2 Project Details

2.1 Assessment of Alternatives

2.1.1 Wind Farm Site Selection Within Zone 1

2.1.1.1 In order to identify suitable areas for development within the MORL Zone, a zonal constraints assessment process was carried out (BMT Cordah & RPS, 2009; MORL, 2010b). This included an assessment of the known spatial constraints to wind turbine development associated with engineering properties of the area (e.g. water depth and geological properties where known) and physical (tidal currents and wave regime), biological (flora and fauna present within the area) and human (e.g. fisheries, aviation, navigation etc.) environmental constraints. All information used in the assessment was obtained from public sources.

2.1.1.2 With regards to wind farm development, the zone wide constraints were determined to be the following:

- Presence of marine mammals throughout the zone. It was not possible using available data to identify "hot spots" of marine mammal activity within the zone;
- Presence of seabirds throughout the zone. It was not possible using available data to identify "hot spots" of bird activity within the zone;
- Potential interference to military and aviation radar;
- Although levels of navigation were low through the zone, there was potential for interference to navigation through the zone area; and
- Potential interference to commercial fisheries. It was not possible using available data to identify "hot spots" of fisheries activity within the zone.

2.1.1.3 As the entire MORL Zone is over 22 km from the coastline, the majority of the zone was classified as having a potential low effect on seascape and landscape, based on guidelines from BMT Cordah Ltd (2003) and DTI (2005).

2.1.1.4 Of the entire zone, the Western Development Area (WDA) was considered at the time to have more significant spatial constraints to wind farm development (see Figure 2.1-1, Volume 6 a). These constraints included:

- Presence of a large section of the Ministry of Defence Practice Area (D807), at which time, an objection to turbine development was received from the Defence Estates because of the potential interference to aircraft training activities (now removed);
- Presence of a small section of buffer zone between wind turbine development in the Moray Firth zone and the adjacent Beatrice Offshore Wind Limited (BOWL) proposed wind farm;
- Potential for development of the Polly well within the Beatrice oil field (now agreed in principle);
- Potential interference to helicopter access within 6 nm of the existing oil platforms in the north-west of the zone[1];

[1] Note that since this assessment the consultation zone has increased to 9 nm

- Potential interference to the navigation access route to the existing oil platforms in the north-west of the zone; and
- Closer proximity to the Moray Firth and Dornoch Firth & Morrich More SACs, compared to the eastern section of the zone.

2.1.1.5 The main spatial constraints in the Eastern Development Area (EDA) included:

- Presence of a small section of the Ministry of Defence Practice Area (D807), at which time, an objection to turbine development was received from the Defence Estates because of the potential interference to aircraft training activities (now removed);
- Presence of a buffer zone between wind turbine developments in the Moray Firth zone and the adjacent Beatrice Offshore Wind Limited (BOWL) proposed wind farm (now agreed in principle);
- The presence of a consented route for the Scottish Hydro Electric Transmission Limited (SHETL) High Voltage Direct Current (HVDC) link from Blackhillock to the DC hub, Shetland and Caithness; and
- Overlap with a safety buffer zone associated with the SHEFA telecommunications cable.

2.1.1.6 When compared to the EDA, the WDA offered a more constrained development area. However, due to the aging nature of the Beatrice and Jackie platforms it was anticipated that some of these constraints may be alleviated over time. Therefore, it was decided that the EDA would be developed prior to the WDA. The EDA is large enough to allow the entire Project capacity of 1,500 MW to be developed within its boundaries. If the full capacity of the EDA is not realised, MORL may consider progression of the WDA up to a maximum of 500 MW (but within the overall 1,500 MW capacity for MORL Zone).

2.1.1.7 It was decided that the EDA should be divided into three different areas (Telford, Stevenson and MacColl). To identify the site boundaries within the EDA, detailed survey work and engineering analysis was carried out including geophysical and geotechnical surveys and a resource assessment in order to assess the technical suitability of the area. Environmental surveys were done in conjunction with extensive consultation which was undertaken for all receptors. This allowed an understanding of the environmental baseline to be developed which in turnallowed the site boundaries to be developed. The sites are shown in Figure 1.1-2, Volume 6 a.

2.1.1.8 The main reasons for the site divisions are:

- Maximisation of wind energy capture;
- Equitable distribution of the most favourable bathymetry between the three sites; and
- The geological properties of the area are split across the sites so that no one site has a significantly more technically challenging geology.

