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Abbreviations and Acronyms

AC	Alternating Current
CIV	Cable Installation Vessel
CSV	Construction Support Vessel
EIA	Environmental Impact Assessment
ELC	East Lothian Council
ES	Environmental Statement
GBS	Gravity Base Structure
HDD	Horizontal Directional Drilling
HLV	Heavy Lift Vessel
HVAC	High Voltage Alternating Current
ICOL	Inch Cape Offshore Limited
JUV	Jack Up Vessel
kV	Kilovolt
LAT	Lowest Astronomical Tide
MHWS	Mean High Water Springs
O&M	Operations and Maintenance
OfTW	Offshore Transmission Works
OnTW	Onshore Transmission Works
OSP	Offshore Substation Platform
SSE	Scottish and Southern Energy
UXO	Unexploded Ordnance
WTG	Wind Turbine Generator

7 Description of Development

7.1 Introduction

1 This chapter provides a description of the Development to inform the Environmental Impact Assessment (EIA).

2 The Development consists of a number of components and all permanent and temporary works required to generate or transmit electricity to the national grid:

- The Wind Farm includes Wind Turbine Generators (WTGs), inter-array cables and associated ancillary infrastructure (see *Section 1.3.3* and Table 1.1).
- The Offshore Transmission Works (OfTW) includes the Offshore Export Cable and Offshore Substation Platforms (OSPs) (see *Section 1.3.4* and Table 1.1).

3 As discussed in *Chapter 6*: *Site Selection and Alternatives*, the final design of the Development will continue to evolve post consent until a greater understanding of the site conditions and a WTG selected, this will allow Inch Cape Offshore Limited (ICOL) to take maximum advantage of emerging technology. The description of the Development identifies and describes the 'Design Envelope' which defines the range of parameters associated with reasonably foreseeable technology options.

4 This description is provided as a range of parameters for a number of technologies, hereafter referred to as the Design Envelope (see *Section 7.4* of this chapter). The Design Envelope describes a number of components and all permanent and temporary works required to generate or transmit electricity to the national grid including the Wind Farm and the OfTW.

5 The Onshore Transmission Works (OnTW) (see *Section 7.15*) is subject to a separate application which has been submitted to East Lothian Council (ELC) and the impacts of these works have been considered at an appropriate level to inform the assessment in this EIA Report (see *Section 4.6*).

6 Definitions for the Wind Farm, OfTW, Development Area and Export Cable Corridor are detailed in Table 1.1 of *Chapter 1: Introduction* and are repeated below for ease of reference:

- Offshore Wind Farm/Wind Farm: Includes proposed WTGs, inter-array cables, and other associated and ancillary elements and works (such as metocean buoys). This includes all permanent and temporary works required.
- Offshore Transmission Works (OfTW): The proposed Offshore Export Cable and Offshore Substation Platforms (OSPs). This includes all permanent and temporary works required.
- Development Area: The area which includes proposed WTGs, inter-array cables, OSPs and initial part of the Offshore Export Cable and any other associated works (see Figure 7.1).

- Offshore Export Cable Corridor/Export Cable Corridor: The area within which the proposed Offshore Export Cables will be laid outside of the Development Area and up to Mean High Water Springs (MHWS) (see Figure 7.1).

7 An illustration of the key components of an offshore wind farm is shown diagrammatically in Figure 7.2.

7.1.1 The Onshore Transmission Works (OnTW)

8 The OnTW is subject to a separate application to ELC and the impacts of these works have been considered at an appropriate level to inform the assessment in this EIA Report (see *Section 4.6.1* of *Chapter 4: Process and Methodology*). The EIA Report for the OnTW can be found at:

https://pa.eastlothian.gov.uk/online-applications/applicationDetails.do?activeTab=summary&keyVal=P4LTIAGNH3Y00

9 The OnTW includes underground electricity cables and an onshore substation which receives power from the Offshore Export Cables and processes it for transmission to the existing grid network. The Landfall for Export Cables will be near Cockenzie (Figure 1.2). The OnTW lies within the vicinity of the former Cockenzie Power Station.

Figure 7.1: Location of Development Area, Offshore Export Cable Corridor and Grid Connection

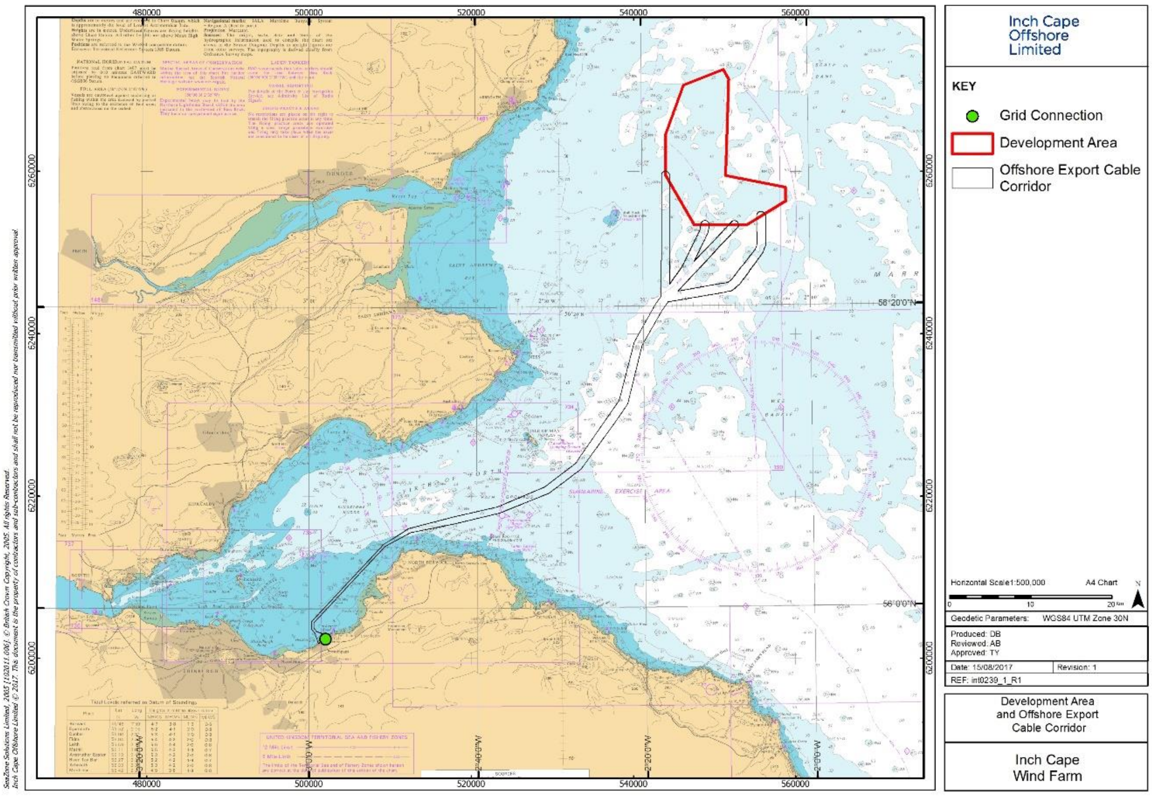
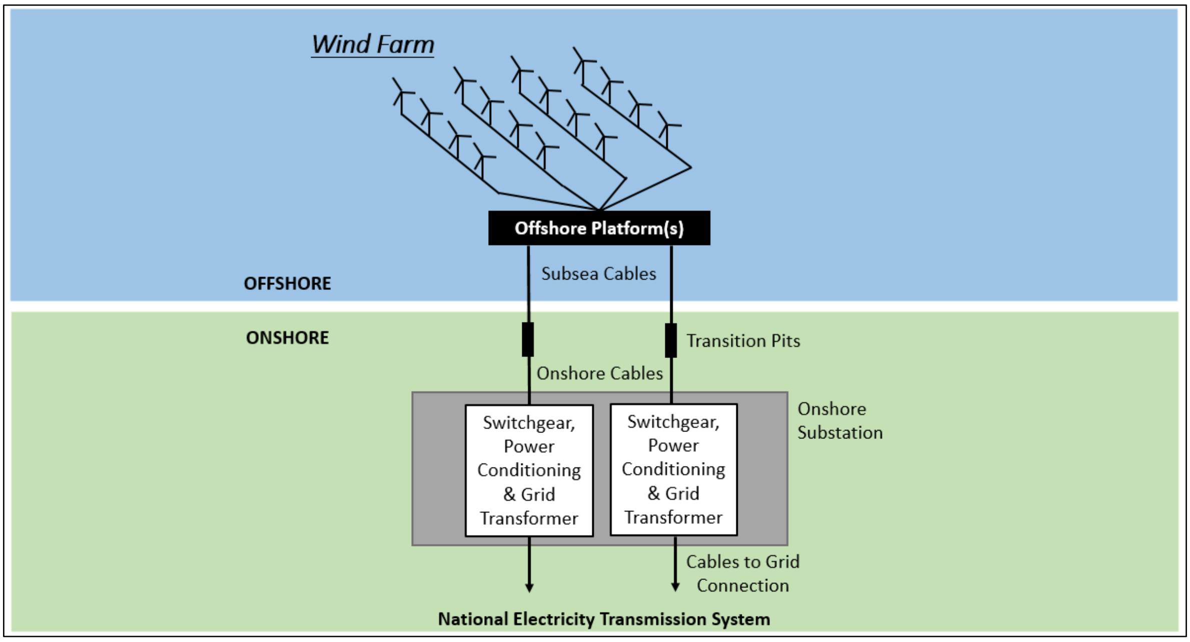


Figure 7.2: Illustration of components



7.2 Development Area

7.2.1 Location and Extent

10 The Development Area is approximately 150 km^2 and is located approximately 15 to 22 kilometres (eight to 12 nautical miles) off the Angus coastline, to the east of the Firth of Tay. The Development Area is shown in Figure 7.3 below. The coordinates of the boundary of the Development Area are listed in Table 7.1 below.

