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Abbreviations and Acronyms

°	Degrees
AC	Alternating Current
DC	Direct Current
GBS	Gravity Base Structure
HAT	Highest Astronomical Tide
ICOL	Inch Cape Offshore Limited
km	Kilometres
LAT	Lowest Astronomical Tide
m	Metres
m/hr	Metres per hour
m/s	Metres per second
MHWS	Mean High Water Springs
MW	Megawatts
O&M	Operations and Maintenance
OfTW	Offshore Transmission Works
OSP	Offshore Substation Platform
WTG	Wind Turbine Generator

7 Description of Development

7.1 Introduction

1 This chapter provides a description of the Project to inform the Environmental Impact Assessment (EIA) presented in this Environmental Statement (ES).

2 This description is provided as a range of parameters for a number of available technologies, hereafter referred to as the Design Envelope (see *Section 7.4*). 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 Offshore Transmission Works (OfTW).

3 The Onshore Transmission Works (OnTW) (see *Section 7.15*) will be subject to a separate application to East Lothian Council and the impacts of these works have been considered at an appropriate level to inform the assessment in this ES (see *Section 4.4.3*).

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

- Offshore Wind Farm/Wind Farm: Includes proposed WTGs, inter-array cables, meteorological masts 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 (see Figure 7.1).

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

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

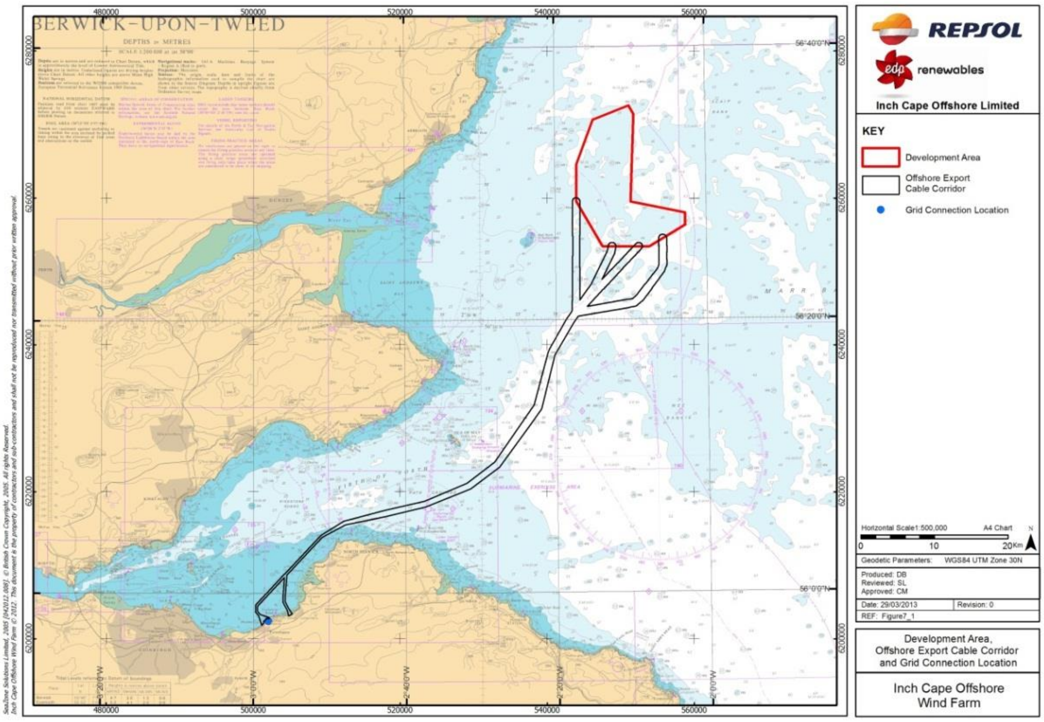
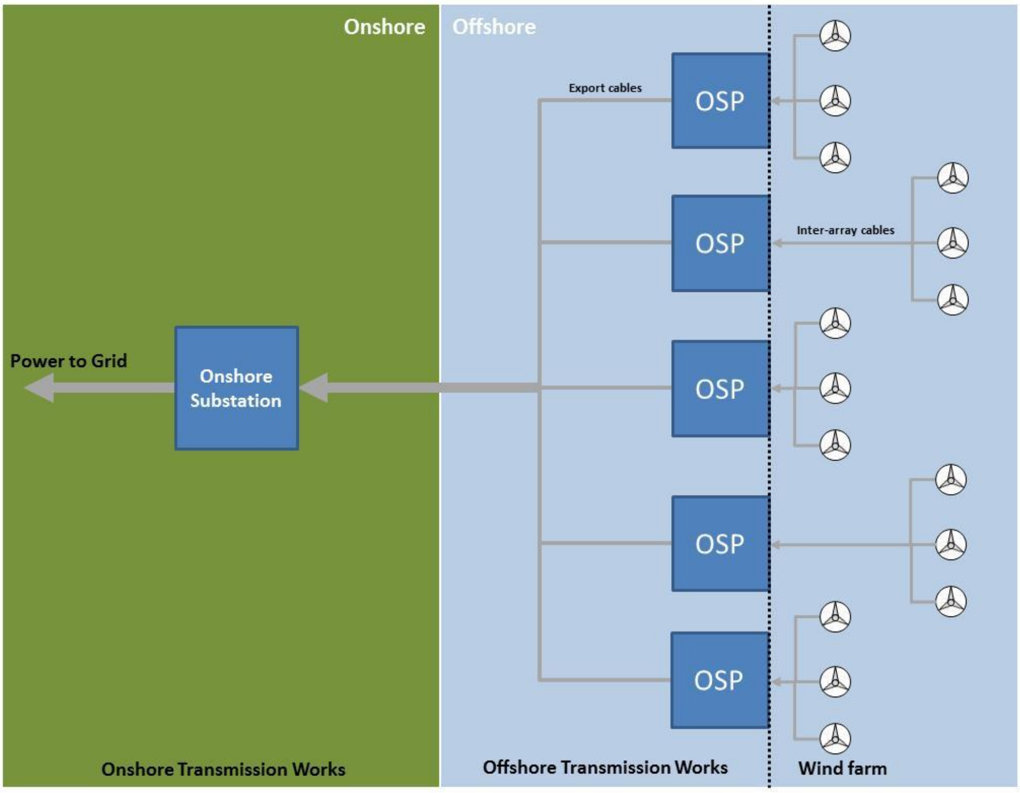


Figure 7.2: Illustration of Components



7.2 Development Area

7.2.1 Location and Extent

6 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 (Source: ICOL)