2.1.1.9 In addition to the constraints identified above in relation to the EDA other constraints present within the identified sites which were studied were:

- Use of the sites by conservation protected species (e.g. birds, marine mammals and salmon);
- Use of the sites by commercial fisheries (e.g. scallop fisheries and squid fisheries);

- Overlap of the Stevenson and MacColl sites with the outer sections of a consultation zone for obstacle free access to the Beatrice platforms for helicopters;
- Overlap of the MacColl site with the outer sections of the SHEFA cable safety zone;
- Interaction with civil and military radar coverage;
- Effect on seascape, landscape and visual receptors; and
- Installation of the SHETL HVDC (High Voltage Direct Current) link from Blackhillock to the proposed DC hub, Shetland and Caithness.

2.1.2 Evolution of the Rochdale Envelope

2.1.2.1 Extensive research has been undertaken in order to define the parameters of the Project. As explained previously a Rochdale Envelope is the range of parameters which set out the realistic maximum and minimum extents of the Project for the purpose of the consent applications. This allows the realistic worst case scenario to be identified for each EIA discipline being assessed. The formulation of the Rochdale Envelope incorporated successive concept engineering screening sessions. A weighted risk matrix to assess each concept / parameter in detail, rating them against the following key drivers:

- Health and Safety (above the "As Low As Reasonably Practical" standard);
- Consenting;
- Cost;
- Wind farm performance; and
- Technical risk.

2.1.2.2 An example of the rating classification is shown in Table 2.1-1 below. From this a detailed spreadsheet was created, detailing all engineering parameters that were considered feasible for the Project. Environmental input was also a key factor in these discussions to ensure consideration was given to possible consenting risks. The Rochdale Envelope was gradually refined through continuous review of risk matrix considerations detailed above along with a consenting / environmental perspective. This has given MORL the finalised Rochdale Envelope that has been taken forward within the environmental impact assessments in this Environmental Statement (ES). Table 2.1-3 below indicates some of the key decisions involved in the refinement of the Rochdale Envelope and the reasons these were made.

2.1.3 Transmission Infrastructure

2.1.3.1 In August 2010 MORL was offered a grid connection at Peterhead Power Station, approximately 88 km south east of the zone. Following this connection offer, an Export Cable Feasibility Study was commissioned (Metoc- Hyder, 2011; Technical Appendix 2.1 A). This study aimed at identifying options and assessing feasibility for 2 km route corridors for export cabling (onshore and offshore) and landfall points, taking into account the likely environmental issues, engineering and health and safety constraints. The study identified potential onshore substation locations (see Figure 1.1-5, Volume 6 a.) Discussions are ongoing with landowners to determine the exact location and layout of the substation(s) on land within the preferred onshore substation area. This will be finalised following production of a masterplan by the owner / operator of the Peterhead Power Station compound which forms part of the preferred area.

2.1.3.2 Criteria based on SHETL guidelines, United Kingdom Cable Protection Committee (UKCPC) recommendations and other best practice were used to define potential marine cable routes (see Table 2.1-2 below).

Table 2.1-1 Concept Engineering Weighted Risk Matrix

Key Driver	Classification of Contribution		
	-3	**0**	**+3**
Safety relative to ALARP	Elements of increased personnel risk and complex technical safety would be difficult to achieve ALARP.	Tolerable level of personnel and technical risk requires some mitigation to achieve ALARP.	Especially safe in operation, personnel exposure.
Consenting	Risk of a severe / significant effect - potential show stopper.	Risk of moderate / minor effect which could result in acceptable permit conditions.	Opportunity for environmental enhancement.
Cost	Significant risk of exceeding target costs requiring significant project management resource.	Tolerable risk of effect on target costs requiring some project management resource.	Potential opportunity to reduce costs.
Execution Schedule	Significant effect on First Generation date.	Ability to meet First Generation date.	Accelerate First Generation date.
Wind Farm performance	Risk of serious adverse effect on performance, availability and energy losses.	Potential minor effect on performance, availability and energy losses.	Negligible effect on performance, availability and energy losses.
Technical Risk	Unproven technology with very little track record.	Technology with only / short track record.	Proven technology with track record.