Figure 7.3: Development Area

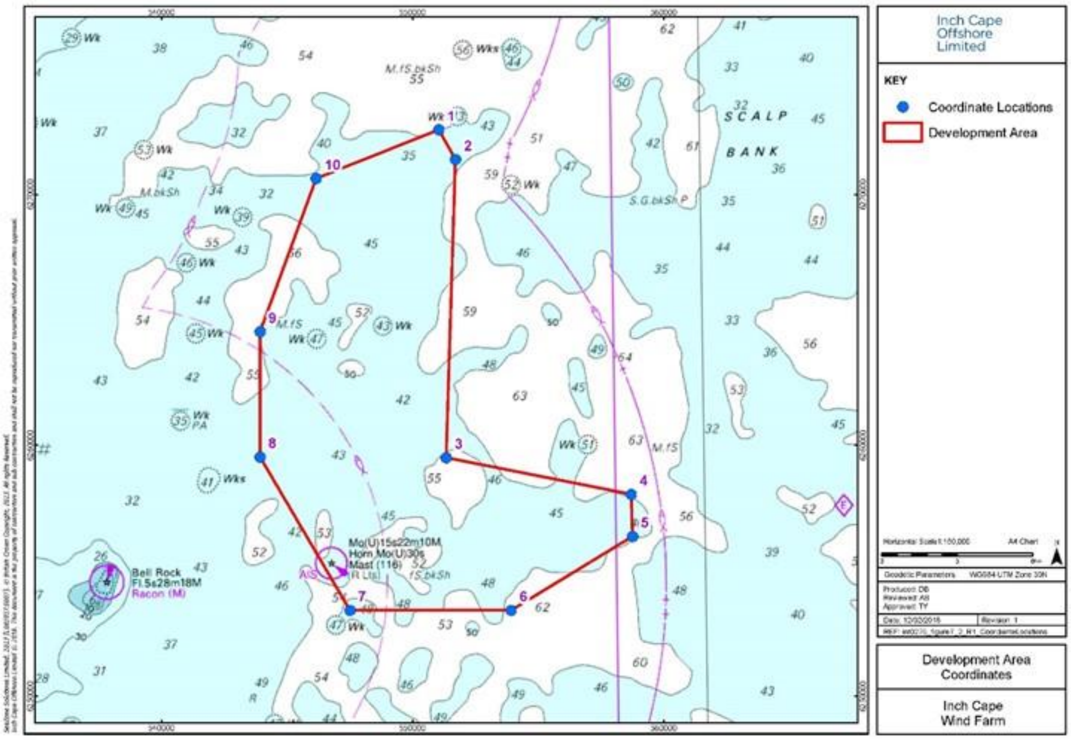


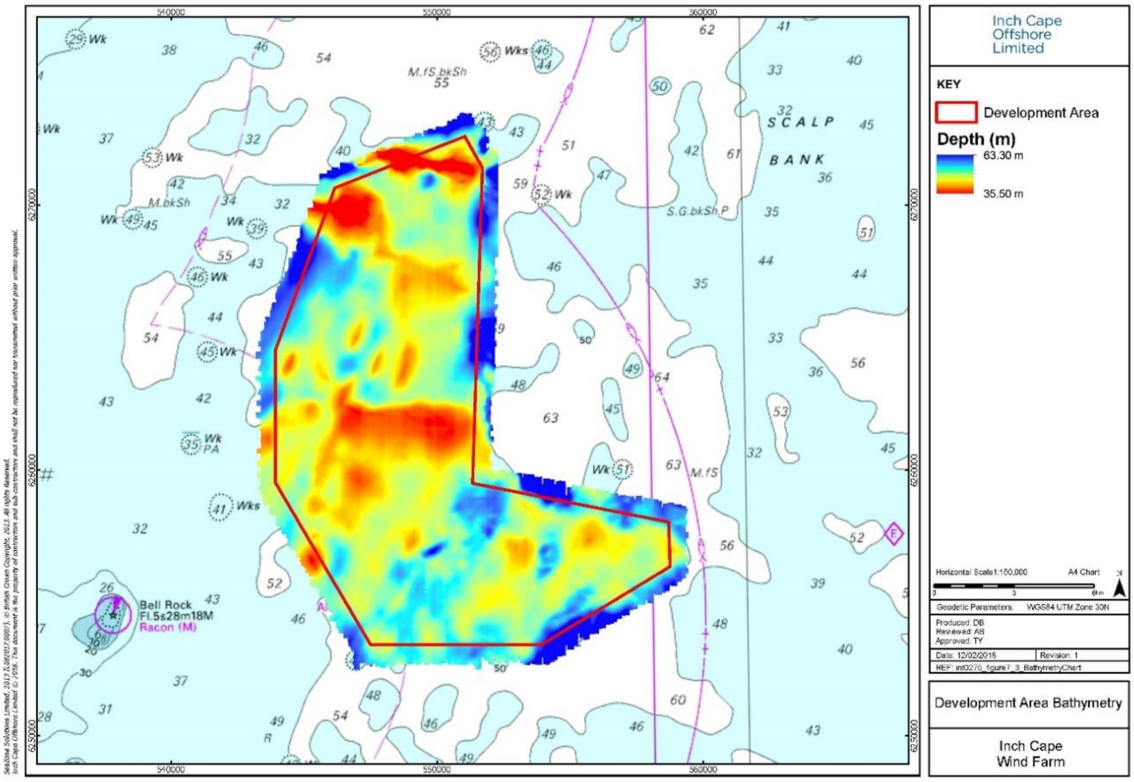
Table 7.1: Development Area coordinates

Map ID	WGS84 X (decimal degrees)	WGS84 Y (decimal degrees)	UTM30N X (Metres)	UTM30N Y (Metres)
1	-2.168960	56.594632	551030.82510	6272572.70670
2	-2.158372	56.583977	551695.53290	6271394.71650
3	-2.166704	56.477201	551327.93370	6259504.04370
4	-2.047320	56.463267	558702.82420	6258048.70300
5	-2.046898	56.448196	558752.07170	6256371.62120
6	-2.125965	56.422319	553914.93410	6253426.81950
7	-2.230138	56.423009	547488.31280	6253426.78710
8	-2.287140	56.478254	543908.46860	6259537.80530
9	-2.286299	56.523044	543908.50810	6264523.50470
10	-2.248812	56.577667	546148.23980	6270627.92630

7.2.2 Physical Characteristics

11 The water depths across the Development Area range from approximately 35.5 m to 63.3 m below Lowest Astronomical Tide (LAT), with 99 per cent of the area lying between 40 m and 57 m LAT. The tidal range is approximately 5.4 m with a mean spring tide range of approximately 4.1 m. The principal tide axis is orientated north north-east/south south-west. The seabed slopes across the Development Area are generally less than 1° with isolated slopes of up to 7° found on the flanks of two sandwave features to the north of the Development Area. Figure 7.4 provides an illustration of the Development Area bathymetry.

Figure 7.4: Development Area bathymetry



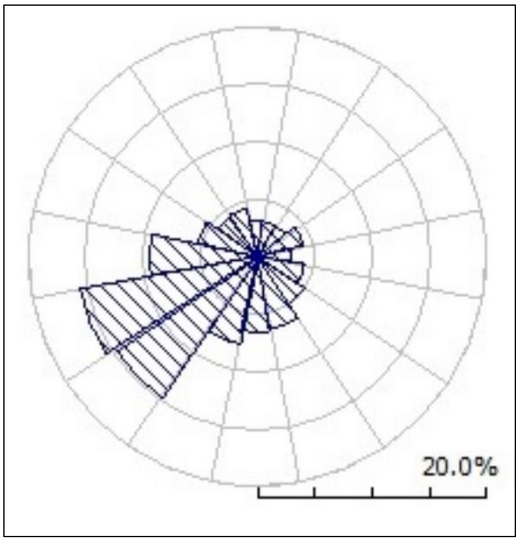
12 The seabed and sub-seabed sediments are generally characterised by variations of sand, clay and gravel with chalk identified at isolated locations.

13 More detail on the physical characteristics of the Development Area is presented, where relevant, in the technical chapters.

7.2.3 Wind Resource

14 A preliminary assessment of the wind resource at the Development Area has been carried out using industry standard modelling. The data for the Development Area provides an output of long-term wind statistics based on 30 years of data and with a spatial resolution of 100 m. The long-term wind direction distribution is presented in Figure 7.5 below and shows that the predominant wind direction is from the south-west.

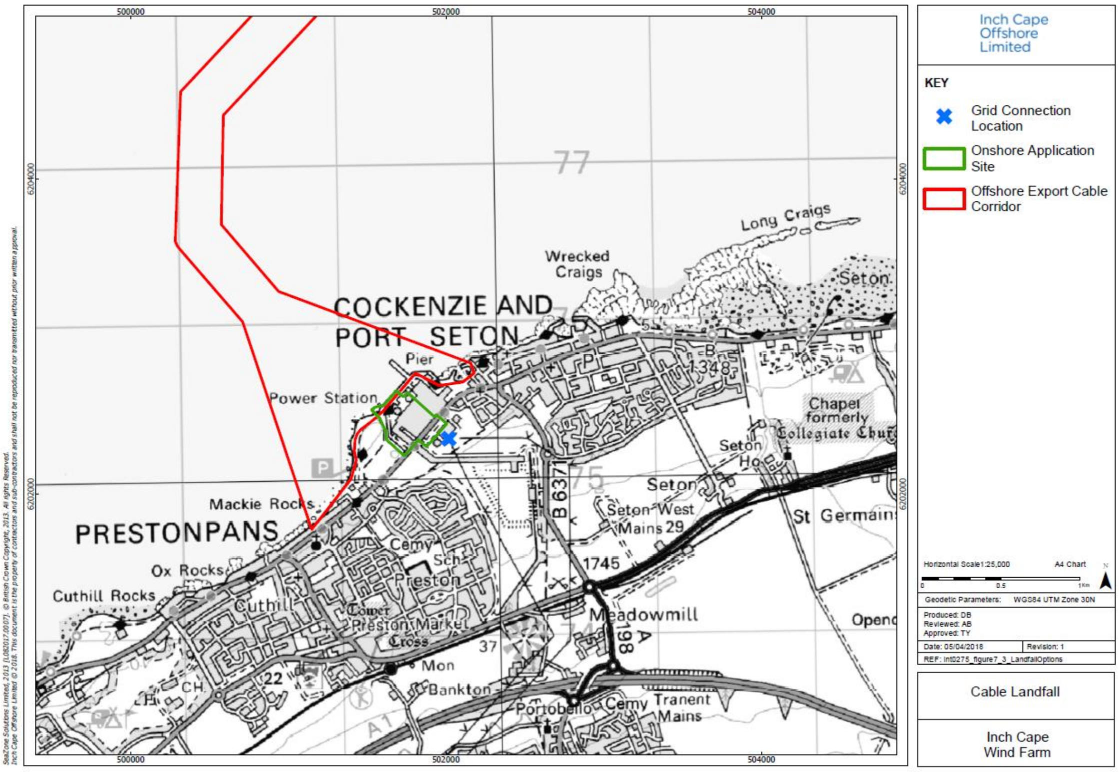
Figure 7.5: Directional wind rose



7.3 Offshore Export Cable Corridor

15 The Offshore Export Cables, which transmit power to shore, will exit the Development Area and transit the seabed to the landfall location near Cockenzie in East Lothian (see Figure 7.6).

Figure 7.6: Cable landfall



16 The Offshore Export Cable Corridor, shown in Figure 7.7, with coordinates listed in Table 7.2 below, is approximately 1.4 km across at the widest point reducing to about 250 m in

shallower areas. The Offshore Export Cable Corridor widens at the coast to incorporate the landfall as shown in Figure 7.6.

17 Up to two export cables will be installed in separate trenches within the Offshore Export Cable Corridor. The distance between the trenches will vary and will generally reduce as the cables approach the landfall.

Figure 7.7: Offshore Export Cable Corridor

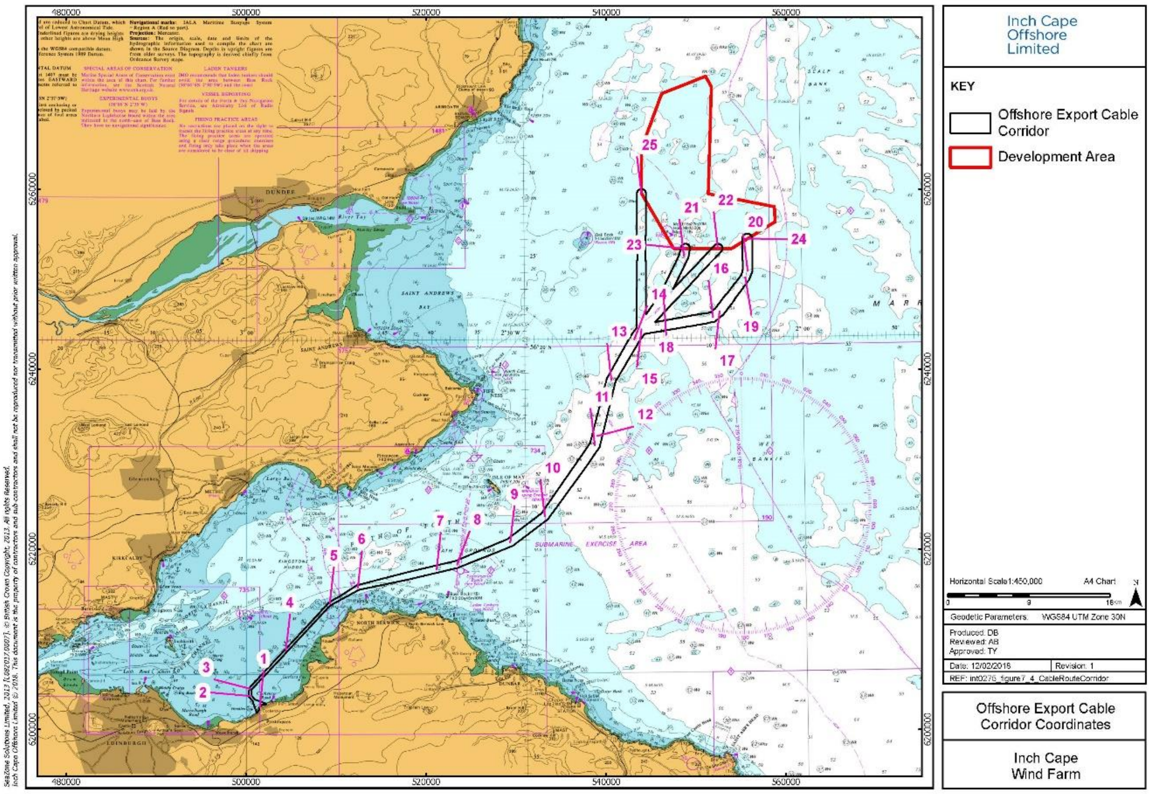


Table 7.2: Offshore Export Cable Corridor coordinates

Map ID	WGS84 X (decimal degrees)	WGS84 Y (decimal degrees)	UTM30N X (Metres)	UTM30N Y (Metres)
1	-2.976427	55.967225	501471.465	6202432.035
2	-2.993258	55.978222	500420.7364	6203655.736
3	-2.993002	55.985496	500436.6114	6204465.362
4	-2.929409	56.023573	504399.9256	6208705.5
5	-2.851017	56.070364	509274.8448	6213920.915
6	-2.800999	56.086513	512383.5347	6215726.15

Map ID	WGS84 X (decimal degrees)	WGS84 Y (decimal degrees)	UTM30N X (Metres)	UTM30N Y (Metres)
7	-2.660148	56.104520	521138.5413	6217764.522
8	-2.623442	56.109184	523418.7545	6218295.409
9	-2.528067	56.130907	529333.7222	6220749.64
10	-2.466089	56.156715	533163.8099	6223650.095
11	-2.375336	56.227333	538729.6525	6231557.109
12	-2.370985	56.236522	538990.0538	6232582.31
13	-2.344561	56.292236	540568.9562	6238798.462
14	-2.302421	56.332492	543131.8341	6243304.565
15	-2.289704	56.342369	543906.7732	6244411.956
16	-2.160814	56.353998	551858.0595	6245795.891
17	-2.148653	56.359760	552601.6012	6246446.49
18	-2.249082	56.373877	546379.4645	6247945.441
19	-2.101608	56.393249	555459.5893	6250210.669
20	-2.097310	56.399898	555715.1818	6250954.211
21	-2.211727	56.415170	548633.9572	6252567.151
22	-2.150177	56.422487	552421.1984	6253426.812
23	-2.208920	56.422876	548797.2524	6253426.883
24	-2.096959	56.431822	555690.1909	6254507.578
25	-2.287140	56.478254	543908.4686	6259537.805

7.4 The Design Envelope

18 The design of the Wind Farm and OfTW cannot be finalised at this stage. This is primarily due to procurement and supply chain considerations of emerging technology, the requirement for further site investigation and continued design, and the timing of investment decisions. The EIA process presented in this EIA Report has therefore been completed using a design envelope. This approach is endorsed by the courts and is standard practise for offshore wind farms as being appropriate for development of this nature.