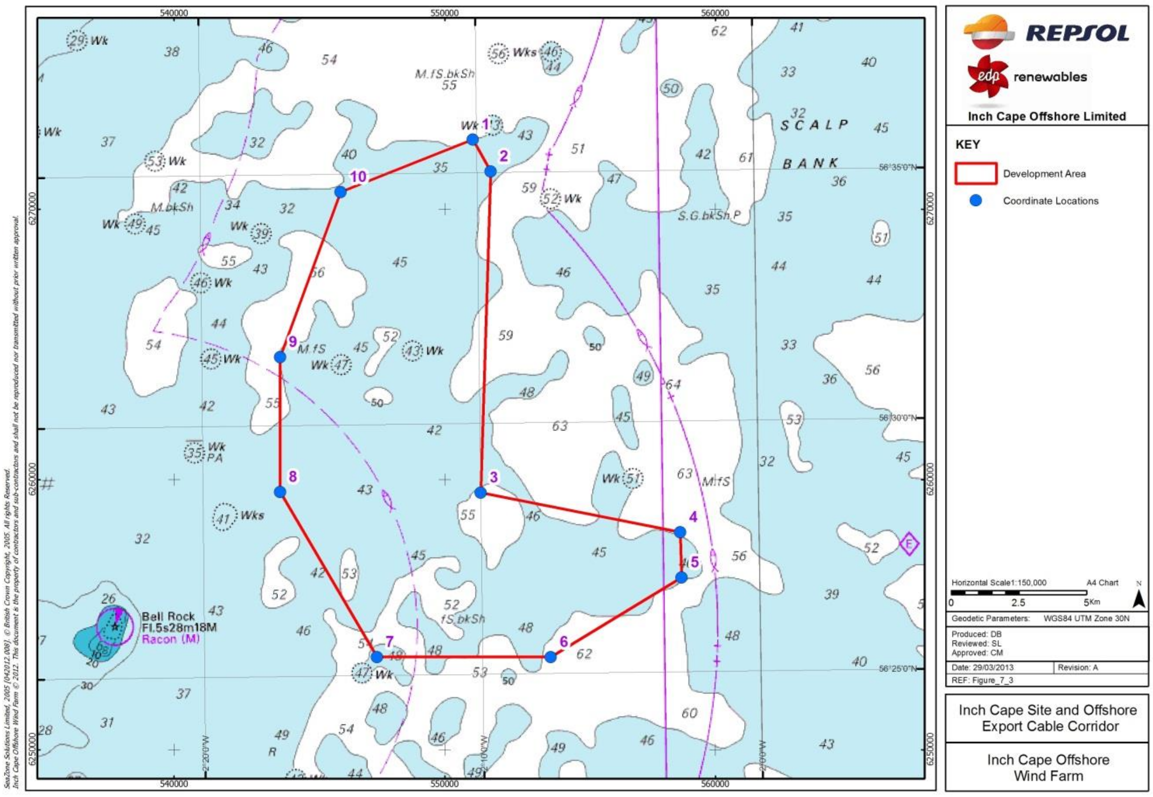


Table 7.1: Development Area Coordinates

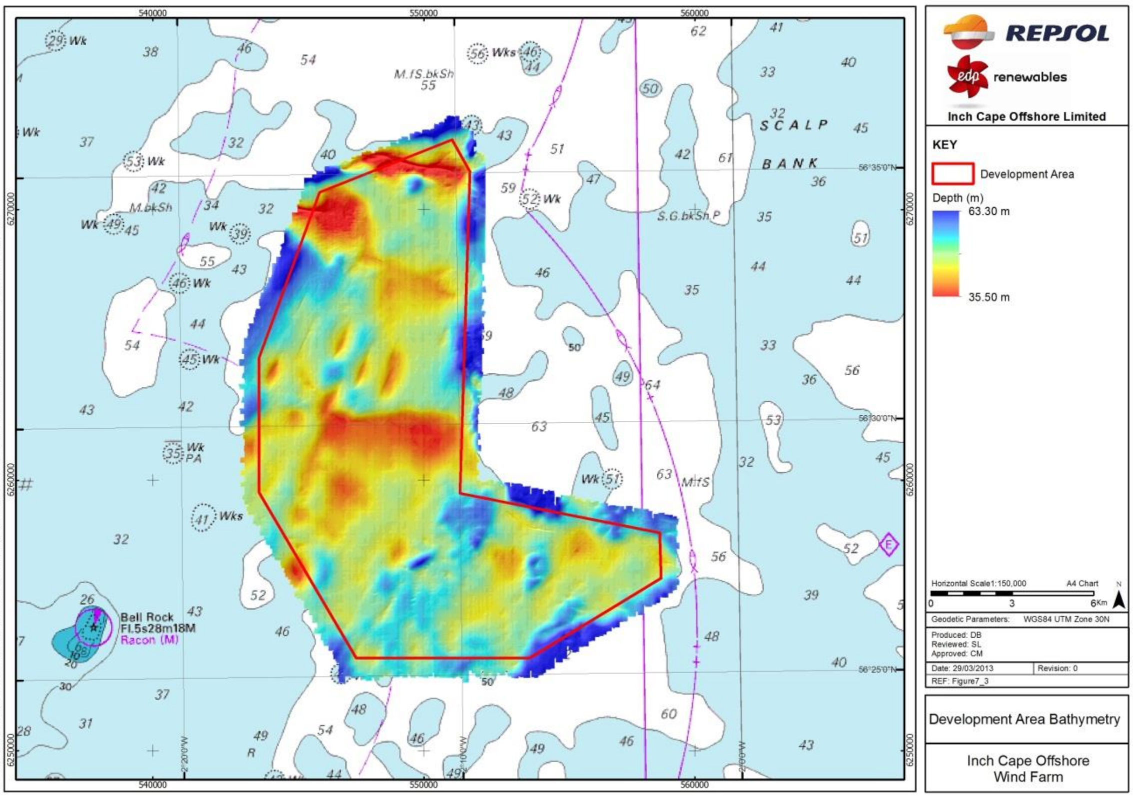
Map ID	WGS84 X (decimal degrees)	WGS84 Y (decimal degrees)	UTM30N X (Metres)	UTM30N Y (Metres)
1	-2.168960	56.594632	551030.82510	6272572.70670
2	-2.158372	56.583977	551695.53290	6271394.71650
3	-2.166704	56.477201	551327.93370	6259504.04370
4	-2.047320	56.463267	558702.82420	6258048.70300
5	-2.046898	56.448196	558752.07170	6256371.62120

Map ID	WGS84 X (decimal degrees)	WGS84 Y (decimal degrees)	UTM30N X (Metres)	UTM30N Y (Metres)
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

7 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 5.5 m with a mean spring tide range of approximately 4.6 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 (Source: ICOL)



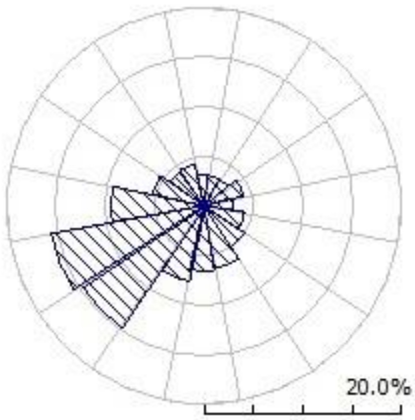
8 The seabed and sub-seabed sediments are generally characterised by variations of sand, clay and gravel with chalk identified at isolated locations.

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

7.2.3 Wind Resource

10 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.

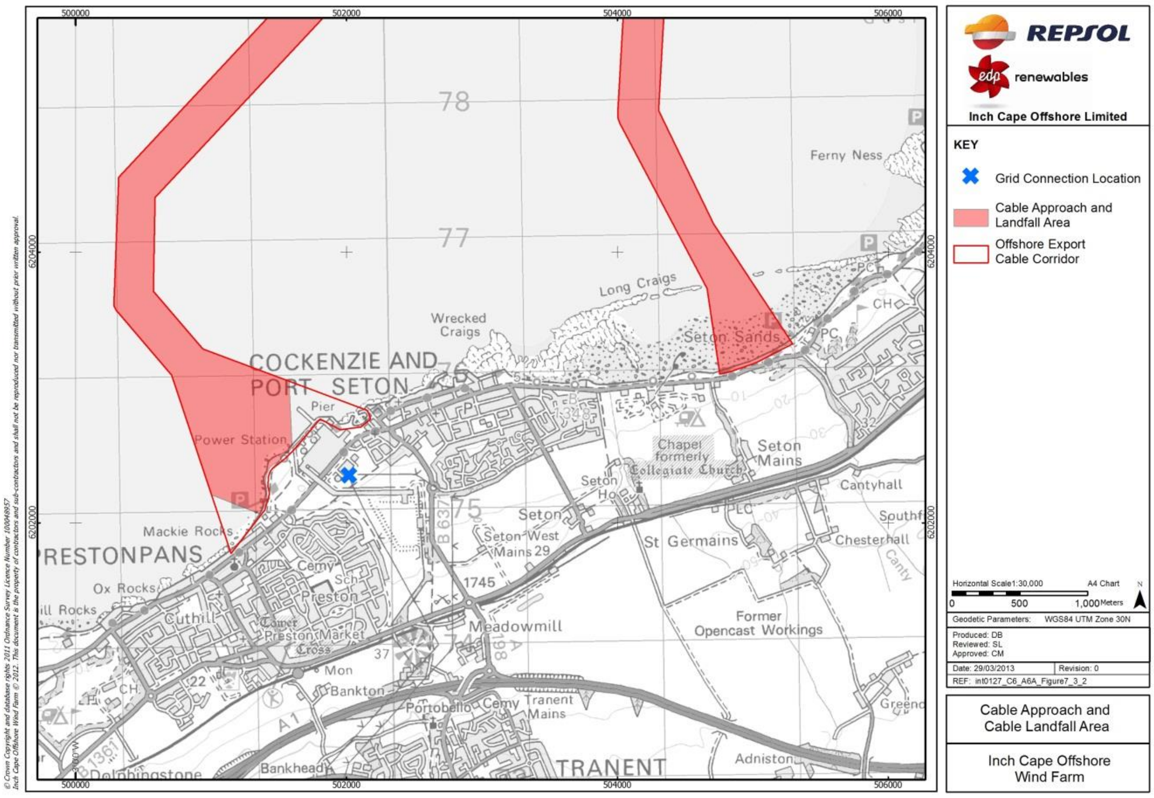
Figure 7.5: Directional Wind Rose (Source: ICOL)



7.3 Offshore Export Cable Corridor

11 The Offshore Export Cables, which transmit power to shore, will exit the Development Area and transit the seabed to a landfall location in East Lothian. Two potential landfall areas have been identified near Cockenzie or Seton Sands (see Figure 7.6). One of these options will be selected as part of the detailed design process.

Figure 7.6: Cable Approach and Landfall Area



12 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 water near to East Lothian.

13 Up to six Export Cables will be installed in separate trenches within the Offshore Export Cable Corridor, with each trench being around one metre wide. The distance between the trenches will vary and will generally reduce in shallower water.