Table 2.1-2 Criteria Used to Define the Potential Marine Cable Routes

Criteria	Factors to be Considered
Cable route length	Minimising cable length should minimise environmental impacts, cable manufacturing and installation costs. The carbon footprint associated with cable manufacture and installation is also directly dependent on the cable route length. The optimal route will ultimately be the shortest feasible route which takes into account the environmental and technical constraints listed below.
Minimise complexity of installation works through choosing optimum water depths **Minimise length of the intertidal area** **Maximise extent of cable route in water depths between 10 to 200 m**	Landing a cable through intertidal areas is typically the most challenging aspect of a cable installation as it represents the inter-face between land and vessel based operations. Both land and marine operations need to be coordinated and the handling of the cable, from the vessel on which it is being held to shore, managed. The tidal regime of the area may also severely constrain the time available for installation operations. A water depth of 10 m is used as an average cut-off for a typical large cable handling vessel. If a route contains sections in shallow water then the larger main installation spread may be unable to operate, requiring an additional cable handling vessel. Sections of cable may also need to be cut and rejoined. Cables need to be designed to resist installation forces, including tensile strains produced during installation and any subsequent recovery for repair. For power cables, the tensile strength is distributed through the cable structure with much of it being provided by the external 'armour' wires. In water depths of 200 m or less, only one layer of armour wires will generally be needed. In water depths greater than 200 m, it is possible that two layers of armour wires may be needed increasing the capital cost of the cable. Waters deeper than 200 m are, therefore, avoided where possible.

Criteria	Factors to be Considered
Maximise potential for cable burial	In order to ensure optimal burial depths can be achieved and maintained for as much of the route as possible, known areas of exposed bedrock, or bedrock with thin covering of sediment, should be avoided during cable routing. Similarly, if there are possible areas of glacial till or boulder clay, which could make installation more challenging, these should be avoided.
Minimise potential for cable re-exposure during operation	Avoid areas of high sediment mobility, such as mobile estuaries, mobile sandbanks and sandwaves, which could result in subsequent exposure and / or spanning of the cable. In certain cases, deeper burial beneath the mobile layer can be achieved by dredging through sandwaves or using specialist tools such as the "vertical injector". Deeper burial increases insulation of the cable and can reduce efficiency of electricity transmission due to thermal heating effects, depending on seabed characteristics and cable capacity. Some cables can be "over-engineered" to resolve this issue, although this may not be possible depending on the cable capacity. Furthermore, whilst routine maintenance work can be undertaken to re-bury exposed cables, cables in highly mobile environments are at risk of damage and or failure which is not an ideal long term scenario, both in terms of cable protection and the environmental impacts associated with ongoing maintenance works. In protected and / or sensitive seabed areas environmental and consenting issues could complicate the feasibility of regular maintenance works, causing delays or restrictions to maintenance work.
Avoidance of sensitive environmental areas. Where it has not been possible to avoid conservation areas, route length within these areas to be minimised	Avoid existing Natura 2000 sites (SACs and SPAs), national protected sites (SSSIs, Marine nature reserves), possible future SACS and SPAs (Annex I habitat, areas of search for offshore SACs). Where routes within protected sites are unavoidable, the interest features of the site should be considered to determine whether the cable can be installed and operated without causing significant environmental effects. The following general principles can be followed in discussion with the relevant conservation bodies: • Seasonal sensitivities. For example: if a site is designated for wintering birds, the Project's installation programme can be scheduled to avoid impacts during the sensitive period. With such mitigation measures implemented routing within the area may be acceptable. If the site is designated for both wintering and breeding birds the seasonal restrictions that are likely to be applied to the Project may be too onerous for the installation to be feasible; • Mobile species: From the point of view of cable installation and operation, the key impact on mobile species (seabirds at sea, fish, mammals) is disturbance during installation activities, which is generally a minor impact that can be managed. However, if the species is breeding, impacts can be more significant; • Benthic species: For benthic species or habitats, significant impacts may be harder to avoid and therefore the cable should be routed away from sites designated for such features if possible. This is particularly true for habitats which do not recover well from disturbance, such as rocky or biogenic reef (mussel beds, *Sabellaria* etc), piddocks in clay, or saltmarshes. Lower significance impacts are likely for mobile sands and muds supporting invertebrates, which do have higher recovery rates, and therefore routing in such areas may be more feasible; • Spawning and nursery areas: Areas where fish spawn on the seabed (such as herring) should be avoided if possible, although if this is not possible the impact can be managed through seasonal restrictions to installation works. Pelagic (in the water column) spawning areas are widespread and cable routing can be undertaken in these areas without significant environmental effects; and • EMF and Heating: Possible issues associated with EMF and heating impacts on sensitive species should also be considered. The significance of this potential impact cannot be determined at this stage, but EMF impacts are likely to be more of a concern in rivers / estuaries where salmon and trout migrate.
Avoidance of areas where there is an increased risk of damage to the installed cable	The following areas should be avoided due to the increased risk of damage to the buried cable: • Known dredging areas should be avoided by a minimum of 500 m where possible; and • Known anchorage areas should be avoided by a minimum of 500 m where possible. Areas containing high levels of munitions contamination should be avoided by cable routing. Munitions are known to migrate along the seabed depending on hydrodynamic conditions and sediment transport pathways operating in the area of concern. Therefore the presence of munitions on the seabed, outside of such areas, cannot be discounted and a survey should be targeted towards establishing the presence and location of munitions on the seabed, where the cable passes in the vicinity of disused munitions disposal sites.