19 The Design Envelope includes a number of components and all permanent and temporary works required to generate or transmit electricity to the National Grid. Design alternatives

which have not been included in the Design Envelope are detailed in *Chapter 6* (see *Section 6.3*).

20 The assessments within each technical chapter are based upon the design parameters which represent the worst case for the receptor under consideration; this is presented in tables at the beginning of these chapters. As each individual impact assessment is based on the worst case parameters specific to their topics, the overall impact assessment represents the worst case scenarios for the Development.

21 Some of the design parameters cannot co-exist and therefore following a precautionary approach, the overall assessment overestimates the potential impacts of the Development.

22 The Design Envelope contains parameters relating to the following components of the Development:

- WTG types and layouts;
- Foundations and substructures;
- OSPs;
- Inter-array cables;
- Export Cables; and
- Operations and maintenance (O&M).

23 The use of a design envelope for the elements of the Wind Farm and OfTW listed above, means that a range of options must be considered in terms of construction and O&M methodologies at this stage.

7.5 Wind Turbine Generators (WTGs)

7.5.1 WTG Description

24 This section provides a description of the WTGs under consideration, including the specification, typical layouts, installation, commissioning, access and operation. A summary of the Design Envelope specifications is included below in *Section 7.5.2*.

7.5.2 WTG Specification and Design

25 A range of WTG suppliers and models are being considered. WTG selection will be dependent on the continued design and progress of the Development and will take account of environmental factors, safety, commercial procurement and technical factors.

26 A typical WTG is shown in Figure 7.8 below. WTGs are comprised of the following main components:

- **Rotor:** the hub with three connected blades which captures the wind energy and converts it to rotational motion;

- **Nacelle:** the box-shaped housing which contains the equipment to convert the rotational motion to electrical power; and
- **Tower:** the cylindrical structure which supports the rotor and nacelle, fixes the WTG to the substructure, and provides the primary access to the nacelle. The tower may also contain power conversion and ancillary equipment.

Figure 7.8: A typical offshore WTG (Source: ICOL)

7.5.3 WTG Layout

27 The layout of the Wind Farm is subject to a design optimisation process including selection and procurement of WTGs, and is dependent on several factors including:

- prevailing wind direction, as WTG rows must be orientated to benefit from the dominant wind direction;
- distance from adjacent WTGs to take account of wake effects and maximise efficiency of energy capture;
- geological conditions;
- bathymetry;
- physical and spatial constraints; and
- environmental and navigational safety considerations.

28 Detail of the design analysis carried out is provided in *Appendix 6A: Design Considerations*.

29 The finalised layout, taking account of the above factors, will conform to the following principles:

- WTGs will either be laid out in a grid, where rows are aligned both down-wind and cross-wind, or in an offset grid where WTGs in the cross-wind rows are offset as illustrated in Figure 7.9 and Figure 7.10 (see below) respectively.
- Either a grid or off-set grid pattern will be used across the Development Area (i.e. both will not be used).
- Cross-wind rows will be aligned perpendicular to the predominant wind direction which is approximately 240°.
- In the down-wind direction the distance between rows may vary to maximise efficiency of energy capture and so the effective spacing may be larger. The grid or offset grid will be subject to micro-siting for each individual WTG of up to +/- 50 m to account for local technical constraints and positioning accuracy. All references to 'alignment' of WTGs should be considered as subject to this practical micro-siting requirement.

Figure 7.9: Illustration of a 'Grid' configuration

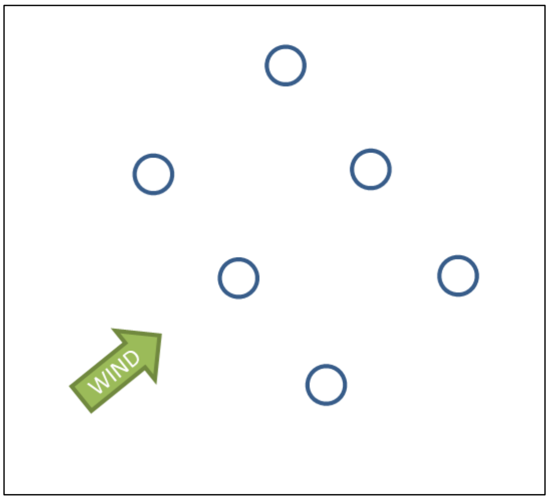
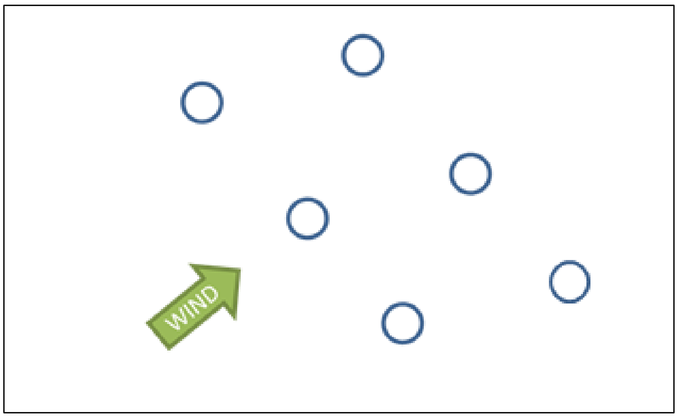


Figure 7.10: Illustration of 'Offset Grid' configuration



30 Where layouts are presented in this EIA Report these comply with the principles above and have been selected to represent the worst case for the particular receptor considered. The layouts shown in these chapters are indicative only and not intended to represent a final design.

7.5.4 WTG Installation and Commissioning

31 There are various methods of installing WTGs which are dependent on a number of factors including; the WTG configuration, manufacturer's specification, substructure type, vessel type and environmental conditions. The following provides an overview of possible methodologies.

- **Individual component installation**: in this case the individual component parts of the WTG (two or three blades, nacelle with hub and a number of tower sections) are delivered from the factory to an onshore facility or directly to the offshore site. Wind turbines are then erected piece by piece offshore using a jack-up vessel (JUV) or floating vessel with heavy lift capability.
- **Onshore sub-assembly**: this is similar to individual component installation; however, some of the components are pre-assembled at the onshore location.
- **Single-lift installation**: the wind turbine is fully assembled onshore and installed in one piece offshore by either a floating vessel or JUV.
- **One-piece installation**: for some foundation and substructure types, it is possible to install the wind turbine onto the substructure at a suitable location and then tow to site, installing both the turbine and substructure in one piece.

32 Following installation, WTGs will be subject to a commissioning and test programme, prior to handover to operation. It is anticipated that the inter-array cables will be installed before WTGs to facilitate early connection and commissioning. In cases where this is not possible temporary diesel generation will be used on each WTG until it is commissioned. The extent of offshore commissioning required will depend on the installation methodology i.e. WTGs that have been pre-assembled onshore will generally require less commissioning offshore.

7.5.5 WTG Operation and Maintenance

33 The WTGs will be operated remotely from an onshore base and use condition monitoring techniques to aid in maintenance planning. O&M is discussed further in *Section 7.11*. Each WTG has a control system to optimise and report on performance. Maintenance activities expected to take place for the WTGs during the operational phase include but are not limited to.

- blade inspection;
- blade repair and replacement;
- routine servicing of nacelle equipment;

- unplanned repair / replacement of nacelle equipment;
- replacement of entire nacelle unit; and
- maintenance of tower and nacelle equipment.

7.5.6 WTG Access

34 The primary means of accessing WTGs will be from vessels. The substructure which supports the WTG will host one or more access systems tailored to certain vessels. The access technique and orientation will be dependent on an assessment of local prevailing wind, wave, tide and current conditions in order to provide safe access and maximise availability. A representative access system is shown in Figure 7.11A and Figure 7.11B in close up.

Figure 7.11A: A representative WTG Access System shown on the substructure (Source: ICOL)

Figure 7.11B: Close up view of the representative WTG Access System (Source : ICOL)

35 If selected as part of operation and maintenance strategy, helicopter access will also be provided by means of a heli-hoist platform at the top of the nacelle. Such platforms are typically four metres by four metres and require specific marking and lighting. This would allow equipment and personnel to be winched to and from WTGs. No helicopter landing facilities are envisaged on any WTGs.

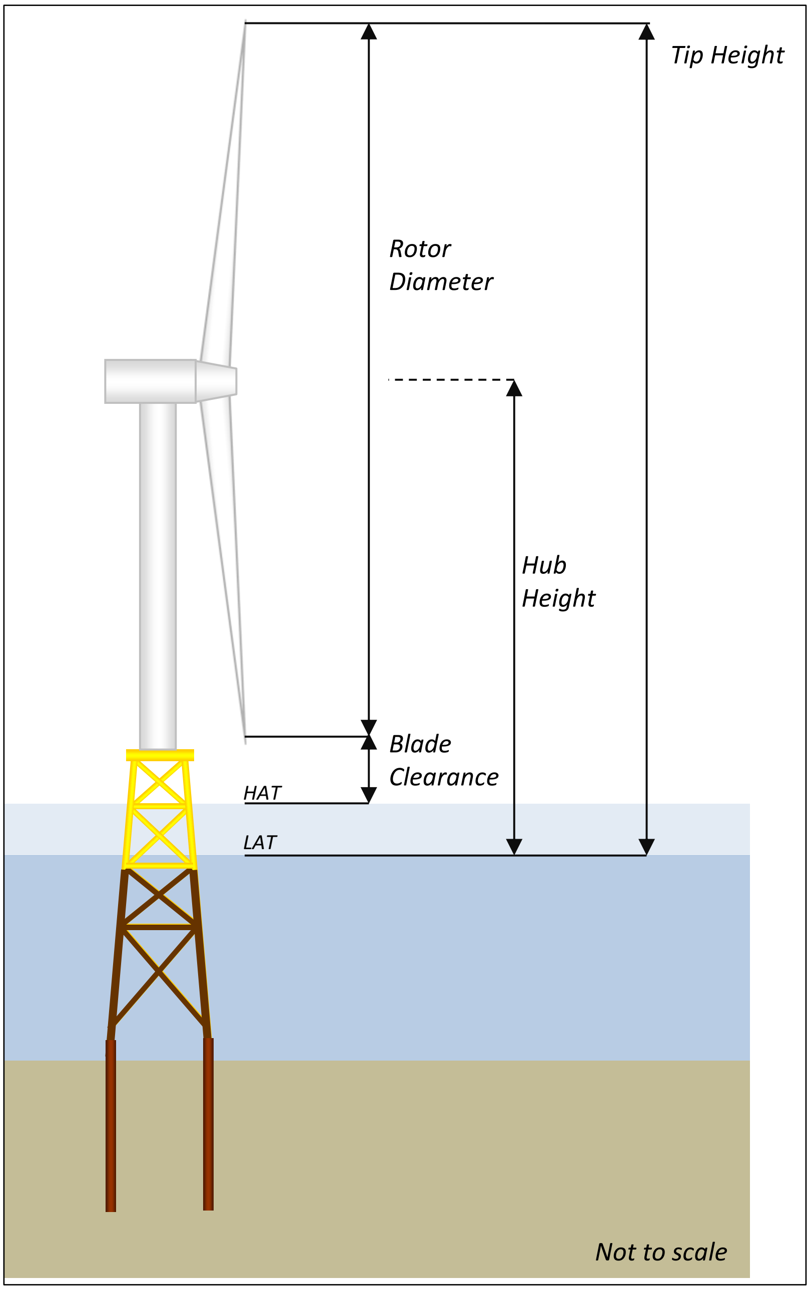
7.5.7 WTG Oils and Fluids

36 All WTGs utilise various lubricants and oils for their operation. The nacelle, tower and rotor are designed and constructed in order to contain leaks thus reducing the risk of spillage into the environment.