Figure 7.7: Offshore Export Cable Corridor (Source: ICOL)

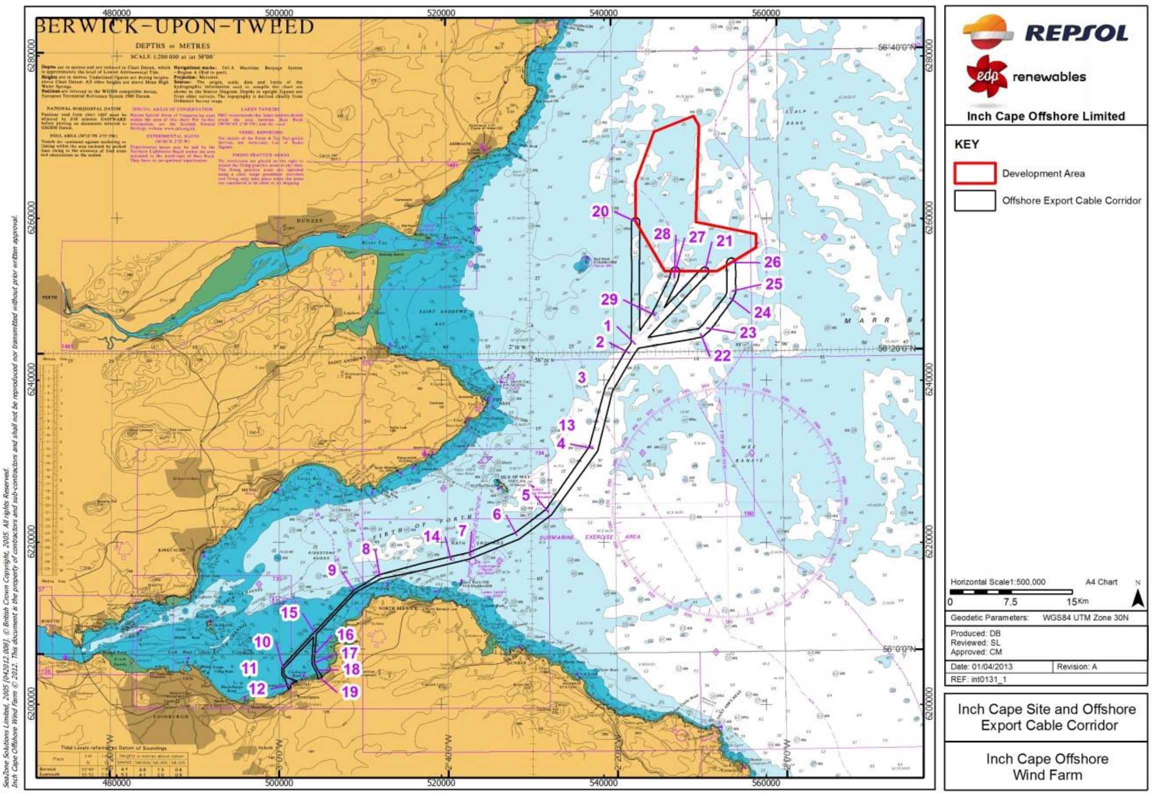


Table 7.2: Offshore Export Cable Corridor Coordinates

Map ID	WGS84 X (decimal degrees)	WGS84 Y (decimal degrees)	UTM30N X (Metres)	UTM30N Y (Metres)
1	-2.289703	56.342369	543906.77	6244411.96
2	-2.302420	56.332491	543131.83	6243304.57
3	-2.344561	56.292235	540568.96	6238798.46
4	-2.375335	56.227333	538729.65	6231557.11
5	-2.466088	56.156714	533163.81	6223650.09
6	-2.528067	56.130906	529333.72	6220749.64
7	-2.623442	56.109183	523418.75	6218295.41
8	-2.800998	56.086512	512383.53	6215726.15
9	-2.851017	56.070363	509274.84	6213920.92
10	-2.993002	55.985496	500436.61	6204465.36

Map ID	WGS84 X (decimal degrees)	WGS84 Y (decimal degrees)	UTM30N X (Metres)	UTM30N Y (Metres)
11	-2.993257	55.978221	500420.74	6203655.74
12	-2.976426	55.967224	501471.47	6202432.04
13	-2.370985	56.236522	538990.05	6232582.31
14	-2.660147	56.104520	521138.54	6217764.52
15	-2.929409	56.023573	504399.93	6208705.50
16	-2.932520	55.999513	504208.61	6206027.50
17	-2.933439	55.990434	504152.29	6205016.94
18	-2.926670	55.982588	504575.47	6204144.19
19	-2.919694	55.974499	505011.77	6203244.39
20	-2.287140	56.478254	543908.47	6259537.81
21	-2.150177	56.422487	552421.20	6253426.81
22	-2.160814	56.353997	551858.06	6245795.89
23	-2.148653	56.359760	552601.60	6246446.49
24	-2.101608	56.393248	555459.59	6250210.67
25	-2.097310	56.399898	555715.18	6250954.21
26	-2.096959	56.431821	555690.19	6254507.58
27	-2.208919	56.422876	548797.25	6253426.88
28	-2.211726	56.415169	548633.96	6252567.15
29	-2.249082	56.373877	546379.46	6247945.44

7.4 The Design Envelope

14 The design of the Wind Farm and OfTW cannot be finalised at this stage. This is primarily due to procurement and supply chain considerations, the requirement for further site investigation and continued design, and the timing of investment decisions. The EIA process presented in this ES has therefore been completed using a design envelope. This approach is recognised within the draft *Marine Scotland Licensing and Consents Manual Covering Marine Renewables and Offshore Wind Energy Development* (Marine Scotland, 2012) as being appropriate for development of this nature.

15 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: Site Selection and Alternatives* (see *Section 6.3*).

16 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 Project.

17 Some of the design parameters cannot co-exist and therefore the overall assessment overestimates the potential impacts of the Project.

18 The Design Envelope contains parameters relating to the following components of the Project:

- WTG types and layouts;
- Foundations and substructures;
- OSPs;
- Inter-array cables;
- Export Cables; and
- Operations and maintenance.

19 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 operations and maintenance methodologies at this stage.

7.5 Wind Turbine Generators (WTGs)

7.5.1 WTG Description

20 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

21 A range of WTG suppliers and models are being considered. WTG selection will be dependent on the continued design and development of the Project and will take account of safety, commercial procurement and technical factors.

22 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

23 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 WTG to maximise efficiency of energy capture;
- geological conditions;
- bathymetry;
- physical and spatial constraints; and
- environmental considerations.

24 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 (Source: ICOL)

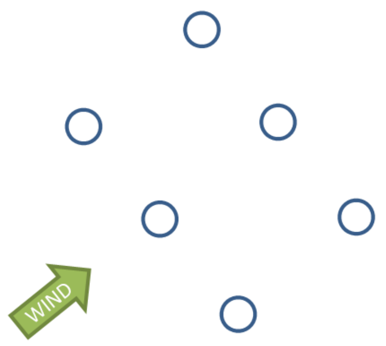
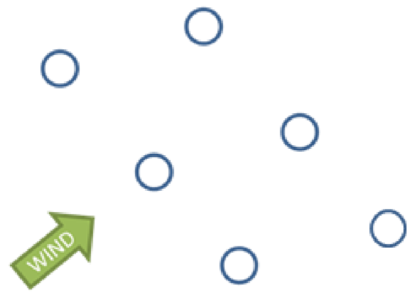


Figure 7.10: Illustration of 'Offset Grid' Configuration (Source: ICOL)



25 Where layouts are presented in *Chapter 10: Metocean and Coastal Processes, Chapter 16: Seascape, Landscape and Visual* and *Chapter 19: Shipping and Navigation* 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

26 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 (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. WTGs are then erected piece by piece offshore using a jack-up or floating vessel with heavy lift capability. This is shown in Figure 7.11 below.

Figure 7.11: Individual Component Installation (Source: Seajacks)

- **Onshore sub-assembly:** This is similar to individual component installation; however some of the components are pre-assembled at the onshore location. The most common combinations are:
  - Fully assembled rotor and hub with separate nacelle and tower section(s); and
  - 'Bunny-eared' nacelle (nacelle and hub with two blades) with separate tower section(s). In this case the third blade is added offshore by a separate lift.
- These sub-assemblies are then erected offshore using a jack-up or floating vessel. An example is provided in Figure 7.12.

Figure 7.12: Fully Assembled Rotor Installation (Source: AREVA, Alpha Ventus)

- **Single-lift installation:** the WTG is fully assembled onshore and installed in one piece offshore by either a floating or jack-up vessel. This process is illustrated in Figure 7.13 below.

Figure 7.13: Single Lift WTG Installation (Source: SCALDIS)

- **One-piece installation:** for some foundation and substructure types, it is possible to install the WTG onto the substructure at a suitable location and then tow to site, installing both the WTG and substructure in one piece, an example of which is illustrated in Figure 7.14.

Figure 7.14: Example of One-piece Installation (Source: Vinci)

27 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

28 The WTGs will be operated remotely from an onshore base and use condition monitoring techniques to aid in maintenance planning. Operations and Maintenance (O&M) is discussed further in *Section 7.11*. Each WTG has a control system to optimise and report on performance.

7.5.6 WTG Access

29 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 7.15A and Figure 7.15B in close up.

Figure 7.15A: A Representative WTG Access System shown on the Substructure (Source: ICOL)

Figure 7.15B: Close Up View of the Representative WTG Access System

30 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. A typical heli-hoist platform is shown in Figure 7.16 below. This would allow equipment and personnel to be winched to and from WTGs. No helicopter landing facilities are envisaged on any WTGs.