Criteria	Factors to be Considered
Minimise crossings with cables and pipelines	The number of crossings with existing and proposed cables and pipelines should be minimised. Undertaking crossings with existing cables necessitates placement of rock berms or mattresses to ensure the cable is protected at the crossing, where burial is not possible. Installation of a crossing increases the environmental impacts of the Project. It results in a permanent structure on the seabed, which will smother the marine life beneath it, and introduces a different type of sediment, which may locally alter the marine ecosystem. The rock berms on the seabed can also represent an obstruction to fishermen, who may risk snagging their gear. Crossings are also financially costly, and may involve lengthy legal discussions with the cable or pipeline owner. A Crossing Agreement (CA) is a voluntary agreement with the crossed party, although it is generally required under the Crown Estate lease, and proceeding with crossings without having obtained the necessary agreements is not recommended. If any pipelines or cables are to be crossed, the crossing angle should be as close to 90º as possible. Any cables and pipelines not crossed should be avoided by a 500 m exclusion zone. Cable routing parallel with existing cables and pipelines should be avoided if possible. Cables and pipelines will have a seabed lease which gives a 250 m no-works zone and a further 250 m notification zone either side of the cable. This is necessary to allow access for repairs, and also should a repair be undertaken, the cable will be re-laid on the seabed in a loop, potentially increasing its proximity to the other cables than previously. Specific measures for individual pipelines and cables will need to be confirmed with the owner / operator.
Avoid existing and proposed seabed developments.	Areas which are currently licensed for other uses or involve physical infrastructure on the seabed need to be avoided. This includes: • *Licensed dredging areas:* The license holder has exclusive rights to the seabed in the licence area; • *Oil and gas infrastructure*: Operational wells platforms operate a 500 m exclusion zone which should be avoided by cable routing. Cable routing is not excluded through oil and gas fields, or licence blocks, as oil and gas developers do not have exclusive seabed rights to the entire block. Plugged and abandoned wells should be avoided as they represent seabed structures over which the cable cannot be buried, but the 500 m exclusion zone is not required; and • *Existing and proposed sites for offshore renewables* (e.g. wind farms, or wave or tidal arrays) should be avoided by a 500 m exclusion zone. Cable routing through the R3 development zones should be avoided if possible, due to the current uncertainty as to where specific wind arrays will be placed and the possible need for additional crossings. However, the Crown Estate has confirmed that the offshore wind developers do not have exclusive rights to the seabed in the R3 zones and cable routing through the zones is permitted. The cable route should seek to develop a route which minimises interactions with the future development of the zone, such as routing adjacent to an existing cable, or through the area of highest shipping activity within the zone. Whilst shipping activity precludes turbine placement, installation of a cable in this area is likely to be acceptable as the buried cables are not an obstruction to shipping. Routing adjacent to an existing cable is converse to the point above regarding avoidance of running adjacent to existing cables, however it may be an acceptable compromise for routing through R3 zones.
Minimise interference with shipping and navigation	Cable installation in certain areas may be unacceptable to the relevant port authorities due to conflicts with their normal operations. This should be determined through discussion with the relevant port authorities. However, should cable installation works restrict key approach channels to major ports, even for a short period of time, this may be considered unacceptable. Port authorities issue licences to undertake marine works in their area of jurisdiction and they can reasonably refuse to issue them. Cable installation may also not be permitted across areas where regular channel maintenance dredging is undertaken by a port authority. This would also be undesirable from the perspective of maintaining cable burial depths and should also be avoided for this reason.
Marine archaeology	The cable route centre-line should avoid wrecks by a 100 m exclusion zone. Positions of known wrecks, and previously unrecorded wrecks will need to be confirmed during cable route survey, and micro routing may be required as a result. Certain wrecks are given additional protection under the Protection of Wrecks Act or the Protection of Military Remains Act, and such wrecks may have a specific exclusion zone designated around them, which would need to be avoided for any seabed disturbing works being undertaken as part of the cable installation.
Military practice areas	The existence of military practice and exercise areas does not generally preclude the installation or operation of marine cables. However, consultation with the MoD has been undertaken to confirm this, where relevant.