7.5.8 Summary of WTG Design Envelope

37 Figure 7.12 below shows an illustrative WTG with definitions of the numeric parameters as stated in Table 7.3 below.

Figure 7.12: Illustration of the design parameter definitions for a WTG (Source: ICOL)



38 The information presented in the Table 7.3 relates to the design options detailed above. The Design Envelope has been used to determine the worst case scenario used in the assessments in each technical chapter. This is consistent with the approach detailed in *Section 4.2.2* of *Chapter 4* of this EIA Report.

39 ICOL proposes to install no more than 72 WTGs.

40 Turbine colouring, lighting, marking, numbering and foghorn requirements will be as per relevant standards and guidance at the time.

Table 7.3: WTG design values

Design Parameter	Value
Number of turbines	Up to 72
Minimum Blade clearance above Highest Astronomical Tide	22 m
Blade tip height (above LAT)	Up to 291 m
Rotor diameter	Up to 250 m
Nominal minimum turbine spacing	1,278 m

7.6 Foundations and Substructures

7.6.1 Foundations and Substructures Description

41 The following section describes the possible foundation and substructure options for WTGs and OSPs.

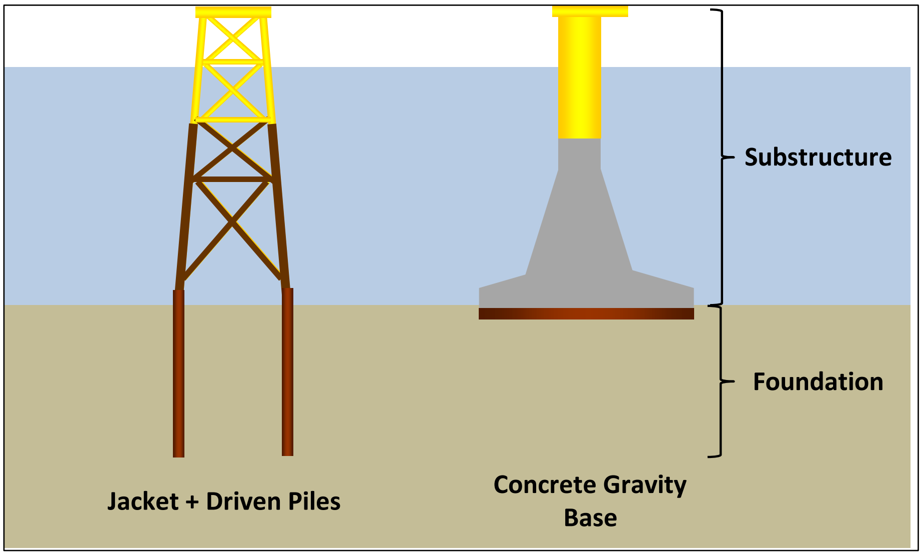
42 The final selection of foundation and substructure type will depend on various technical, environmental and economic factors such as water depths, compatibility with WTG, deliverability, constructability and whole life economics.

43 The following definitions are used throughout this section:

- **Substructure:** the structure which supports the WTG or OSP, fixed to the foundations the majority of which is below the water line (Figure 7.13 below).
- **Foundation:** the arrangement which fixes the substructure to the seabed and is predominantly below the seabed level (Figure 7.13 below).
- **Shadow (m^2):** the total area of seabed under the substructure (Figure 7.19 and Figure 7.20).
- **Footprint (m^2):** the total area of seabed under the substructure which is not exposed.
- **Scour Protection Footprint (m^2):** the area under which protection is placed in order to prevent erosion of the seabed around the foundation. Scour protection material is usually gravel or crushed rocks. Scour protection is explained further in *Section 7.6.6*.
- **Excavated Volume (m^3):** the maximum possible volume of seabed material removed by dredging for seabed preparation.

- **Drilled Volume (m^3):** The volume of material removed if drilling prior to installation of a pile. It has been assumed that the drilled volume equates to the volume of the pile.
- **Dredger Affected Area (m^3):** the area of the seabed that may experience some level of compaction or disturbance due to its proximity to the area requiring seabed preparation.

Figure 7.13: Foundation and substructure definition (Source: ICOL)

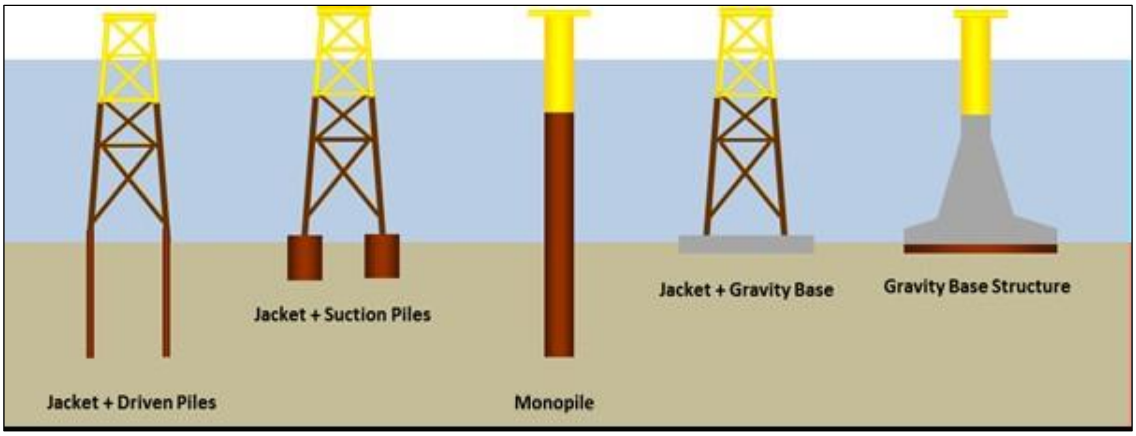


44 Foundations and substructures are subdivided into the following categories which are described in more detail in the relevant sections and can be seen in Figure 7.14 below:

- Steel frame structures: Also known as ‘jackets’, these structures are constructed mainly from steel tubular members similar to a lattice tower, typically with 3 or 4 legs;
- Monopiles: A single large diameter steel tubular pile which is driven (or drilled if soil conditions dictate) into the seabed and may extend to above LAT; and
- Gravity Base Structures (GBS): A mainly concrete and steel reinforced structure which uses the weight of the structure combined with possible internal ballast to maintain position.

45 A hybrid solution also exists that incorporates elements of the gravity base and steel framed options. The dimensions of the hybrid will fall within the envelope created by the four leg jackets and the GBS.

Figure 7.14: Foundation and Substructure Types (Source: ICOL)



7.6.2 Foundations and Substructures Installation Sequence

46 The foundations and substructures will be fabricated at an onshore location and then transported directly to the Development Area either by being towed, using a 'feeder' vessel or using the installation vessel itself.

47 The foundations and substructures can then be installed in various different sequences:

- Foundation and then substructure e.g. driven piles using a template and then jacket, or seabed preparation and then concrete gravity base;
- Substructure and then foundation e.g. jacket and then driven piles.; or
- Foundation and substructure combined: e.g. jacket + gravity base, jacket + suction piles or gravity base.

48 Following installation of the main structures additional items such as scour protection can be installed if required.

49 Where substructures have piled foundations, ICOL assumes there would be a maximum of two concurrent piling activities ongoing at any one time in the Development Area.

50 Some seabed preparation (e.g. boulder clearance and clearance of unexploded ordnance (UXO), in addition to preparation specific to the installation of GBS as described above) may be required prior to the installation of substructures and foundations.

7.6.3 Steel Foundations and Substructures

51 There are various steel substructures under consideration for the Development including a four-legged jacket and a single large pile.

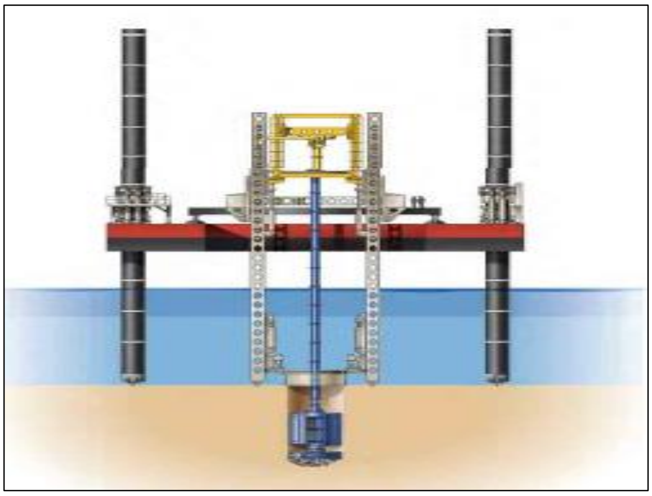
52 Steel substructures can be fixed to the seabed using different types of foundations (Figure 7.13 and Figure 7.14). The suitability of each of these types for use on the Development will be subject to local soil conditions and will require further analysis to be undertaken prior to construction. Other considerations such as cost and equipment availability may also affect

the selection of foundation type. Each type can typically be deployed from either floating or jack-up vessels.

53 Foundation types and installation methods are introduced and illustrated below:

- **Drilled Piles:** 'sockets' are drilled into the seabed and then the piles are inserted and grouted in place. In some cases, the pile itself can be used as the drilling too. Drill cuttings will either be returned down the pile or to the seabed locally at the pile. This may be directly or via a vessel depending on the technique employed. An illustration of a typical pile drilling operation is shown in Figure 7.15 below.

Figure 7.15: Illustration of pile drilling (Source: Fugro)



- **Driven Piles:** piles are driven into the seabed by striking them with a hydraulic hammer. Drilling may be used in the event of a pile becoming stuck due to hard soil conditions and then the pile would be driven again until final penetration is reached. A typical pile driving operation is shown in Figure 7.16.

Figure 7.16: A typical pile driving operation (Source: VSF)

- **Suction Piles:** pumps are attached to large 'can'-like piles and the water is pumped out of them. This reduces internal pressure and the combination of external water pressure and self-weight pushes the pile into the seabed. Suction Piles are only suitable in certain specific soil conditions and within the Development Area there may only be discrete areas suitable for this technique. An example of a structure with suction piles is shown in Figure 7.17.

Figure 7.17: An oil and gas platform with suction piles (Source: Ithaca)

- **Hybrid Gravity Base:** a steel framed structure could be supported by a gravity base foundation which would fix the structure to the seabed by weight alone or also using a similar effect to a suction pile in combination. An illustration of a hybrid jacket and GBS is shown in Figure 7.18 below.

Figure 7.18: An illustration of a hybrid jacket and GBS (Source: ICOL)