Figure 7.16: A Typical Heli-hoist Platform (Source: SSE)

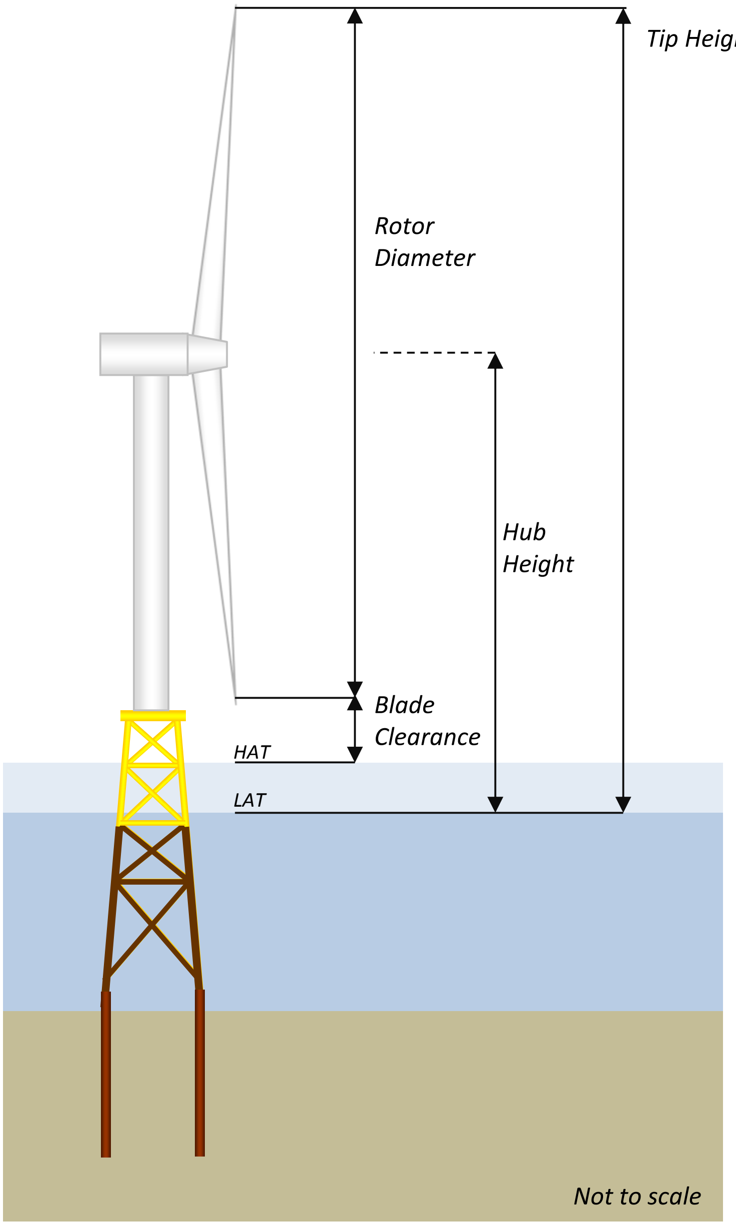
7.5.7 WTG Oils and Fluids

31 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

32 Figure 7.17 below shows an illustrative WTG with definitions of the numeric parameters as stated in Table 7.3 below.

Figure 7.17: Illustration of the Design Parameter Definitions for a WTG (Source: ICOL)



33 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 4.4.1*.

Table 7.3: WTG Design Values

Design Parameter	Value (Maximum or Range)
Maximum number of WTGs	213
Minimum down-wind and cross-wind spacing (m)	820
Rotor diameter range (m)	120–172

Design Parameter	Value (Maximum or Range)
Blade tip height range (m)	152–215 (above LAT*)
Blade Clearance above HAT* (m)	22
Indicative Hub height range (m)	92–129 (above LAT*)

*Lowest/Highest Astronomical Tide

7.6 Foundations and Substructures

7.6.1 Foundations and Substructures Description

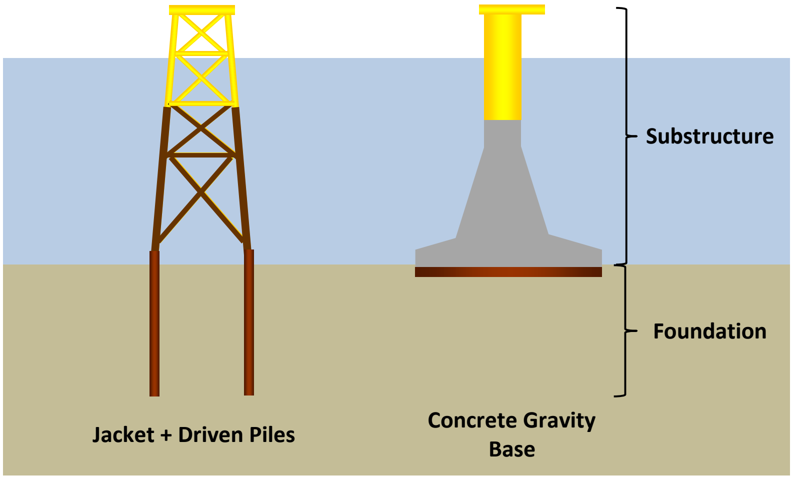
34 The following section describes the possible foundation and substructure options for WTGs and OSPs. A summary of the Design Envelope is included at the end of *Section 7.6.7*.

35 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.

36 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 7.18 below).
- **Foundation:** the arrangement which fixes the substructure to the seabed and is predominantly below the seabed level (Figure 7.18 below).
- **Shadow (m^2):** the total area of seabed under the substructure (Figure 7.24 and Figure 7.25).
- **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 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 7.18: Foundation and Substructure Definition (Source: ICOL)



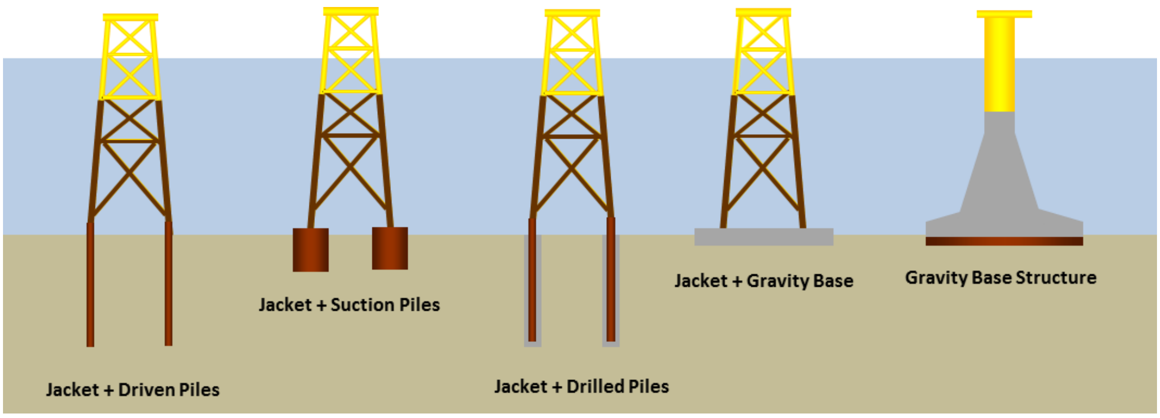
37 Details of the quantities for the foundation and substructure types are summarised in *Section 7.6.7* below.

38 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 7.19 below:

- Steel frame jackets: Also known as 'jackets' these structures are constructed mainly from steel cross members similar to a lattice tower.
- Gravity Base Structures (GBS): A mainly concrete and steel reinforced structure which uses the weight of the structure and internal ballast to maintain position.

39 A hybrid solution also exists that incorporates elements of the gravity base and steel framed options but will fall within the envelope created by the four legged jacket and concrete gravity base (jacket dimensions will be no greater and the gravity base dimensions will be smaller).

Figure 7.19: Foundation and Substructure Types (Source: ICOL)



7.6.2 Foundations and Substructures Installation Sequence

40 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.

41 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.
- Foundation and substructure combined: e.g. Jacket + Gravity Base, Jacket + Suction Piles or GBS.

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

7.6.3 Steel Framed Foundations and Substructures

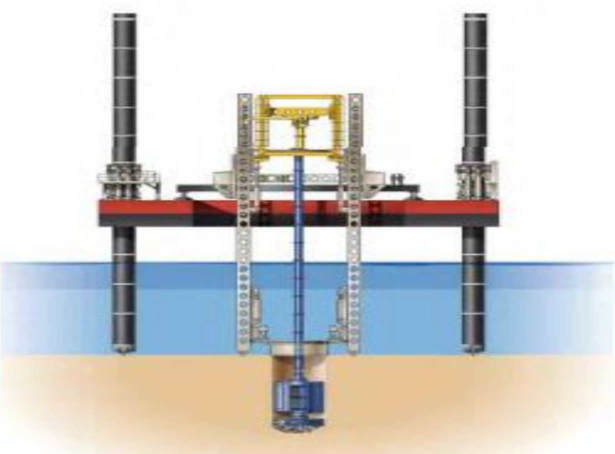
42 There are various steel framed jacket substructures under consideration for the Project; in this case a four-legged jacket has been assessed as a representative arrangement for the purpose of identifying the worst case. Monopiles are not included in the Design Envelope for the Project due to technical constraints linked primarily to water depth in the Development Area.

43 Steel framed substructures can be fixed to the seabed using different types of foundations (Figure 7.23 and Figure 7.24). The suitability of each of these types for use on the Project 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.

44 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 tool although, this is a new concept in the early stages of development and not yet proven to be technically suitable or commercially viable for large subsea piling. 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 7.20 below.

Figure 7.20: 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 7.21.

Figure 7.21: 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 7.22.

Figure 7.22: 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 gravity base structure is shown in Figure 7.23 below.

