utilised.

205 Depending on the vessels used for the installation, for the shallow water sections beyond the landfall it may be necessary to use additional barges or anchored platforms to allow for the cable installation.

Plate 3.4 Dynamically Positioned Cable Lay Vessel (Courtesy of Technip)

206 All the subsea cables would be buried in order to provide protection from all forms of hostile seabed intervention, such as fishing activity (trawler and otter boards), dragging of anchors and the minor risk of dropped objects. The subsea cables are also buried to ensure stability in the tidal conditions and eliminate the risk of free-spans causing cable fatigue.

207 The degree of cable burial proposed relates to a combination of the anticipated ground conditions as well as the perceived threat, and as such it is not proposed to bury deeper than is considered necessary.

208 The final method of cable installation and depth of burial would be determined at a later date and would vary depending on more detailed soil condition surveys and equipment selected.

209 The cables are likely to be buried using a combination of two or three techniques. Typical tools from each are shown in plates 3.5, 3.6 and 3.7.

Ploughing

210 Ploughing would be carried out using an underwater cable plough that executes a simultaneous lay and burial technique by lifting a wedge of sediment, allowing the cable to fall into this trench. A separate operation may be necessary to fold the sediment back on top of the cable. Such an operation mobilises very little sediment. The trench could typically be controlled to match the burial depth requirement which maybe between 0.6 m and 3 m deep. The trench width for the greatest depth maybe up to 10 m wide depending on soil conditions and would displace 405, 000m^3 over the 26 km cable length, with a potential for a loss of 10.38 m^2 of habitat per metre of cable laid.

Jetting

211 Cable burial from a ROV (Remote Operated Vehicle) that utilise high-pressure water jets to fluidise a narrow trench into which the cable is located. A working assumption for the trench dimension is 0.5 m wide and up to 2 m

deep. The jetted sediments settle back into the trench and with typical tidal conditions the trench coverage is reinstated over several tidal cycles. This could be undertaken in a single operation or multiple operations.

Mass Flow Excavation

212 Cable burial using mass flow excavation where a propeller is placed above the target and a jet of water is directed to the target to wash the seabed away in a specific location. The cable is then laid into the open trench. The propeller can then be reused to provide infill or allow natural backfill.

213 As the export cables are relatively short, it is proposed to install the export cables in the same way as the inter-array cables, should conditions allow.

214 The seabed in the proposed export corridor and inter-array area consists of sand overlaying glacial clays. The method chosen would depend on the depth of overlaying sand and detailed analysis of the soils along the proposed route.

Plate 3.5 ROV Jet Trenching Tool (Courtesy of Technip)

Plate 3.6 Subsea Plough (Courtesy of Technip)

Plate 3.7 Mass Flow Excavation Tool (Courtesy of RoTech)

215 Depending upon installation method chosen, the cable approaches to each wind turbine j-tube (the cable “bight”) would not be buried in the final few metres. It is proposed that these cable sections would be subsequently buried using appropriate techniques to be agreed prior to construction (mattress installation, diver air lifting etc).

216 Alternatively, a shallow rock, grout bag berm, or cast iron casing may have to be installed where other burial techniques are unsuccessful.

3.12 Wind Farm Operations and Maintenance

3.12.1 Access to the Site and Safety Zones

217 Operation and maintenance of the offshore wind farm would continue 24 hours per day, 365 days per year, and therefore the Applicant would require access to site at any time.

3.12.1.1 Safety Zones

218 The Applicant would likely apply for safety zones under Section 95 of the Energy Act 2004 for the following safety zones during wind farm operation:

- each structure including (wind turbine) structure would there under have a safety zone of 50-100 m radius prohibiting entry for non-project vessels

3.12.2 Wind Farm Control

219 The wind turbines are configured so that they operate with a minimum of supervisory input. The wind turbines are monitored and controlled by micro-processors installed within the wind turbine tower. Should a wind turbine develop a fault, the status of the fault is diagnosed, and if necessary the turbine is automatically shut down for safety purposes a fault signal is sent to the onshore operator. The wind turbine operation is based upon a “fail-safe” philosophy.

220 All information relating to on-site conditions (wind speed, direction, etc), wind turbine status and generated output is held within a central Supervisory Control and Data Acquisition (SCADA) system linked to each individual turbine micro-processor. The SCADA system is controlled from an operations base ashore, and allows for the remote control and shutting down of any individual wind turbine (or a number of wind turbines) should circumstances dictate.

3.12.3 Wind Farm Inspection and Maintenance

221 The EOWDC would be serviced and maintained throughout the life from a local port, possibly Aberdeen or Peterhead. Following the commissioning period of a commercial wind farm scheduled servicing interval for the wind turbines would usually be every twelve months. As this project is a test centre it is expected that there may be more visits for data gathering etc.

222 Maintenance of the wind farm is normally separated into three different categories:

- physical periodic inspections
- scheduled maintenance
- un-scheduled maintenance

223 The integrity of the installation needs to be checked on a regular basis by remote monitoring and physical inspections of foundations, sea cables and scour protection which is likely to be undertaken at a frequency of 1–5 years.

Maintenance of scour protection may require periodic installation of additional scour protection material.

3.12.4 Physical Periodic Inspections

224 Periodic inspections would be carried out to determine the technical condition of the offshore installation. These inspection campaigns take half a day for the wind turbine and the top part of the foundation and half a day for the underwater inspections. The execution of these inspections would be planned in the periods of the year with the best access conditions, preferably in summer.