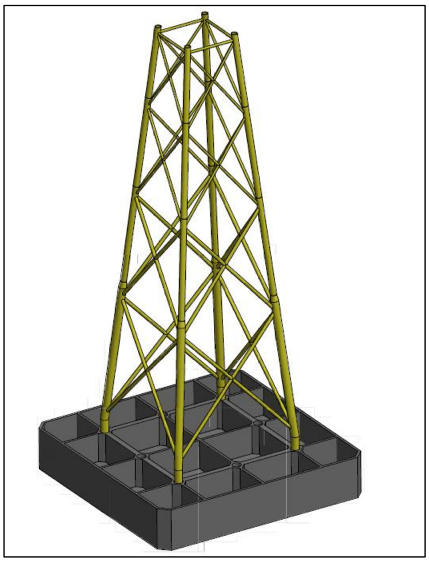
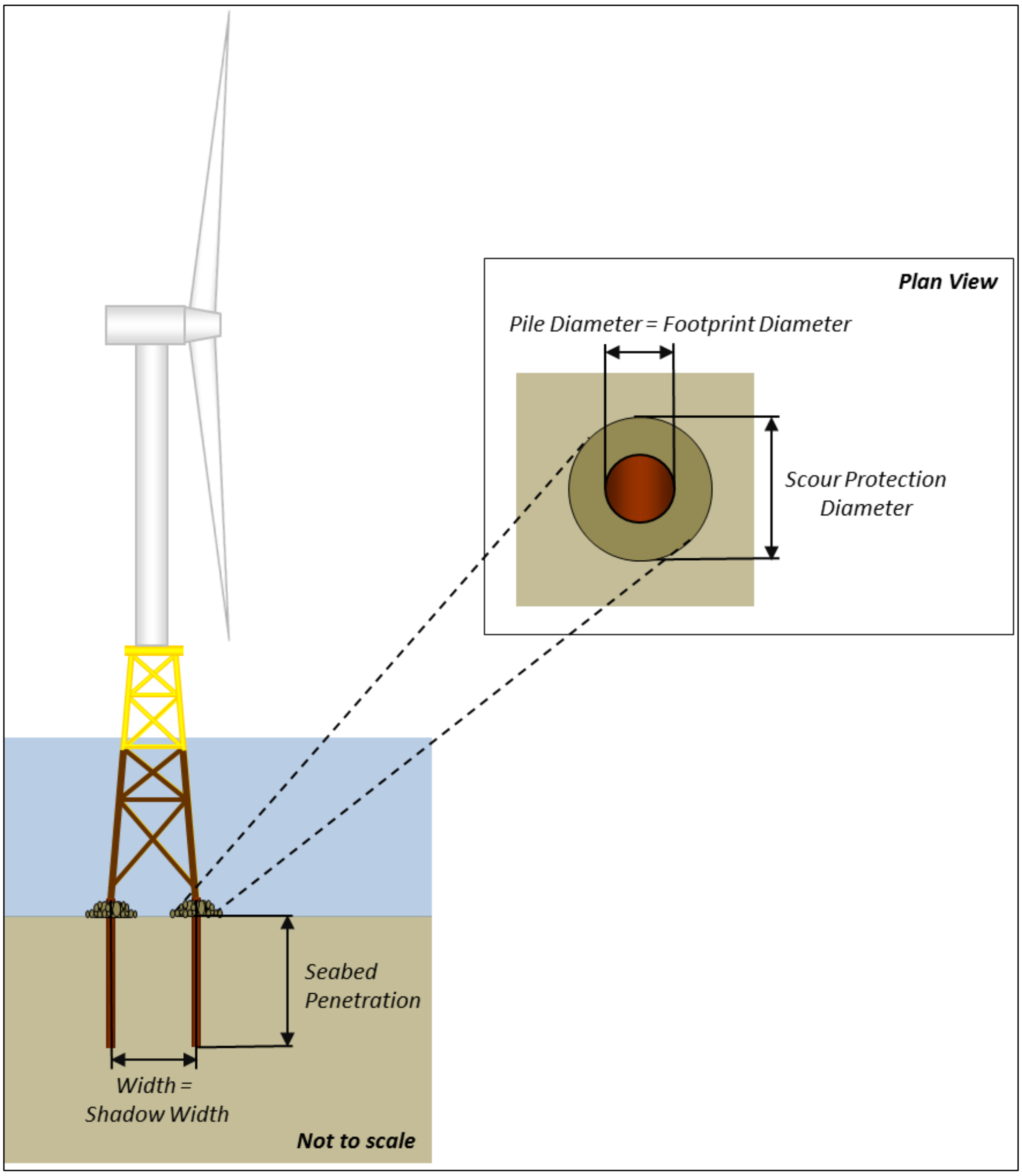


Figure 7.19: Illustration of the design parameter definitions for steel foundations and substructures (Source: ICOL)



7.6.4 Piling

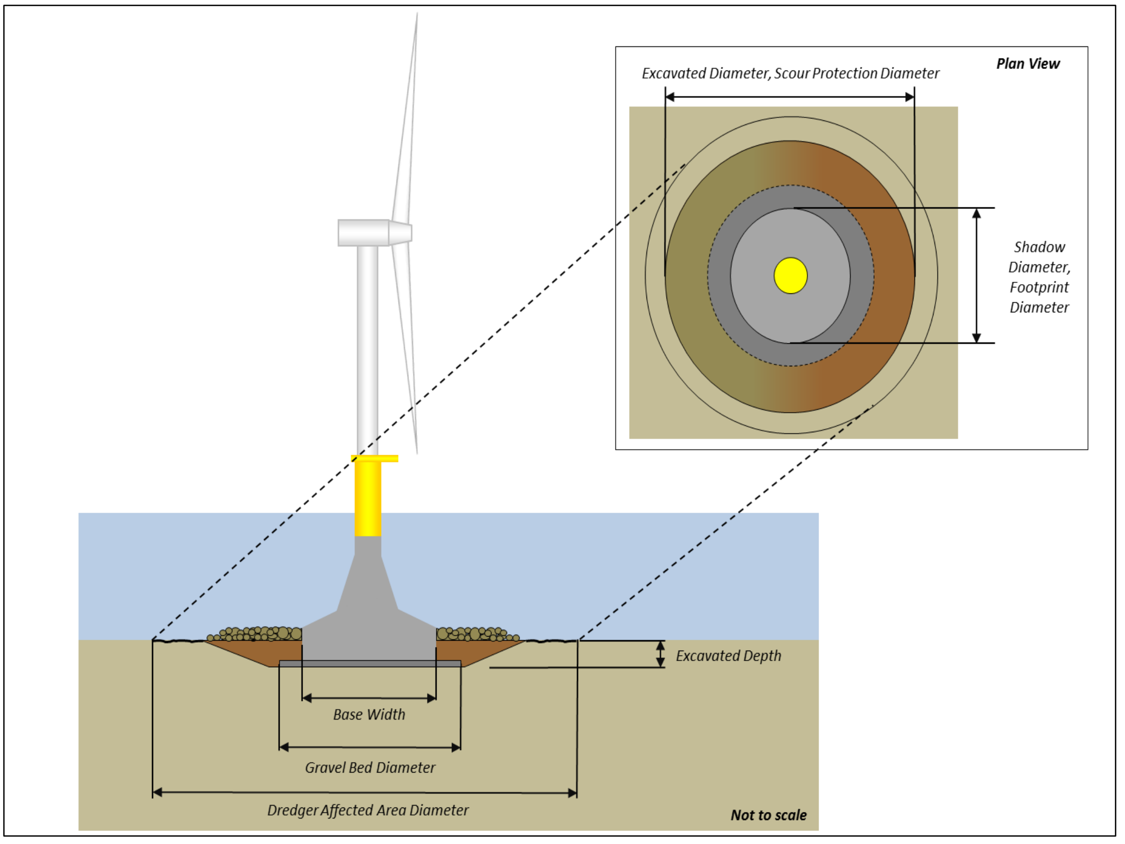
54 A maximum of two concurrent piling activities are considered for the Development. In accordance with *Section 7.10* an indicative programme is that this may take place over an estimated 9 months over a one-year period, with actual piling duration covering approximately 30 per cent of the working time.

7.6.5 Gravity Base Structures (GBS)

55 There are various configurations of GBS under consideration for the Development. A conical based substructure has been used for the purposes of identifying the worst case for assessments since this generally results in the largest footprint, volume and cross sectional area (see Figure 7.20).

56 The final design of a GBS will depend on further analysis of seabed conditions at specific locations within the Development Area. Seabed preparation (excavation, placement of gravel and backfill using a dredging vessel) is often required. Depending on soil conditions, this requirement may be reduced or eliminated by the use of a perimeter 'skirts' which penetrate the seabed and provide greater stability.

Figure 7.20: Illustration of the design parameter definitions for GBS (Source: ICOL)



57 Once the GBS is placed on the seabed, ballast is generally required using dense gravel or sand to weigh the structure down to the seabed.

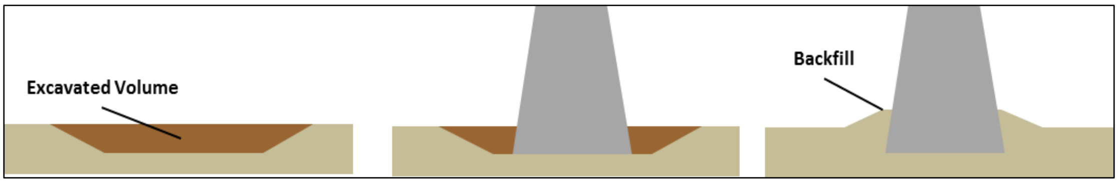
58 In the event that seabed preparation is required, the following options are possible for the excavated volume of seabed material. The following options could be used individually or in combination depending on ground condition and construction techniques and are listed below in order of preference:

- Use as backfill material around WTG foundations.
- Deposit within the foundation/substructure as ballast.
- Re-use of material for other unrelated activities.
- Deposit to the seabed at an off-site offshore licensed location.

59 In the event that the material is used as backfill or ballast, it has been assumed that this material can be deposited by a controlled fall pipe arrangement. The excavated material will

be retained within the Development Area close to the foundation location. The excavated material may be used as backfill following installation of the foundation where practicable. A significant amount of material may be used for ballast. This is illustrated in Figure 7.21.

Figure 7.21: Illustration of a potential backfill methodology (Source: ICOL)



7.6.6 Scour Protection

60 When new elements are introduced to the seabed there will be a resultant change in water flows in close vicinity to the new structure. This can lead to localised seabed particle displacement and associated erosion around the structure, known as scour. The extent of the scour is dependent upon the type of sediment encountered, the size of the structure or obstruction and the wave and current velocities. A level of structure exposure due to scour erosion can be allowed for in design, however, there are instances where this is not sufficient and preventative measures against scour are required. Scour protection is generally material which cannot be moved by the momentum of increased flow around the structure e.g. suitably sized gravel and rock. Concrete mattresses or similar techniques can also be used.

61 The amount of scour protection required for each type of structure has been estimated with the currently available information and is presented in Table 7.4 and Table 7.5 below. This will continue to be refined as the Development design progresses.

7.6.7 Operation and Maintenance

62 Maintenance activities expected to take place on the WTG substructures and foundations during the operational phase include but are not limited to;

- structural inspection of the substructure;
- local seabed scour inspection;
- reinstatement of scour protection if required;
- maintenance painting above the waterline; and
- maintenance of the boat landing system.

7.6.8 Summary of Foundation and Substructure Design Envelope

63 The information presented in Table 7.4 and Table 7.5 relate to the design options detailed above. The Design Envelope has been used to determine the worst case scenario used in the assessments in each technical chapter. This is consistent with the approach detailed in *Section 4.2.2* of *Chapter 4*.

Table 7.4: Design Envelope parameters (WTG jacket substructure and pile foundations including monopiles)

Design Parameter	Value (Maximum or Range)
Drilling/Piling Events (WTGs)	288*
Number of Sides	4
Jacket Top Width (m)	30**
Jacket Base Width (m)	60
Maximum Seabed Penetration (m)	70
Maximum energy capacity of hammer	5000kJ***
Aggregate Pile Diameter (m) (eg 4 piles of 3m diameter)	12
Shadow (m^2) - Total seabed area under each substructure including those exposed	3,600
Footprint (m^2)- Total seabed area under each substructure which is not exposed	113****
Footprint Including Scour Protection (m^2) for each substructure	804

* Based on four piles for each of the WTGs.

** includes allowance for boat landings and laydown area.

***The maximum energy capacity for piled jackets will be around 2400kJ

**** Aggregate area under four piles of 3m diameter is 28 m^2 and under a single pile of 12m diameter 113 m^2.

Table 7.5: Design Envelope parameters (WTG GBSs)

Design Parameter (for each structure)	Value (Maximum or Range)
Top Width (m)	30*
Base Diameter (m)	90
Excavated Diameter (m)	125
Scour Protection Diameter (m)	125
Dredger Affected Diameter (m)	140
Excavated Depth (m)	0 - 5**
Shadow (m^2) - Total seabed area under each substructure including those exposed	6,361
Footprint (m^2)- Total seabed area under each substructure which is not exposed	6,361
Footprint including Scour Protection (m^2) for each substructure	12,272
Dredger Affected Area Footprint (m^2) (includes scour protection and footprint)	15,400
Maximum Excavated Volume per unit (m^3)	60,000***
Gravel Bed/Grout Diameter (m)	100
Gravel Bed/Grout Depth (m)	2.5

* Includes allowance for boat landings and laydown area.

** Depths of excavation may be greater than five metres if the sediment conditions dictate.

*** It is expected that the majority of foundation locations will not require this level of excavation and the extrapolated figure for the entire site will not equate to the maximum volume times the number of WTGs.

7.7 Offshore Substation Platforms (OSPs)

7.7.1 Introduction

64 This section provides a description of the OSPs.

65 The Alternating Current (AC) OSPs collect the power generated by the WTGs and transform it to a higher voltage level to allow it to be transmitted to shore via Offshore Export Cables.

66 The final design and number of OSP(s) required will be dependent on a number of factors, particularly the WTG power rating, number and layout. Initial design work suggests that up to two OSPs may be needed.