Figure 7.23: An Illustration of a Hybrid Jacket and Gravity Base Structure (Source: ICOL)

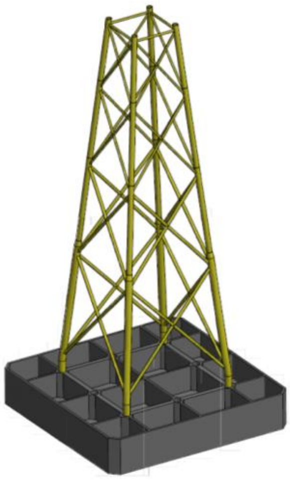
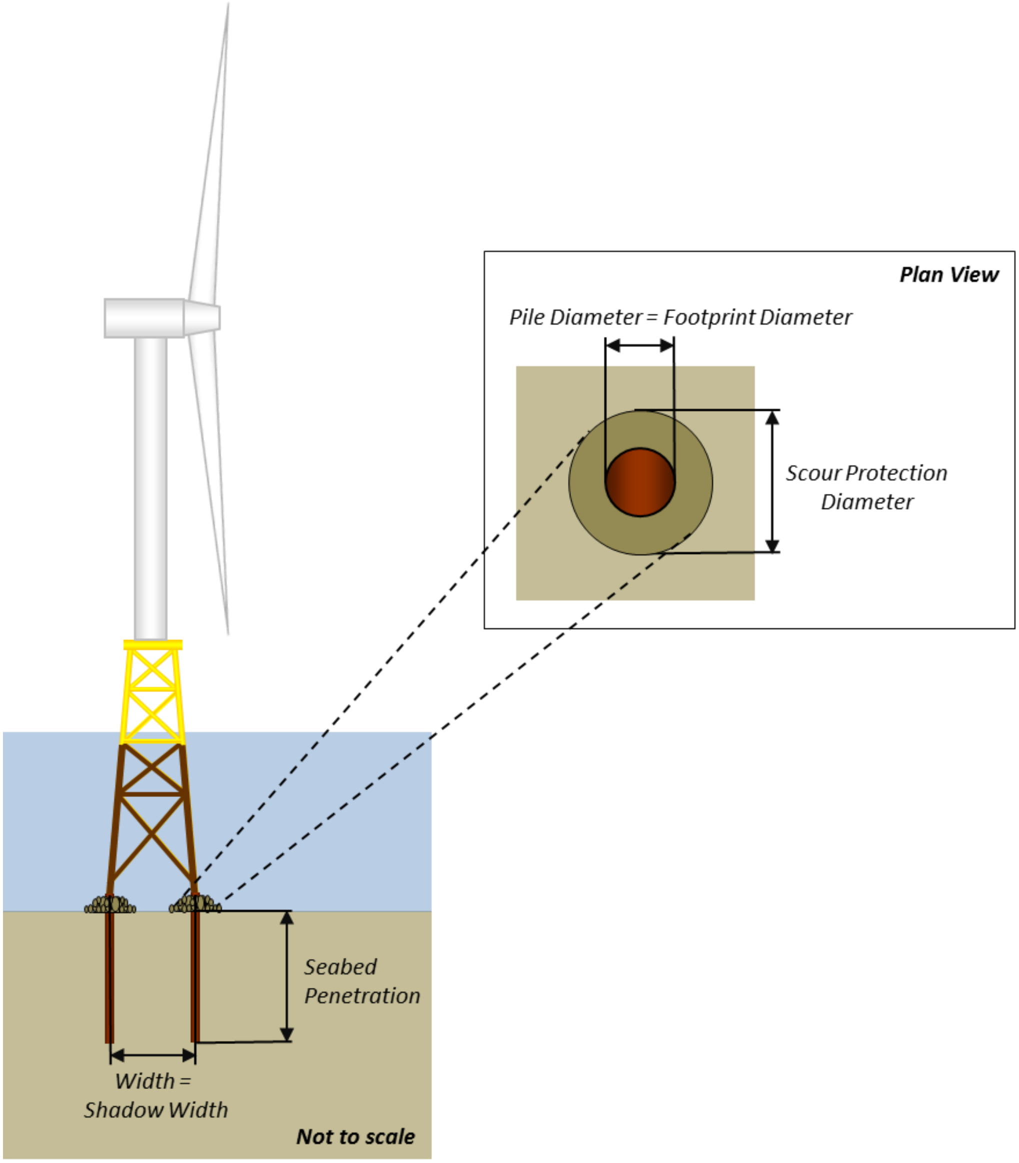


Figure 7.24: Illustration of the Design Parameter Definitions for Steel Framed Foundations and Substructures (Source: ICOL)



7.6.4 Piling

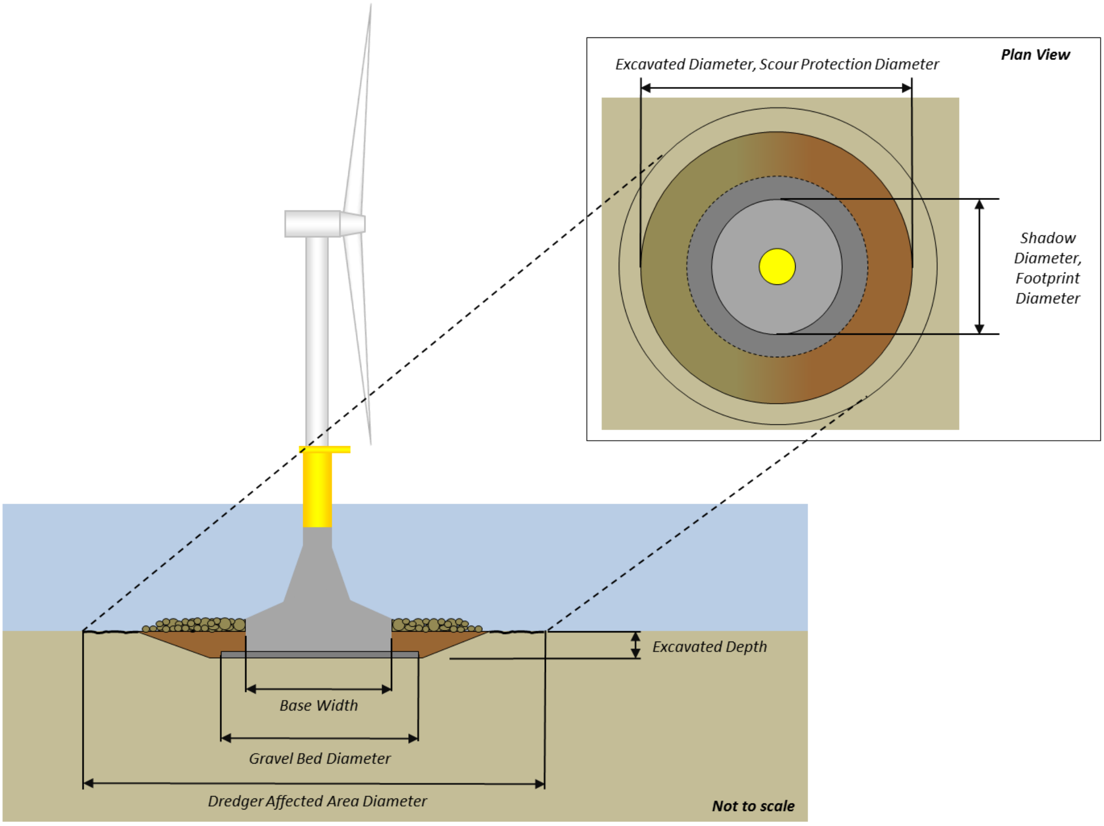
45 A maximum of two concurrent piling activities are considered for the Project. In accordance with *Section 7.10* this will take place over an estimated two year period, with actual piling duration covering approximately 11 per cent to 23 per cent of the time.

7.6.5 Gravity Base Structures (GBS)

46 There are various configurations of GBS under consideration for the Project. 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 7.25).

47 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 7.25: Illustration of the Design Parameter Definitions for GBS



48 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.

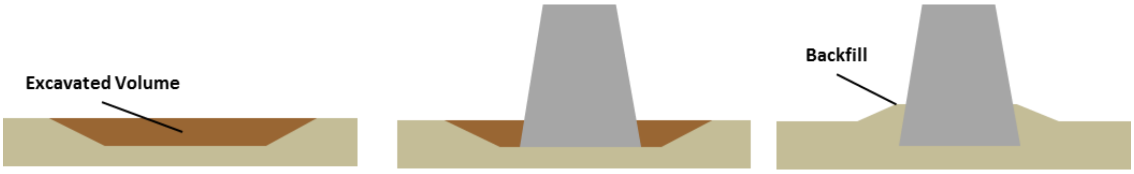
49 In the event that seabed preparation is required, the following options are possible for the excavated volume of seabed material. The following options could be used individually or in combination depending on ground condition and construction techniques and are listed below in order of preference:

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

50 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. It is possible that all of the excavated volume will be used as backfill following installation of the foundation. A

significant amount of material could be used for ballast. It is therefore likely that a balanced cut and fill can be achieved, although a limited proportion of material may still be removed. This is illustrated in Figure 7.26.

Figure 7.26: Illustration of a Potential Backfill Methodology.



7.6.6 Scour Protection

51 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. 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. specifically selected gravel and rock. Concrete mattresses or similar techniques can also be used.

52 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 Project design progresses.

7.6.7 Summary of Foundation and Substructure Design Envelope

53 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 4.4.1*.

Table 7.4: WTG Steel Framed Jacket Design Values

Design Parameter	Value (Maximum or Range)
Drilling/Piling Events	852*
Number of Sides	4
Jacket Top Width (m)	30
Jacket Base Width (m)	60**
Maximum Seabed Penetration (m)	60

Design Parameter	Value (Maximum or Range)
Scour Protection Diameter (m)/pile	16
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	28***
Footprint Including Scour Protection Footprint Substructure (m^2)	804
Drilled Volume at each Substructure (m^3)	1,680

* Based on four piles per each of the 213 WTGs.