2.1.3.3 Criteria adapted from the Holford rules2 were used to identify potential onshore underground cable routes.

2.1.3.4 The criteria that were used to identify potential onshore underground cable routes are:

- Consider avoiding areas of environmental designation in which underground cable construction, operation or decommissioning might affect the purpose of designation;
- Consider the ground and slope conditions along the route into which the cable system must be installed. Consider whether the ground is stable and can it reasonably be expected to remain stable and suitable for the service life of the cable system. Consider if the ground is suitable for use in reinstatement to avoid the need for imported backfill;
- Consider the practicality of moving any obstructions which would constrain the cable route;
- Consider whether the cable route will have an adverse effect on the local and surrounding environment. Consider whether this effect be mitigated by route selection;
- Consider whether the cable route can be viewed from above, and if so, what length will be seen, at what distance, over what type of ground cover, with what probability of successful long term reinstatement;
- Consider whether the cable route is one within which it is safe to construct a cable system. Consider, if constructed, will the cable system provide the required service life? Will the system be economic and maintainable? Will the installation be safe and have an acceptable level of reliability when in operation for owners, operators and third parties?;
- Consider the disruption the construction, operation and decommissioning of a cable route would cause to third parties, is it possible to mitigate and is it possible to do this by route selection?;
- Consider avoiding wet areas and habitats that are sensitive to the construction, operation and decommissioning of underground cables, particularly habitats that are difficult to reinstate successfully;
- Consider avoiding areas known to be occupied by protected species and / or their habitats;
- Consider following existing linear features particularly those that have already created habitat disturbance such as existing overhead lines or habitat and hydrological disturbance such as roads or railways;
- Consider access for construction and operation. Consider use of existing roads and tracks and consider the existing road network in terms of the effects of road closure and disruption. Consider the use of existing crossings / structures at roads and railways. For river crossings consider height and steepness of banks, substrate and width of river and use of existing structures;
- Detailed Routing Considerations:
  - Preferable to avoid areas of flooding for joint bays;
  - Preferable to avoid steep side slopes (cross slopes) and gradients;

[2] Holford Rules are guidelines for the routing of new high voltage overhead transmission lines

  - Preferable to follow existing linear features, particularly those that have already created disturbance, such as roads or existing overhead line wayleaves;
  - Preferable to make as much use of existing access as possible but preferable to avoid reliance on rural roads that would require alteration;
  - Preferable to avoid loss of landscape features such as individual trees, hedges, semi-natural and other woodlands and commercial forestry, preferable to utilise existing gaps;
  - Preferable to cross water courses and other infra-structure at the most accessible points;
  - Preferable to avoid known archaeology;
  - Preferable to avoid water supplies;
  - Preferable to avoid areas where excavation or ground levels may change in the future;
  - Preferable to avoid areas with unstable, contaminated or high thermal resistivity ground; and
  - Preferable to avoid settlements, particularly those with a concentrated pattern of development.
- Deviation Considerations:
  - Avoid if possible unknown archaeology when it is identified;
  - Avoid if possible the root zones of semi-mature and mature trees;
  - Avoid if possible cable route obstructions such as large boulders;
  - Avoid if possible ground with high thermal resistivity;
  - Avoid if possible unsafe, unstable or contaminated ground;
  - Avoid if possible protected species and / or their habitats particularly during the breeding season;
  - Avoid if possible close proximity to existing overhead lines, cables and other system equipment which may require system outages; and
  - Avoid if possible close proximity to other utilities and services.

2.1.3.5 The Metoc-Hyder study (Technical Appendix 2.1 A) assessed the following options:

- Thirteen potential offshore transmission infrastructure (OfTI) cable routes;
- Three primary potential onshore transmission infrastructure (OnTI) cable routes, branching out to connect to OfTI routes close to the coast;
- Eleven proposed landfall points; and
- A 2 km route corridor.