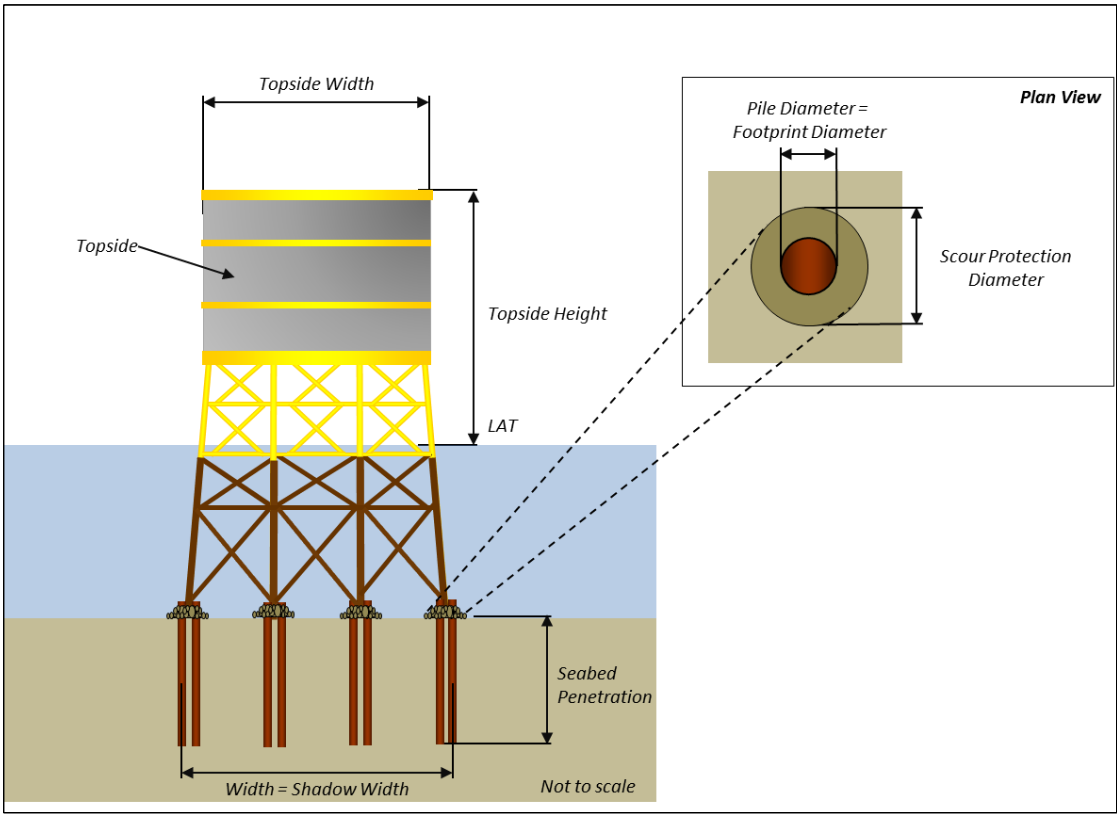
67 All OSPs will be located within the Development Area. The optimal layout of OSPs will be determined by the WTG and associated electrical distribution layout and transmission cable routing. The layout will also be subject to a technical and environmental constraints analysis considering factors such as water depth and seabed conditions, among others. A full investigation of seabed conditions will be carried out concerning potential locations prior to construction.

68 Further details and dimensions of the OSPs are provided in the summary of the Design Envelope specifications included in *Section 7.7.7*.

7.7.2 OSP Specification and Design

69 The OSP is generally a 'box-like' structure, often referred to as a 'topside', which is set above the sea level on a substructure fixed to the seabed by a foundation. The foundation and substructure options for OSPs are the same as the options outlined in *Section 7.6* although they may be larger than those considered for WTGs. A representative OSP is shown in Figure 7.22.

Figure 7.22: Illustration of the design parameter definitions for an OSP (Source: ICOL)



70 It is likely that each OSP topside will contain some or all of the following:

- Health and safety equipment;
- Electrical and control systems including switch gear, transformers, cable and associated plant;
- Communication equipment;
- Workshop for small repairs;
- Emergency accommodation and welfare facilities;
- Heli-hoist platform
- Crane(s); and
- Small power generation.

7.7.3 OSP Installation and Commissioning

71 The OSP topsides will be fabricated at an onshore location and then transported to the Development Area for installation on top of the substructure. The topsides would either be transported to site via barge and then installed with a Heavy Lift Vessel (HLV) or Jack Up Vessel (JUV), or taken directly to their location and installed using a HLV or JUV. For larger OSP topsides a 'float over' concept may be used where the topside is lowered onto the substructure rather than lifted on.

72 There is also the possibility of using self-installing OSPs to avoid the requirement of a HLV. Self-installing platforms use a similar principal to JUV's described in *Section 7.10.2* to elevate the topsides above the water and would use foundation and substructure types discussed in *Section 7.6.3* and *Section 7.6.5*.

73 Following installation, OSPs will go through a commissioning and test programme.

7.7.4 OSP Access

74 OSPs will have access facilities for maintenance visits via vessel and helicopter, similar to those identified for WTGs in *Section 7.5*. A heli-hoist platform would be used for helicopter access.

7.7.5 OSP Operation and Maintenance

75 The anticipated maintenance activities to be carried out on the OSP substructure and foundations during the operational phase are as listed in *Section 7.6.7*.

7.7.6 OSP Oils and Fluids

76 Any equipment on the OSP which contains any significant quantities of oil and lubricants, e.g. diesel generators and transformers will be contained within an open steel bund which would be capable of holding 110 per cent of the volume of the largest tank. Diesel transfer will be in double skinned tanks and will be stored in bunded areas. Any contaminated drainage would be collected within the integral drainage system which would incorporate a sump and separator prior to discharge overboard. An oil sensor would control the discharge valve and close if oil was detected in order to prevent the discharge of contaminated water.

77 Switchgear insulation will either be Gas Insulated Switchgear using Sulfur Hexafluroide (SF6) as the insulating medium or Air Insulated Switchgear. The transformer coolant system would use a liquid coolant with natural or forced air convection system.

78 OSPs will not normally be manned; accommodation would be only used in exceptional conditions such as emergencies or sudden adverse weather. Waste would be collected, recovered and disposed of onshore or collected, macerated and discharged to the sea. The latter option would reduce site operational requirements and maintenance visits.

7.7.7 Summary of OSP Design Envelope

79 The information presented in Table 7.6 and Table 7.7 relate to the design options detailed above. The Design Envelope has been used to determine the worst-case scenario used in the assessments in each technical chapter. This is consistent with the approach detailed in *Section 4.2.2*.

Table 7.6: OSP Steel substructure design values

Design Parameter	Value (Maximum or Range)
Number of OSPs	Up to 2
Topside Height above LAT (m)	70
Topside Width and Length (m)	100*
Drilling/Piling Events	16**
Aggregate Pile Diameter (m) (eg 8 piles of 3m diameter or 2 piles of 12 m)	24
Jacket Top Width and Length (m)	100
Jacket Base Width and Length (m)	100
Seabed penetration (m)	60
Scour Protection Diameter (m)/pile	16
Shadow (m^2) - Total seabed area under each substructure including those exposed	10,000
Footprint (m^2) - Maximum seabed area under each substructure which is not exposed.	500 ***
Footprint including Scour protection at each substructure (m^2)	3,200
Drilled Volume at each Substructure (m^3)	6,785

* Includes allowance for boat landings and laydown area.

** Based on maximum 8 piles per each of the two OSPs.

*** This is based on four 10 m x 12 m mud-mats to support the steel framed jacket structure before piling.

Table 7.7: OSP GBSs design values

Design Parameter	Value (Maximum or Range)
Top Width (m)	100
Base Diameter (m)	130
Excavated Diameter (m)	260
Scour Protection Diameter (m)	180
Dredger Affected Diameter (m)	300
Excavated Depth (m)	0 – 5**
Shadow (m2) - Total seabed area under each substructure including those exposed	13,273
Footprint (m2)- Total seabed area under each substructure which is not exposed	13,273
Footprint including Scour Protection Footprint (m2)	25,447
Dredger Affected Area Footprint (m2) (includes scour protection and footprint)	70,686
Maximum Excavated Volume per unit (m3)	114,012***

* All stated quantities are per each GBS

** In isolated occasions depths of excavation may be greater than five metres if the sediment conditions dictate. For assessment these should be considered in a qualitative sense only due to the low frequency of their occurrence.

*** It is expected that they majority of foundations locations will not require this level of excavation and the extrapolated figure for the entire Development Area will not equate to the maximum volume times the number of OSPs.

7.8 Inter-array Cables

7.8.1 Introduction

80 A network of subsea cabling will be used to connect WTGs and OSPs together and carry the power generated to the OSP(s) at a voltage of less than 132 kilovolt (kV). The cables will include three-core copper or aluminium electrical conductors, fibre optic communications cables, insulation and armouring.

81 The final layout and configuration of cabling will depend on a number of factors including WTG type, number and physical layout, but will be optimised to minimise costs and electrical losses. The cables will be configured in loops or branches and it is anticipated that there will be up to 190 km total length of inter-array cabling.

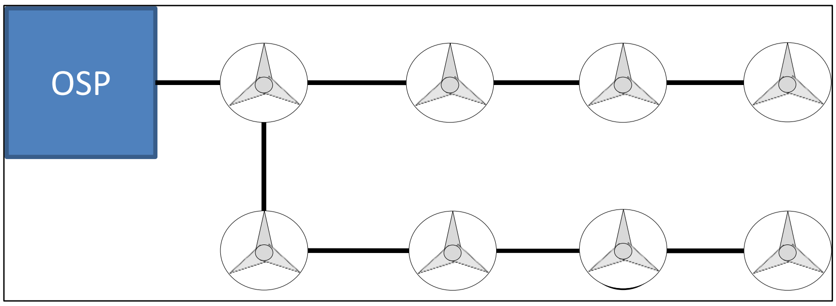
7.8.2 Specification and Design

82 The cable type to be utilised is likely to be a solid polymeric or rubber insulation, three core, offshore grade cable with either aluminium or copper cores. The cores will be contained in cable bundles and will not be separately trenched.

83 The cables can be configured in either of the following arrangements:

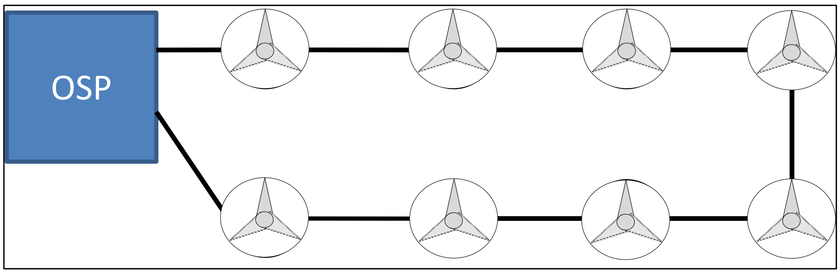
- **Branches:** This is where the first or second WTG has three cables into the base, allowing a single cable into the platform but two strings out from the first WTG, normally in a U shape. An illustration of a branch arrangement is given in Figure 7.23 below.

Figure 7.23: An illustration of a Branch Inter-array Cable configuration (Source: ICOL)



- **Loops:** This is where WTGs are arranged in strings, each pair of strings is connected at the far end by a cable. This is to provide a route for export of limited power in the event of a cable fault and for backup supply to WTGs. An illustration of a loop arrangement is given in Figure 7.24 below.

Figure 7.24: An illustration of a Loop Inter-array Cable configuration (Source: ICOL)



84 If more than one OSP is installed, they may be interconnected by cabling. The maximum voltage for inter-platform cabling will not exceed the maximum AC export cabling voltage of 275 kV. The extent of the possible cabling between OSPs has not yet been determined but the total cabling length within the Development Area will not exceed the amount stated for the inter-array cabling of 190 km. This would be confirmed on definition of final layout and electrical design configuration.

7.8.3 Installation

85 The target burial depth will be determined by way of a cable burial risk assessment. An index will be produced that assesses the level of protection from specific risks offered by the relevant burial depth. Therefore, burial depth may vary and will be dependent on risks and ground conditions. At this stage it is anticipated that the target burial depth for the array cables will be approximately one metre (as is typical for offshore hydrocarbon pipelines and umbilicals). The actual design depth of burial is based on a number of factors, including potential environmental effects, fishing and other activities, dropped object risk assessments and other considerations.

86 The target burial depth may not always be feasible due to the nature of the seabed. In instances where adequate burial cannot be achieved, alternative protection will be deployed.

87 There are various techniques in which the cable can be installed:

- **Lay then burial:** The cable is laid on the seabed or in a pre-cut trench and then buried in separate installation activities, sometimes using different vessels; or
- **Simultaneous lay and burial:** The cable is laid and buried simultaneously.