**includes allowance for boat landings and laydown area.

***Area under each of four piles with diameter of three metres. This is a conservative figure for footprint assessments and the pile diameter utilised for noise modelling is based on a refined assessment and uses a smaller pile.

Table 7.5: WTG Gravity Base Structures Design Values

Design Parameter	Value (Maximum or Range)
Top Width (m)	20*
Base Diameter (m)	65
Excavated Diameter (m)	95
Scour Protection Diameter (m)	95
Dredger Affected Diameter (m)	125
Excavated Depth (m)	0 - 5**
Shadow (m^2) - Total seabed area under each substructure including those exposed	3,318
Footprint (m^2)- Total seabed area under each substructure which is not exposed	3,318
Footprint including Scour Protection Footprint (m^2)	7,088
Dredger Affected Area Footprint (m^2) (includes scour protection and footprint)	12,272
Maximum Excavated Volume per unit (m^3)	28,503***

Design Parameter	Value (Maximum or Range)
Gravel Bed/Grout Diameter (m)	75
Gravel Bed/Grout Depth	2.5

*includes allowance for boat landings and laydown area.

** In isolated occasions 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

54 This section provides a description of the OSPs. There are two types of OSPs being considered for the Project and a decision will be made in the future about the transmission technology:

- Alternating Current (AC) OSPs collect the power generated by the WTGs and transform to a higher voltage level to allow it to be transmitted to shore via Export Cables.
- Convertor station OSPs that convert the AC power produced by the WTGs to Direct Current (DC) for transmission to shore.

55 The final design and number of OSPs required will be dependent on a number of factors, particularly the WTG power rating, number and layout. Initial design work suggests that up to five OSPs may be needed.

56 AC OSPs and AC/DC convertor station OSPs may be combined to a single multifunctional OSP. For the purposes of assessments it has been assumed that the dimensions of all OSPs, including combined ones, are the same. AC and DC platforms are collectively referred to as OSPs for the remainder of this section.

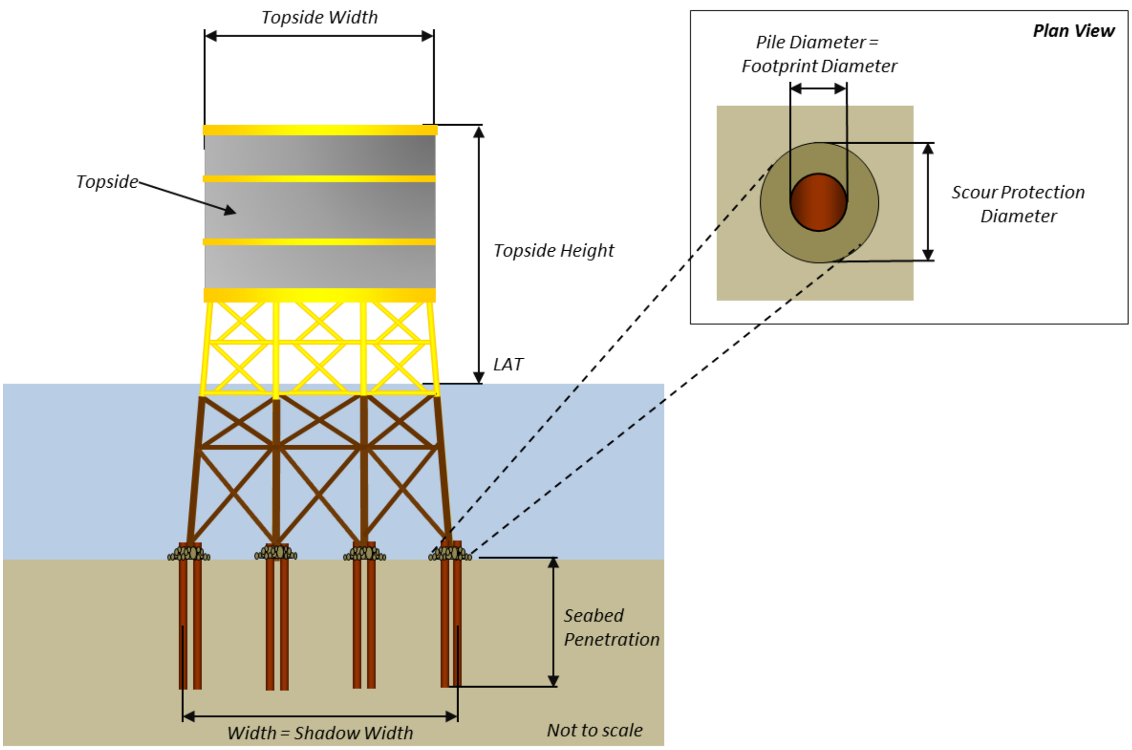
57 All OSPs will be located within the Development Area. Individual OSP platforms may be located in proximity to each other and potentially joined by a bridge(s). The optimal layout of OSPs will be determined by the WTG and associated electrical distribution layout and transmission cable routing. The 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.

58 Further details and dimensions of the OSPs are provided in the summary of the Design Envelope specifications included in *Section 7.7.6*.

7.7.2 OSP Specification and Design

59 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 will be larger than those considered for WTGs. A representative OSP is shown in Figure 7.27.

Figure 7.27: Illustration of the Design Parameter Definitions for an OSP (Source: ICOL)



60 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-deck;
- crane(s);
- small power generation; and
- High Voltage DC (HVDC) conversion modules (if DC).

7.7.3 OSP Installation and Commissioning

61 The OSP topsides will be fabricated and assembled at an on shore location and then transported to the Development Area for installation on top of the foundation and substructure (which would be installed in a similar way to that discussed in *Section 7.6.2*). The topsides would either be transported to site via barge and then installed with a Heavy Lift Vessel (HLV) or taken directly to their location and installed using an HLV. For larger OSP topsides a 'float over' concept may be used where the topside is lowered onto the substructure rather than lifted on.

62 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 jack-up vessels 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*.

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

7.7.4 OSP Access

64 OSPs will have access facilities for maintenance visits via vessel and helicopter, similar to those identified for WTGs in *Section 7.5.6*. A heli-pad or heli-hoist platform would be used for helicopter access.

7.7.5 OSP Oils and Fluids

65 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.

66 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.

67 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.

68 In order to safeguard helicopter operations, re-fuelling facilities may be included on the OSP. Appropriate spill and fire protection measures would be incorporated into the design as necessary to comply with relevant standards.

7.7.6 Design Envelope

69 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 4.4.1*.

Table 7.6: OSP Steel Framed Jacket Design Values

Design Parameter	Value (Maximum or Range)
Topside Height above LAT (m)	70
Topside Width and Length (m)	100*
Drilling/Piling Events	80**
Pile Diameter (m)	3
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 16 piles per each of the five 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 Gravity Base Structures 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 (m^2) - Total seabed area under each substructure including those exposed	13,273
Footprint (m^2)- Total seabed area under each substructure which is not exposed	13,273
Footprint including Scour Protection Footprint (m^2)	25,447
Dredger Affected Area Footprint (m^2) (includes scour protection and footprint)	70,686
Maximum Excavated Volume per unit (m^3)	114,012**

* 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

70 Subsea cabling will be used to connect WTGs together and distribute the power generated to the OSPs. The cables will be AC and a maximum of 66 kV and will include electrical conductors, communications cables (fibre optics), insulation and cable protection. 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. Further details are provided in the summary of the Design Envelope specifications included in *Section 7.8.5*.

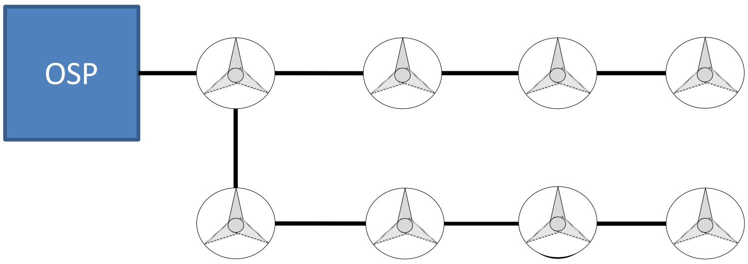
7.8.2 Specification and Design

71 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. It is anticipated that there will be between 147 km to 353 km total length of inter-array cabling depending on Wind Farm layout.

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

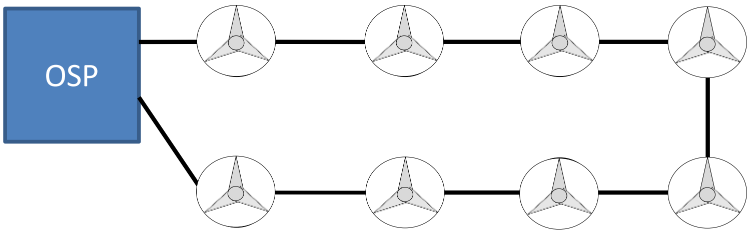
- **Branches:** This is where the first or second WTG has three cables into the base, allowing a single cable into the platform but two strings out from the first WTG, normally in a U shape. An illustration of a branch arrangement is given in Figure 7.28 below.

Figure 7.28: 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 7.29 below.

Figure 7.29: An Illustration of a Loop Inter-array Cable Configuration (Source: ICOL)



73 The OSPs including AC OSPs and AC/DC convertor station OSPs may be interconnected by cabling. 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 353 km. This would be confirmed on definition of final layout and electrical design configuration. The maximum voltage for inter-platform cabling will not exceed the maximum AC export cabling voltage of 275 kV.