225 The periodic inspections would be carried out according to the supplier's and project specifications. The work scope typically includes function and safety tests, visual inspections, analysis of oil samples, inspection of subsea cables and scour protection.

3.12.5 Scheduled Maintenance

226 Scheduled maintenance applies primarily to inspections and work on wear parts like replacement of brake pads and filters, check of bolts, lubrication, oil change on gear box or hydraulic systems susceptible to failure or deterioration in between the periodic overhauls. A scheduled maintenance of each turbine is likely to take place every twelve months.

227 Scheduled maintenance would be performed using relatively small crew vessels from the local harbour.

3.12.6 Unscheduled Maintenance

228 Unscheduled maintenance applies to any sudden defects. The scope of such maintenance would range from small defects easy to solve with the crew vessels used for the scheduled maintenance to complete failure or breakdown of main components. For the replacement of main components like gearboxes, generators or blades bigger jack-up barges would be needed. The replacement of main components is not to be expected in the first fiver operational years.

3.12.7 Operation Management (Environmental)

229 There are no anticipated direct discharges to the atmosphere during normal operation of the wind turbines.

230 There are no anticipated solid discharges into the marine environment during normal operation of the wind turbines. All waste generated during operation, for example associated with maintenance, would be collected and disposed of by licensed waste management contractors to licensed waste management facilities onshore.

231 There are no anticipated direct aqueous discharges to the marine environment during normal operation of the wind turbines However, there is a small risk of accidental discharges from the wind turbines array or marine vessels associated with operations and maintenance.

232 During the operations phase of the wind farm an Environmental Management System, based upon the system implemented for the construction phase, would be in place. The system would ensure that the environmental monitoring, as specified in the statutory consents, is undertaken and reported, and that the wind farm is operated and maintained in an environmentally responsible manner.

233 It is anticipated that the following aspects would be featured in the Environmental Management System during the operational phase:

- Environmental Management System
- Environmental Management Plan
- Environmental Monitoring Protocol
- Emergency Response Plan
- Incident Reporting and Non Conformance Procedure
- Collision Risk Management Plan
- Marine Pollution Contingency Plan
- Waste Management Plan
- Dropped Objects and Materials Recovery Plan

234 The plans would generally be shorter versions of the corresponding construction plan – however, if major unscheduled maintenance works are required the construction plans may need to be invoked if larger construction vessels are required.

3.13 Wind Farm Decommissioning

3.13.1 Introduction

235 The Applicant recognises the importance of considering the decommissioning process at an early stage, and is committed to decommissioning the wind farm to the standard wind industry protocol at the agreed time. The implementation of the Energy Act 2004 includes an outline protocol for decommissioning. The following sections provide a description of the current intentions with respect to decommissioning, with the intention to review the statements over time as industry practices and regulatory controls evolve.

3.13.2 Programme for Decommissioning

236 As part of the implementation of the Energy Act 2004, some provisions relating to decommissioning are to be proposed. The anticipated sequence of events at present is as follows:

237 The developer submits a decommissioning plan at the time of gaining consent (precise timings to be refined). This plan would be costed and would have an outline schedule attached. Over the lifetime of the project, the plan would be reviewed and updated if necessary. When the wind farm is ready to be decommissioned, the operations take place in accordance with the agreed documentation

238 Post decommissioning monitoring would be performed in accordance with the approved decommissioning plan.

3.13.3 Facilities to be Decommissioned

239 The key offshore components of the proposed EOWDC to be decommissioned are:

- 11 wind turbines and their associated foundations
- inter-array cables between the wind turbines
- export cables for connection to the electricity transmission network
- scour protection around foundations

240 At the end of the operational life of the project (approximately 22 years) it is anticipated that all structures above the seabed would be completely removed by reverse lay, that is, the reverse construction sequence.

3.13.3.1 Wind Turbines

241 The structures above the seabed would be removed piecemeal in the reverse order of the construction procedure, using offshore cranes or, alternatively, the entire structure could be removed in a single activity using a heavy lift vessel. At the end of their individual life, the offshore wind turbines would be removed and either refurbished or recycled. The wind turbines are designed to allow removal. A typical decommissioning process for a wind turbine is set out below:

- de-energize and isolate from Grid (may be undertaken in phases)
- mobilise suitable heavy lift vessel(s) to the wind farm location
- remove rotor component parts
- cut wind turbine inter-array cables adjacent to the substructures
- remove nacelle including generator
- remove wind turbine tower
- transport all components to an onshore site at which they would be processed for reuse, recycling or safe disposal

3.13.3.2 Foundations

242 For steel foundations, piles would be cut to a sufficient target depth below the seabed to ensure that they do not become exposed. All salvaged steel to be lifted on a barge and transported to land. A jack-up type vessel would typically be used for this operation.

243 Reinforced concrete or steel gravity based structures, would be demolished by the use of demolition tools, jackhammers, diamond saw, or hydraulic splitting with the resultant material recovered for reuse.

244 The exact method of removal would be in line with regulations in place at the time of decommissioning.

3.13.3.3 Cables

245 With respect to subsea cables, it is likely that these would be removed unless it can be demonstrated that they do not pose a risk to other users of the sea and removing them leads to a greater impact on the environment than leaving *in situ*.

246 The export cables and inter-array cables would be buried to a depth ranging between at least 0.6 and 3 m below seabed. Further studies would examine if the proposed burial depths of these cables are likely to be sufficient to leave in situ. If the option to leave *in situ* is proposed then contingency plans would be put in place to ensure appropriate actions are carried out if the cables do become exposed.