88 Cables may be ploughed or jetted into the seabed or laid into a pre-cut trench which is then backfilled. The following are typical tools:

- **Boulder clearance plough**: clears boulders from the cable route to enable other excavation and burial tools to be used;
- **Trenching plough**: can be used either to pre-trench (the cable is then installed into the pre-cut trench) or post trench (trenching then carried out following cable lay onto the

seabed.) In both cases a separate backfill plough is used to push the spoil heaps created by trenching over the cable thus creating the required cable cover;

- **Cable burial ploughs**: buries the cable by lifting a wedge of soil, placing the cable at the base of the trench and allowing the soil to naturally backfill behind the plough. Subsequent passes may be required with a backfill skid to move trenched material on top of the cable for full protection. Ploughs are generally towed by surface vessels;
- **Jetting Trenchers**: buries the laid cable by directing water jets towards the seabed and cutting and/or liquidising the soil beneath the cable. Displaced material is suspended in the water and then resettles over the cable which settles into the soil slurry created by the water jets through self-weight. This process is controlled to ensure that sediment is not displaced too far from the cable. Jetting trenchers are commonly self-propelled or mounted as skids onto Remotely Operated Vehicles (ROV); and
- **Mechanical Cutters:** Mechanical cutters can be fitted to tracked cable burial vehicles and are used to cut narrow trenches into hard or rocky seabed. The mechanical cutter consists of a rotating disc or chain fitted with a number of replaceable teeth.

89 Some seabed preparation (e.g. boulder clearance and clearance of UXO and other seabed obstructions) may be required prior to the installation of subsea cabling.

7.8.4 Cable Protection

90 It is anticipated that inter-array cables will be buried to a typical depth of circa one m below the original seabed level.

91 Where cables cannot be buried due to seabed conditions or other constraints, they will be protected using one of, or a combination of, the following techniques:

- **Rock Placement:** After the cable has been laid it can be provided with protection in the form of a crushed rock covering. The crushed rock can either be installed through a fall-pipe from a rock placement vessel or directly placed with a grab device that lowers the rock to the seabed. A typical rock fall pipe vessel is shown in Figure 7.25.

Figure 7.25: A typical rock placement vessel (Source: Boskalis)

- **Mattresses:** consist of small concrete blocks connected together with polypropylene rope. The mattresses are lowered over the laid cable by a vessel crane. The rope between the blocks allows the mattresses to drape over the cable. The weight of the mattress keeps the cable stable on the seabed and the concrete blocks protect the cable from damage. A typical concrete mattress is shown in Figure 7.26 below.

Figure 7.26: Concrete mattress laid over a test pipe (Source: SPS)

- **Sand/ grout Bag Placement:** Sand/ grout bags can be regarded as a smaller scale version of mattresses. The bags can either be pre-filled or empty bags are taken to the seabed and then a diver coordinates the filling of the bags from a pumping spread located on the vessel. A typical grout bag is shown in Figure 7.27 below.

Figure 7.27: Sand-grout bag laid over a test pipe (Source: BERR)

- **Uraduct/ Metal Shells:** are polymer or metal shells which may be used in areas close to structures. It is not likely that this protection technique will be used on longer exposed lengths of cable.

7.8.5 Operation and Maintenance

92 Maintenance activities expected to take place on the inter-array cables during the operational phase include but are not limited to;

- cable repair by recovering the cable from it's trench, splicing in a new section and placing in watertight tubular steel housing then reburying or protecting the repair section;
- cable route inspection;
- reburial of sections of cable identified as in need of lowering; and
- placement of concrete mattresses or rock placement over sections of the cable identified as in need of protection.

7.8.6 Summary of Inter-Array Cable Design Envelope

93 The information presented in Table 7.8 relates to the design options detailed above. The Design Envelope has been used to determine the worst-case scenario used in the assessments in each technical chapter. This is consistent with the approach detailed in *Section 4.2.2*.

Table 7.8: Inter-array cabling design values

Parameter	Value (Maximum or Range)
Voltage (kV)	<132
Cable length (km)	190
Cable burial (% of cables buried)	90 - 100
Trench Affected Width per cable (m)	12-15*
Trench Depth (m)	Typically 1.2 m, but up to 3 m**

* The area of the seabed that may experience some level of compaction or disturbance due to the footprint of the cable trenching equipment. Exceptionally, where trench depth is much deeper (e.g. 3 m) to minimise snagging risk, the affected width may be up to 40 m.

** The exact trench depth will be based on a risk assessment based on seabed conditions and may vary.

7.9 Export Cable

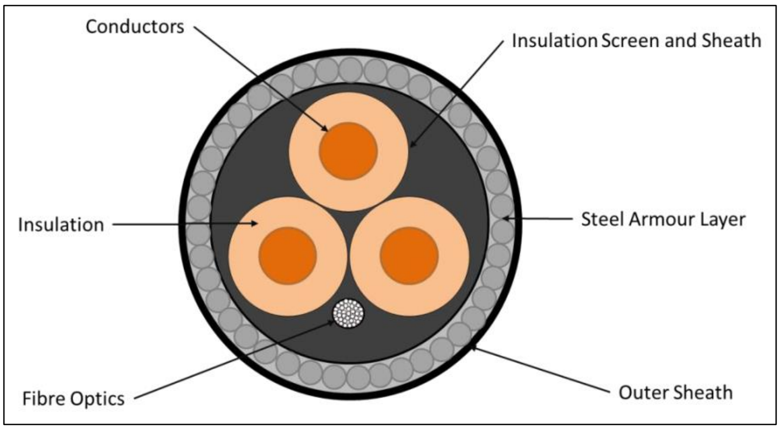
7.9.1 Introduction

94 Export cables will consist of up to two AC cables which will run from the OSPs to landfall.

7.9.2 Design and Specification

95 The type of cables used will depend on the final engineering design, technical specification and supplier. A typical cable cross sectional cable configuration is shown in Figure 7.28 below.

Figure 7.28: Illustration of a typical cable cross section (Source: ICOL)



96 A typical high voltage alternating current (HVAC) cable will be around 250 mm in diameter and will comprise of three copper or aluminium conductor cores with polymer insulation and a fibre optic cable bundle. The cable will be insulated, sheathed and armoured.

7.9.3 Installation

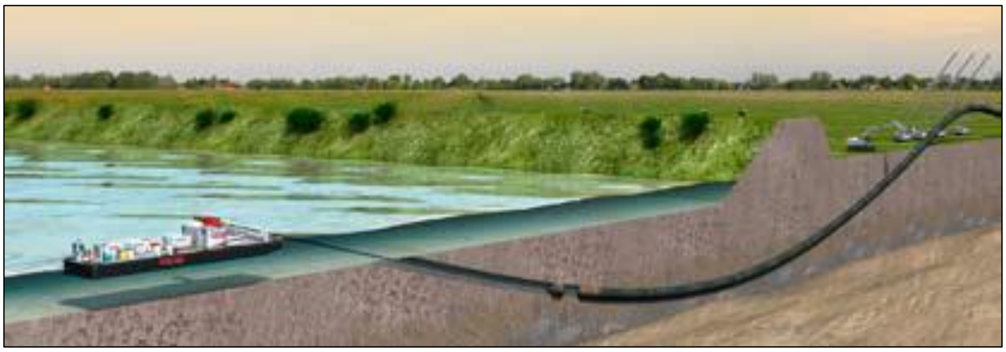
97 Each of the export cables will be laid in separate trenches through the sub and intertidal areas. Due to technical and practical constraints around access to cables and local conditions cable separation is generally four times the water depth with a minimum separation of 50 m.

98 The target burial depth will be determined by way of a cable burial risk assessment. An index will be produced that assesses the level of protection from specific risks offered by the relevant burial depth. Therefore, burial depth may vary and will be dependent on risks and ground conditions. At this stage it is anticipated that the target burial depth for the export cables will be approximately one to three metres. The actual design depth of burial is based on a number of factors, including potential environmental effects, fishing and other activities, dropped object risk assessments and other considerations.

99 In addition to the installation options for the inter-array cables detailed in *Section 7.8.3* the following additional installation methods may potentially be utilised for the export cable at landfall:

- **Horizontal Directional Drilling (HDD):** This involves drilling a hole from the landward side of the landfall to a point below low tide where marine equipment can operate. The cable is installed through a pipe which is drilled under the landing location. A small diameter pilot hole is initially drilled under directional control to a predetermined path and then the hole is widened. The diameter of the hole is sized to take a conduit through which the cable(s) are pulled. The cable can then be installed by pulling through the pipe. A typical HDD operation is illustrated in Figure 7.29 below.

Figure 7.29: Illustration of a typical HDD operation (Source: NACAP)



- **Open Cut Trenching**: consists of excavating a trench across the landfall location and below low tide level to a point where marine vessels and equipment can operate and continue trenching. Construction of a temporary causeway across the landfall and through the low tide level may be required to provide a base for excavation equipment to dig a trench alongside the causeway. On the beach or in shallow water a back–hoe dredger may be used. In deeper water specialist dredging/trenching equipment could be used. From the cable lay vessel, the export cable is brought to the landfall by a combination of floating and pulling ashore from the cable pit.

100 The suitability of any cable trenching method is dependent on water depth. Table 7.9 below summarises the burial methods relevant to the Offshore Export Cable Corridor.

Table 7.9: Burial methods

	Landfall	Sub-tidal Areas
Burial Ploughs	Yes	Yes
Jetting Trenchers	Yes	Yes
Mechanical Cutters	Yes	Yes
Open Trenching	Yes	No
HDD	Yes	No

101 Each cable laying operation is expected to be carried out continuously subject to requirements for set up and movement of vessels and cable splicing operations if required. A typical cable lay rate is 300 m/hr to 500 m/hr. In difficult operational or geotechnical conditions progress may be slower.

102 If a cable has to cross existing infrastructure, such as other cables or pipelines, special arrangements will be required. For example: a layer of concrete mattresses or grout bags may be fitted over the top of the existing cable/pipeline. The new cable/pipeline would be run over this protective layer and then itself protected with a further layer of mattresses or grout bags. The methodology for crossing arrangements will be developed in agreement with third party cable/pipeline owner/operators where relevant.

103 It may be the case that the installation vessel cannot accommodate the complete export cable route length, therefore each export cable would be installed as two or more separate sections which will require to be spliced together on the installation vessel to make them electrically continuous. Typically, the primary protection of the spliced connection is a watertight tubular steel housing approximately 0.8m in diameter and 6.0m long. The cable overlength resulting from the splicing operation is accommodated by offsetting the spliced connection on the seabed relative to the nominal cable route. The offset is typically equivalent to the prevailing water depth. The spliced connection is trenched and buried (and protected if necessary) to the same specification as the rest of the export cable.

104 The export cables will typically be laid starting at the landfall and finishing at the offshore site, with each cable being installed separately. It is likely that cable laying will progress sequentially subject to cable delivery times and other operational constraints such as weather. Depending on the final design of the electrical infrastructure the installation of cables may also be phased to match the installation of other electrical equipment.

7.9.4 Operation and Maintenance

105 The anticipated maintenance activities to be carried out on the export cables during the operational phase are as listed in *Section 7.8.5*.

7.9.5 Cable Protection

106 Where possible ICOL intends to bury the export cables, in separate trenches, typically to circa one to three metres below the seabed. Where cables cannot be buried due to seabed conditions or other constraints, they will be mechanically protected as per the inter-array cables. Due to technical and practical constraints around access to cables and local conditions cable separation is generally four times the water depth with a minimum separation of 50 m.

107 The protection options for the Offshore Export Cable are similar to those discussed in *Section 7.8.4*. The information presented in Table 7.10 relates to the design options detailed above. The Design Envelope has been used to determine the worst case scenario used in the assessments in each technical chapter. This is consistent with the approach detailed in *Section 4.2.2*.

Table 7.10: Export cabling design values

Parameter	Value (Maximum or Range)
Voltage (kV)	Up to 275 (AC option)
Cable length (km)	83.3
Cable burial (% of cables buried)	80 - 100
Cable Lay rates (m/hr)	300 - 500
Number of Cables/Trenches	2
Trench Affected Width per cable (m)	12-15*
Trench Depth (m)	Typically 1.2 m, up to 3**

* The area of the seabed that may experience some level of compaction or disturbance due to the footprint of the cable laying equipment. Exceptionally, where trench depth is much deeper (e.g. three metres) to minimise snagging risk, the affected width may be up to 40 m.

** The exact trench depth will be based on a risk assessment based on seabed conditions and may vary.

7.10 Construction Programme

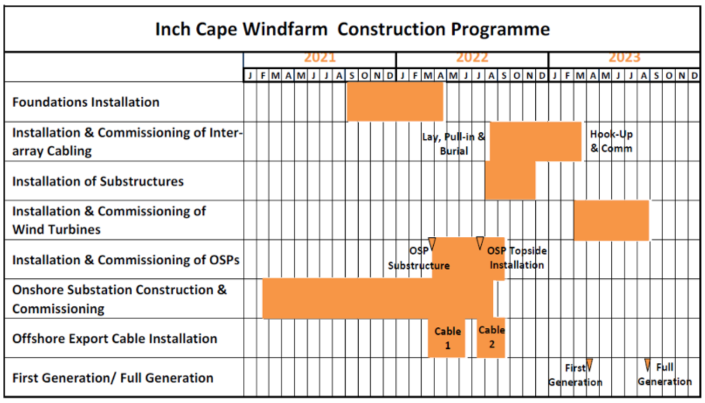
7.10.1 Current Schedule

108 A detailed construction programme will be developed as design and procurement activities progress. Pre-construction surveys are likely to be carried out 6 months in advance of construction. The construction activities are expected to start around 2021 and work will take approximately 24 months over a three year period. Activities may not be continuous and the sequence of activities may change. Engineering and procurement activities will precede the construction phase. The main construction activities and their anticipated durations are outlined in Table 7.11 below. An illustrative activity bar chart is shown in Table 7.12 below.