7.8.3 Installation

74 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. Further analysis will be carried out of the Development Area seabed conditions as part of the cable protection and burial study. The study will consider the technically and economically achievable burial depths based on the Development Area specific ground conditions. 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.

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

- **Lay then burial:** The cable is laid and then buried in separate installation activities, sometimes using different vessels.
- **Simultaneous lay and burial:** The cable is laid and buried simultaneously.

76 There are various techniques in which the cable can be buried with typical techniques including:

- **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 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 or tracked vehicles. A typical cable burial plough is shown in Figure 7.30 below.

Figure 7.30: A Typical Cable Plough (Source: ICOL)

- **Jetting Trenchers:** buries the laid cable by directing water jets towards the surrounding seabed. Displaced material is suspended in the water and then resettles over the cable which will bury through self-weight. This process is controlled to ensure that sediment is not displaced too far from the cable. Jetting trenchers are commonly mounted to self-propelled Remotely Operated Vehicles (ROV). A typical ROV mounted jetting trencher is shown in Figure 7.31 below.

Figure 7.31: A Typical Jet Trenching Tool (Source: Modus)

7.8.4 Cable Protection

77 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 the cable is covered with rocks. The rocks 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 replacement vessel is shown in Figure 7.32.

Figure 7.32: A Typical Rock Placement Vessel (Source: DEME)

- **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 7.33 below.

Figure 7.33: 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 7.34 below.

Figure 7.34: 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 Design Envelope

78 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 4.4.1*.

Table 7.8: Inter-array Cabling Design Values

Parameter	Value (Maximum or Range)
Voltage (kV)	66
Cable length (km)	353
Cable lay rates (m/hr)	300- 500

Parameter	Value (Maximum or Range)
Cable burial (% of cables buried)	90 - 100
Trench Width per cable (m)	1
Trench Affected Width per cable (m)	6*
Trench Depth (m)	0 - 3
Target Trench Depth (m)	1

*The area of the seabed that may experience some level of compaction or disturbance due to the footprint of the cable laying equipment.

7.9 Export Cable

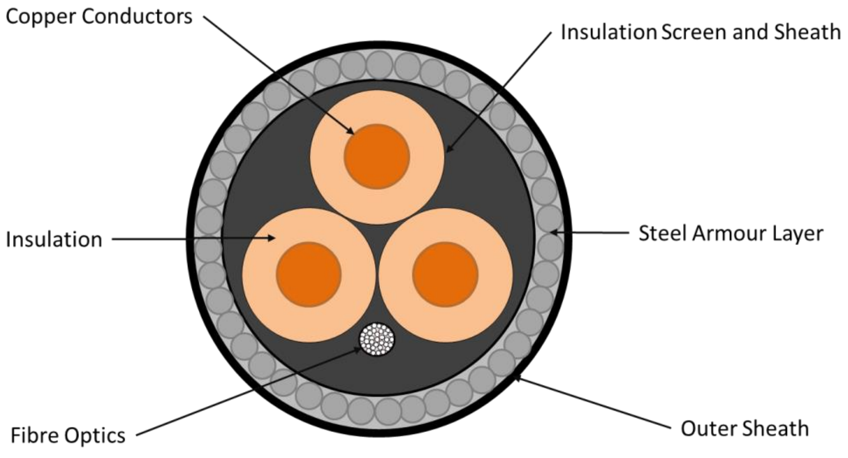
7.9.1 Introduction

79 Export cables will consist of up to six AC or DC cables which will run from the Development Area to landfall in the vicinity of Cockenzie or Seton Sands in East Lothian (see Figure 7.6).

7.9.2 Design and Specification

80 The type of cables used will depend on the final engineering design, technical specification and supplier. A typical cable cross sectional configuration is shown in Figure 7.35 below.

Figure 7.35: Illustration of a Typical Cable Cross Section (Source: ICOL)



81 A typical high voltage alternating current (HVAC) cable will be around 250 mm and will comprise of three copper conductor cores with polymer insulation and a fibre optic cable bundle. The cable (with the three cores) is likely to have an insulation screen, a lead alloy sheath and a polymer over sheath. The assembly is then encased in steel armouring and a final outer sheath. HVDC cables will have a different electrical configuration but will be similar in size and length.

7.9.3 Installation

82 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.

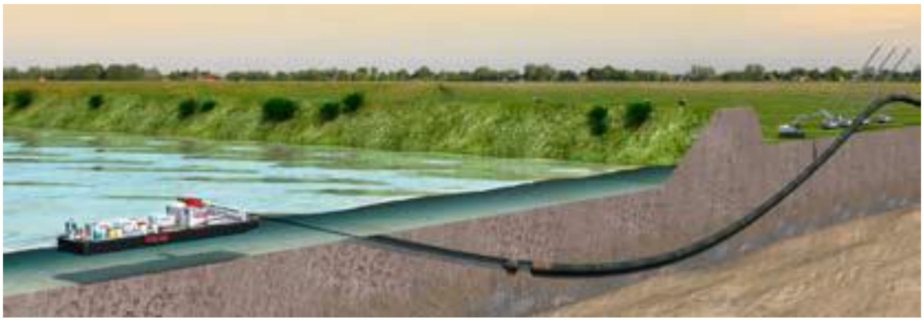
83 In addition to the installation options for the inter-array cables detailed in *Section 7.8.3* the following additional installation methods may potentially be utilised for the Export Cable:

- **Mechanical Rock Wheel Cutters:** Mechanical rock wheel cutters can be fitted to tracked cable burial vehicles and are used to cut narrow trenches into hard or rocky seabed. The rock wheel cutter consists of a rotating disc fitted with a number of replaceable teeth. A typical rock-wheel cutter is shown in Figure 7.36 below.

Figure 7.36: A Typical Rock Wheel-cutter (Source: CTC Marine)

- **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 7.37 below.

Figure 7.37: 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.

84 The suitability of any cable installation 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

	Intertidal Areas	Sub-tidal Areas
Burial Ploughs	Yes	Yes
Jetting Trenchers	No	Yes
Mechanical Rock Wheel Cutters	Yes	Yes
Open Trenching	Yes	No
Horizontal Directional Drilling	Yes	Yes

85 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.

86 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.

87 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 Cable Protection

88 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 4.4.1*.

Table 7.10: Export Cabling Design Values

Parameter	Value (Maximum or Range)
Voltage (kV)	320 (DC option) 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	4 - 6
Trench width per cable (m)	1
Trench Affected Width per cable (m)	6
Trench Depth (m)	0 - 3
Target Trench Depth (m)	1

7.10 Construction Programme

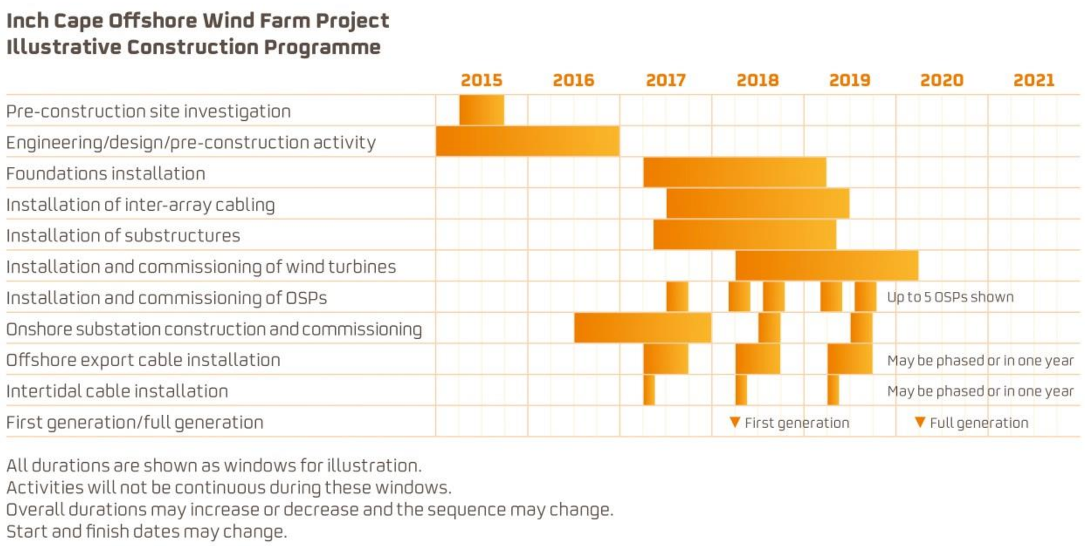
7.10.1 Current Schedule

89 A detailed construction programme will be developed as design and procurement activities progress. The construction activities are expected to start in 2016 and work will occur over approximately four years. 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
Pre-construction surveys and investigation	6 months
Foundation installation and associated site preparation	2 years
Inter-array cable installation	2 years
Installation of Substructures	2 years
Installation and commissioning of WTGs	2 years
Installation and commissioning of meteorological masts	2 months
Installation and commissioning of OSPs	3 months
Export cable installation (excluding intertidal)	9 months
Intertidal cable installation	6 months

Table 7.12: Illustrative Construction Programme



90 Maximum effects on receptors arising from cumulative piling activities is assumed to occur if all three projects within the Firth of Forth and Tay area pile within the same time. Chapters 13, 14 and 15 assess this scenario as worst case in the cumulative assessments presented. It is recognised that with the current construction timescales (see Table 7.12) for the Project presented within this chapter, and programme schedules for Neart na Gaoithe (Mainstream Renewable Power, 2012) and Firth of Forth Phase 1 (Seagreen Wind Energy Limited, 2012)

presented within their respective ES's, concurrent piling of all three projects is not likely. However, the assessments presented consider all three projects piling concurrently (2016) to allow for potential programme slippage and overlap of piling schedules, and as such are considered to be a conservative representation of worst case for each receptor.