Table 7.11: Main construction activities and anticipated durations

Main Construction Activity	Anticipated Duration
Foundation installation and associated site preparation	9 months
Inter-array cable installation	1 year
Installation of substructures	6 to 9 months
Installation and commissioning of wind turbines	6 to 9 months
Installation and commissioning of OSPs	6 months
Export cable installation (excluding intertidal)	9 months
Intertidal cable installation	6 months

Table 7.12: Illustrative construction programme*



*Please note the following: All durations shown as windows for illustration; Activities will not be continuous during these windows; Overall durations may increase or decrease and the sequence may change; Start and finish dates may change.

109 The nature of offshore work requires operations to be planned on a 24 hour, seven days a week basis; however work will not be continuous over the whole construction programme. All of the above durations are subject to change which may arise, for example, from weather, site conditions, equipment lead times and supply programmes, sequential work requirements, and logistical issues.

110 An overview of the logistics associated with construction is provided below in *Section 7.10.2*.

7.10.2 Construction Logistics

<u>**Vessel Types**</u>

111 The construction of the Wind Farm will use a variety of vessels and there are different vessel options for each task. The following provides an overview of the type of vessels which may be used:

- **Self-propelled Jackup Vessels (JUV):** the water depths in the Development Area are deeper than the working capacity of most existing jack-up vessels. Use of a jack-up installation vessel will therefore require vessels with a wider operating range to be available. These would generally be self-propelled and able to install a combination of WTGs, foundations and substructures and potentially OSPs. Jack-ups would transit to the location required and then elevate themselves on extendable legs to achieve a stable platform. An example of a jack-up vessel is shown in Figure 7.30 below.

Figure 7.30: A typical JUV (Source: Swire Blue Ocean)

- **Floating Heavy Lift Vessels (HLV):** self-propelled floating HLVs conduct tasks using dynamic positioning (a control system which governs the vessels propulsions systems to keep position). In some cases, mooring may also be required. HLVs can be used for a variety of tasks including installing WTGs, foundations and substructures and OSPs. An example of a floating HLV is shown in Figure 7.31 below.

Figure 7.31: A typical HLV (Source: SHL)

- **Construction Support Vessels (CSV):** are similar to HLVs but much smaller and can conduct tasks such as piling and general subsea construction support work. An example of a CSV is shown in Figure 7.32 below.

Figure 7.32: A typical CSV (Source: SS7)

- **Cable Installation Vessels (CIV):** inter-array and export cables will be installed using floating cable installation vessels. These are usually self-propelled but may be towed or assisted. These vessels use a cable 'reel' or 'carousel' which feed a subsea installation tool, such as a cable plough. They are likely to be slightly larger than a CSV with cable installation equipment on deck Figure 7.33 below.

Figure 7.33: A typical CIV (Source: Van Oord)

- **Crew Transfer Vessels:** During commissioning there will be a requirement to transfer personnel to and from WTGs and OSPs. It is envisaged that similar vessels may be used during operation and maintenance phases as in *Section 7.11.2*.

7.10.3 Vessel Movements

112 The likely vessel movements, defined as a return entry exit from the Development Area, associated with the construction programme are dependent on the following:

- final concept selection for WTG, substructures and foundations and associated works;
- locations and facilities at port(s) or other shore facilities used to support the construction phase; and
- availability of vessels within the vessel types described above to be used for the offshore construction works.

113 At this stage it is not known how the Wind Farm will be built and there are many scenarios for the numbers and type of construction vessels that could be used. Assumptions of vessel movements have therefore been made in the relevant topics to allow an assessment on particular receptors. It has been assumed that around 1,500 vessel movements may be required over the construction period.

7.11 Operation and Maintenance

7.11.1 Introduction

114 It is likely that the Development will be managed, operated and maintained from an onshore facility for the duration of its anticipated lifetime. Onshore activities may be combined in one or more locations and will include the following:

- Marine Operations Centre for management of operations of the Wind Farm;
- Port facilities where vessels, maintenance equipment, spares and consumables are stored;
- Marine Terminal for management of work and personnel; and
- Helicopter hangar and base (if required).

115 Operation and maintenance (O&M) activities for all aspects of the Development may be required at any time, 24 hours per day and 365 days per year.

116 The majority of control activities will be undertaken remotely from shore from the Marine Operations Centre, however offshore access and intervention will be required to maintain and potentially repair or refit plant and equipment, such as and not limited to those listed below. Maintenance can be generally separated into three categories:

- **Planned maintenance**: This includes general inspection and testing, recertification and cleaning of equipment, investigation of faults and minor fault rectification, as well as replacement of consumables. It is anticipated that these events will be undertaken out-with winter months as the weather is likely to be more favourable, offering an increased maintenance window. Scheduled maintenance and inspection of each wind turbine is likely to occur every six to twelve months depending on individual turbine operations. Inspections of support structures and subsea cables will be performed on a periodic basis.

- **Unplanned maintenance**: This applies to defects occurring that require rectification out-with the planned maintenance periods. The scope of such maintenance would range from small defects on non-critical systems to failure or breakdown of main components potentially requiring them to be repaired or replaced.
- **Periodic overhauls**: These will be carried out in accordance with equipment manufacturer's warranty and specifications. These are likely to be planned for execution in periods of the year with the best access conditions.

117 The following section provides an overview of the potential O&M strategies and requirements. The final O&M strategy will be dependent on various factors such as the WTG type, number and onshore facility location(s).

7.11.2 Operations and Maintenance (O&M) Strategies

118 Different strategies may be adopted for O&M and these may vary over the life of the Development. These can generally be described as follows:

- **Shore-based:** use of one or more local port or harbour facilities on the east coast of Scotland to dispatch personnel and equipment using vessels such as catamarans or surface effect vessels. These are generally referred to as Crew Transfer Vessels (CTVs). These vessels may accommodate up to 24 technicians who would be transferred each day to a number of WTGs or OSPs during a trip. These vessels vary in size and specification, with the larger vessels generally able to access WTGs in more challenging sea conditions, and able to carry larger cargo loads. The project is likely to employ several of this vessel type.
- **Offshore-based:** use of an offshore vessel, typically known as a Service Operation Vessel (SOV), which is based semi-permanently at the wind farm location. Personnel and equipment would be dispatched directly from the SOV, generally via a gangway deployed from the vessel utilising Dynamic Positioning (DP) technology. These vessels may accommodate around 30 - 60 people with a crew change about every 14 days. The vessel may also require allocated anchorage/mooring areas within the Development Area and may return to shore in extreme conditions. These vessels commonly carry an on-board warehouse of spares as well as workshops, offices and on occasion, Marine Operations Centre facilities. The project is likely to employ one of this vessel type.

119 As the offshore wind market has developed, a number of alternative shore-based and offshore-based solutions have become available. These include Advanced CTVs with larger cargo capacity and operational sea condition limitations, CTV/SOV hybrids offering limited offshore accommodation facilities for shorter periods of time and motherships; large SOV type vessels able to launch CTVs from the offshore environment. It is likely that the

boundary between CTV vessels and SOV vessels will continue to blur, as each developer designs bespoke solutions to meet the specific needs of their project.

120 Helicopter operations may be required for both strategies, however the primary means of access would be via vessel. If used, helicopters would either mobilise from an existing facility or from a base developed specifically for the Development. Jack-ups, HLVs (HLVs) and CSVs may also be required for unplanned maintenance and/or periodic overhauls. These larger vessels may be mobilised from the regular operation facilities or from further afield depending on availability and logistical considerations.

7.12 Decommissioning

121 Following the operational phase a decommissioning plan will be prepared as part of the on-going development work and will be subject to approval from Scottish Ministers following the requirements of Section 105 of the *Energy Act 2004* outlined in *Chapter 3: Regulatory Requirements, Section 3.2.4*.

122 For the purpose of this EIA Report the following has been assumed for decommissioning, at this time:

- It is assumed that the timescales associated with the removal of the major components are similar to those outlined for installation.
- It is assumed that the vessel types, number of vessels, and number of vessel movements required for the removal of the major components are similar to those outlined for construction.

7.13 Safety Zones

7.13.1 Construction (and Decommissioning)

123 In accordance with the *Electricity (Offshore Generating Stations) (Safety Zones) (Application Procedures and Control of Access) Regulations 2007*, it is expected that a 500 m safety zone around each renewable energy installation will be applied for under Section 95 of the *Energy Act 2004* during the period of construction (and decommissioning) works and 50 m during the period of commissioning (and decommissioning). Section 62 of the *Scotland Act 2016* amends Section 95 of the *Energy Act 2004* making Scottish Ministers the appropriate Minister for safety zones. In order to minimise disruption to navigation by users of the sea, safety zones are expected to be established around such areas that have activities actually taking place at a given time. As such the safety zones are expected to follow throughout the different areas of the Development Area and phased as construction work is undertaken. The exact locations will be subject to detailed engineering informing the construction plan and are to be determined at a later stage prior to application.

124 It is standard safe working practice to establish minimum safe passing distances around areas of vessel activity that present a navigational safety risk to marine users. This includes

providing information of planned works and a requested safe clearance distance. These safety zones are generally 500 m and roll with the vessel during its operation.

125 Within port limits the relevant Harbour Authority may also choose to establish safety or exclusion zones around works, should a navigational safety risk be posed for example, due to the proximity to navigational channels or volume of traffic. This will be discussed with the relevant Harbour Authority during the works planning process.

126 Safety Zones, and/or any other exclusions required, will be implemented and communicated though standard protocol (i.e. Notice to Mariners).

127 Where required, each technical chapter has noted whether the inclusion of safety zones is taken into account in the assessment as part of the Development's Design Envelope.

7.13.2 Operation

128 Under the *Electricity (Offshore Generating Stations) (Safety Zones) (Application Procedures and Control of Access) Regulations 2007*, the standard dimensions for a safety zone during the operational phase is a radius of 50 m measured from the outer edge at sea level of the proposed or existing WTG tower. A request for larger safety zones may be made if a justification can be made in the application to Scottish Ministers. The requirement for operational safety zones will be considered as part of the project safety case on review of the mutual risks posed, post construction, to the Wind Farm and third parties and will be dependent on the outcomes of the detailed engineering phase.

7.13.3 Maintenance

129 During periods of major maintenance works and where a risk is posed to marine users or wind farm technicians, further temporary 500 m zones may be applied for under the *Electricity (Offshore Generating Stations) (Safety Zones) (Application Procedures and Control of Access) Regulations 2007*. This may be undertaken in conjunction with standard vessel safe operating procedures and use of guard vessels.

7.14 Colour Scheme, Markings and Lighting

130 The colouring, markings, numbering, lighting and foghorn requirements for the WTGs within the Development Area will be agreed with the appropriate navigation and aviation authorities (e.g. Northern Lighthouse Board, Civil Aviation Authority) per the current relevant standards and guidance issued by these authorities.

7.15 Onshore Works

7.15.1 Introduction

131 Consideration of the Development in this EIA Report will require assessment of the onshore works in so far as they are relevant. The Intertidal works described in *Section 7.9.3* will also be subject to consideration as part of the onshore planning process.

132 In the unlikely event that abnormal loads are required during the construction phase of the Wind Farm or OfTW information will be provided in a Traffic and Transport Plan.

7.15.2 Location

133 The grid connection offer is to connect at an existing substation at Cockenzie. Due to economic and practical constraints all works will be developed as close as practical to the existing national grid infrastructure, once all third party agreements are in place.

7.15.3 Onshore Export Cable

134 Underground cables will transmit the energy generated by the WTGs from the landfall location to an onshore substation. The onshore substation will collect the power transmitted from the offshore and onshore export cables and adapt it to the required conditions for export to the National Grid Network.

7.15.4 Onshore Substation

135 Although there will be a number of onshore infrastructure components, the development of an onshore substation will be the primary onshore asset. The footprint of the substation is estimated to be approximately 3.5 hectares.

136 Construction of the substation is programmed to take approximately 24 months. All of the infrastructure will be manufactured offsite and further studies will be undertaken to ensure that ground conditions are suitable and any existing contaminants are dealt with in an appropriate manner prior to the commencement of works.

References

Great Britain Parliament (2004). *Energy Act 2004*. Available at: http://www.legislation.gov.uk/ukpga/2004/20/contents [Accessed 06/04/2018]

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