91 Where a number of activities are expected to occur concurrently the implications of such overlaps have been considered in the appropriate chapters of this ES.

92 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.

93 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>

94 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 Jack-up 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 7.38 below.

Figure 7.38: A Typical Jack-up Vessel (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 7.39 below.

Figure 7.39: 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 7.40 below.

Figure 7.40: 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 7.41 below.

Figure 7.41: A Typical CIV (Source: SS7)

- **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 will be used during operation and maintenance phases as in *Section 7.11.2*.

7.10.3 Vessel Movements

95 The likely vessel movements 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.

96 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 boat 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 3,500 vessel movements may be required over the construction period.

7.11 Operation and Maintenance

7.11.1 Introduction

97 It is likely that the Inch Cape Offshore Wind Farm will be managed, operated and maintained from an onshore facility. Onshore activities may be combined in one or more locations and will include the following:

- Control room for remote operation of WTGs;
- Port facilities where vessels, maintenance equipment, spares and consumables are stored;
- Onshore operations base for management of work and personnel; and

- Helicopter hangar and base (if required).

98 Operation and maintenance (O&M) activities may be required at any time, 24 hours per day; 365 days per year, this is a critical factor in the selection of facilities.

99 The majority of control activities will be undertaken remotely from shore using a control centre, however offshore access and intervention will be required to maintain and potentially repair or refit plant and equipment. Maintenance can be generally separated into three categories:

- **Planned maintenance:** This includes general inspection and testing, investigation of faults and minor fault rectification, as well as replacement of consumables. It is anticipated that these events will be undertaken during summer months as the weather is likely to be more favourable, offering an increased maintenance window. Scheduled maintenance and inspection of each WTG is likely to occur every six to twelve months. Tasks will be undertaken by a minimum of two technicians. 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.

100 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 Strategies

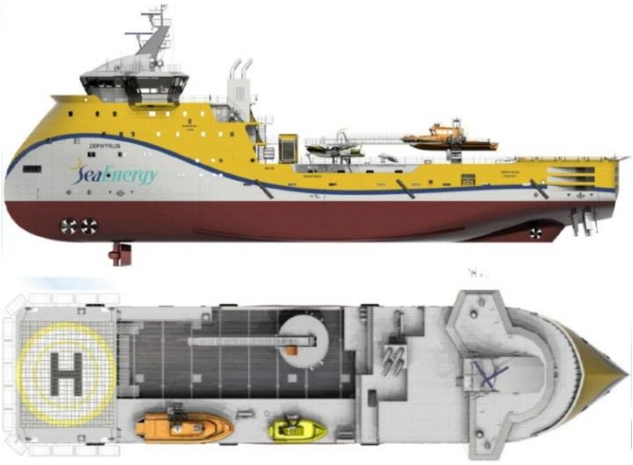
101 Different strategies may be adopted for O&M and these may vary over the life of the Project. These can generally be described as follows:

- **Shore-based:** use of one or more local port or harbour facilities on the east coast of Scotland to dispatch personnel and equipment using smaller vessels, such as catamarans. These vessels may accommodate up to 24 people who would be transferred to number of WTGs or OSPs during a trip. A typical shore-based O&M vessel is shown in Figure 7.42 below.

Figure 7.42: A Typical O&M Vessel (Source: Windcat)

- **Offshore-based:** use of an offshore vessel, typically known as a 'mothership', which is based semi-permanently at the wind farm location. Personnel and equipment would either be dispatched directly from the mothership, or from smaller vessels deployed from the mothership. These vessels may accommodate around 50 - 80 people with a crew change about every 30 days. An example of a mothership is shown in Figure 7.43 below. The vessel may also require allocated anchorage/mooring areas within the Development Area and may return to shore in extreme conditions.

Figure 7.43: An Illustration of a Mothership (Source: SeaEnergy Marine)



102 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 project. Jack-ups, 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.

7.11.3 Wind Measurement

103 It is envisaged that up to three meteorological masts (met masts), including one which is planned to be installed prior to construction, will be required during the operation of the Project in order to monitor wind resource at the Wind Farm and verify the performance of WTGs. A draft Marine License has been issued for the location of one of the met masts, the

location of the remaining two has not yet been determined but will be located within the Development Area.

104 If a fixed met mast design is utilised then the foundation, substructure and installation options for the met masts are the same as those previously described for WTGs and OSPs. The dimensions of these will be no larger than those described. A typical offshore met mast is shown in Figure 7.44 below.

Figure 7.44: A Typical Traditional Met Mast Structure (Source: Mainstream Renewable Power)

105 As an alternative to a fixed met mast, a floating mast or floating lidar system may be used (see Figure 7.45 below). This will consist of a buoy or floating substructure (spar–buoy) with either a lattice mast or a lidar unit on top.

Figure 7.45: A Typical Floating Lidar (Source: AXSYS)

7.11.4 Meteorological Buoys

106 It is envisaged that up to three metocean buoys or seabed mounted measurement devices will be located within the Development Area in order to gather data on the wave, tidal and currents of the Development Area. The location of each buoy has yet to be determined but

they will be within the Development Area. Typical measurement devices are shown in Figure 7.46 and Figure 7.47 below.

Figure 7.46: A Typical Metocean Buoy (Source: Fugro)

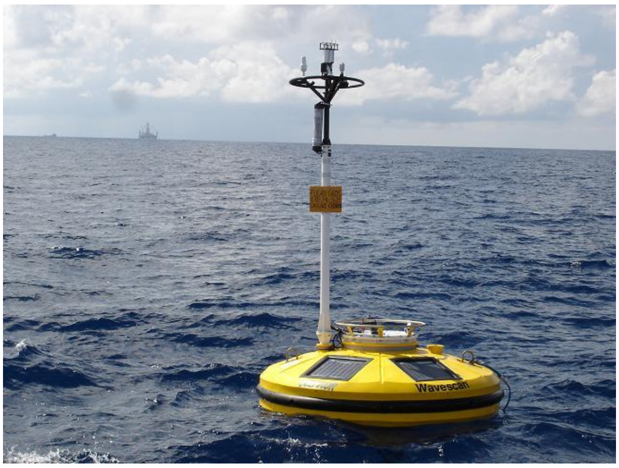
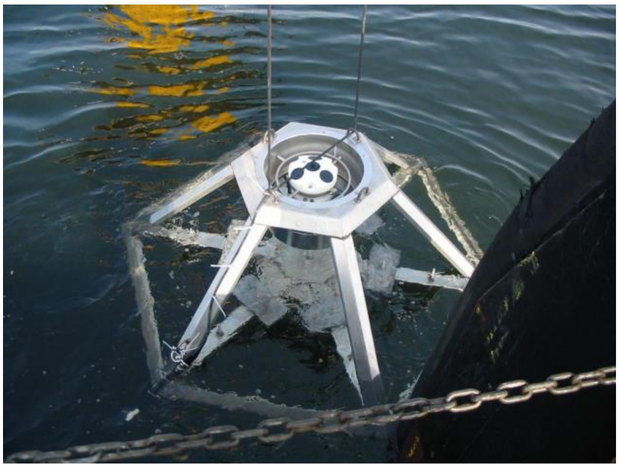


Figure 7.47: A Typical Seabed Mounted Measurement Device Being Deployed (Source: Partrac)



7.12 Decommissioning

107 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 the Department of Energy and Climate Change (DECC) following the requirements of the *Energy Act 2004* outlined in *Chapter 3: Regulatory Requirements, Section 3.2.5*.

108 For the purpose of this ES 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 and Exclusion Zones

7.13.1 Construction

109 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 works and 50 m during the period of commissioning. 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.

110 It is standard safe working practice to establish exclusion zones 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.

111 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.

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

7.13.2 Operation

113 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 DECC. 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

114 During periods of major maintenance works and where a risk is posed to marine users or wind farm technicians, further temporary 500 m exclusion 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

115 The colouring, markings, 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

116 Consideration of the Project in this ES 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.

7.15.2 Location

117 The location of these onshore works has not yet been finalised. 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

118 Once onshore, the Export Cables will be routed underground and connect to the onshore substation. Electrical power from the Wind Farm will be transformed in the onshore substation for export to the national grid.

119 Installation will require a trench to be dug to accommodate the cables and for it to be reinstated following installations.

120 The trench, including a working area, would require a corridor approximately 40 m width. Temporary construction compounds, storage facilities, laydown areas and access/haulage tracks will be required for the onshore cable installation work. All temporary areas will be reinstated after use and waste will be disposed of in an appropriate manner.

7.15.4 Onshore Substation

121 Although there will be a number of onshore infrastructure components, the development of an onshore substation/converter station will be the primary onshore asset. If the transmission cables are HVAC then the footprint of the substation is estimated to be approximately 195 m (wide) by 105 m (long) and 25 m (high) and if DC then it will be approximately 210 m (wide) by 210 m (long) and 20 m (high).

122 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.

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