2.1.3.6 These routes were ranked against environmental, engineering and economical parameters such as:

- Proximity to designated sites;
- Proximity to sensitive environmental features;
- Proximity to known archaeological features;

- Potential effect to identified commercial fishery grounds;
- Proximity to anchorage areas;
- Number of cable & pipeline crossings;
- Installation techniques required;
- Potential landscape / visual effects;
- Number of water courses along the onshore route; and
- Onshore site access.

2.1.3.7 Figure 2.1-2, Volume 6 a shows a map of the route options.

2.1.3.8 Based on the above environmental, technical and economic criteria, the initial 13 offshore routes identified were narrowed down to eight landfall points (Portgordon, Sandend, Inverboyndie, Fraserburgh Beach, Fraserburgh Golf Car Park, Philorth, Inverallochy and Rattray), and the offshore route corridors were reduced down to a width of 500 m (for environmental assessment the route corridor was widened). These eight landfall points and associated onshore and offshore routes were then taken forward into a stage 1 concept engineering study by JP Kenny (JP Kenny, 2011; Technical Appendix 2.1 B). As part of the preparation of the JP Kenny report, there was consultation on the routes identified by Metoc-Hyder with fisheries groups including the Scottish Fishermans' Federation (SFF) and the Inshore Fisheries Group (IFG).

2.1.4 Concept Engineering Study

2.1.4.1 The objective of the stage 1 concept engineering study for the export cable route was to develop, evaluate, compare and rank cable route options from the offshore AC / DC substation to the onshore connection point at Peterhead. The eight landfall points identified in the Metoc-Hyder study were assessed in this study against engineering, physical / third party constraints and environmental and seabed use constraints (see Technical Appendix 2.1 B). GIS data and associated constraint mapping were generated to conduct a detailed desktop route selection process. From this study it was concluded that four landfall points be taken forward to the next stage of Concept Engineering - Sandend, Inverboyndie, Fraserburgh Beach and Rattray North and South (Figure 2.1-3, Volume 6 a). It became clear that the other route options being considered had various inadequacies that made the concept untenable.

2.1.4.2 Concept engineering stage 2 looked at the remaining four routes developing indicative cost estimates and comparing each option against relative complexity, risk and cost.

2.1.4.3 Stage 3 of the study took on board updated information that had become available with the goal to provide finalised preferred offshore and onshore routes. This study had similar objectives to stage 1: Concept Engineering (i.e. to develop, evaluate, compare and rank cable route options). The study considered route options from the AC / DC offshore substation to the connection point at Peterhead. Additional ranking criteria was introduced at this stage comprising socio-economic considerations, risk and through-life cost. As a result of the iterative routing process for option screening, two routes were retained at the end of stage 3: Fraserburgh Beach North and Rattray North. A key input at this stage was discussion between MORL and fisherman in the Moray Firth area, these routes were ultimately agreed on through discussion and taking into account the fisherman's recommendations.

2.1.5 Final Route Selection

2.1.5.1 The offshore routes that were identified for the landfall points at Fraserburgh Beach and Rattray shared a common transmission route corridor for 79.85 km, until they respectively split and run aground at the landfall points; the separation occurs at coordinates, 571778.6, 6403338.5 (WGS84 UTM30N)(Figure 2.1-4, Volume 6 a). The offshore export cable route into Fraserburgh 103.52 km in distance, Rattray is 109.18 km. The principal engineering constraints consisted of substrate condition (i.e. type of sediment and water depth and avoidance of the Southern Trench); while environmental constraints consisted of species distribution within the cable route, as well as navigational and commercial fishing activity.

2.1.5.2 The onshore cable routes from Fraserburgh and Rattray are separate until they join into a common cable route, 3.95 km from the connection point at Peterhead (Figure 2.1-4, Volume 6 a); the onshore export cable route from Fraserburgh is 29.38 km in its entirety and from Rattray the route is 17.58 km. The key engineering constraints were in relation to topography and slope, physical and third party constraints relating to minimal crossings and obstructions, avoidance of complicated land use issues, private properties and built up areas. Potential environmental effects were also considered at this stage (i.e. the avoidance of designated sites for conservation, avoidance of key known ecological and hydrological sensitive areas etc.).

2.1.5.3 Further engineering and environmental studies were undertaken on both routes to understand the advantages and disadvantages of each option; consideration of the landfall point itself had an influence on this. These further studies comprised of option screening sessions between the MORL management team to rank competing export cable routes offshore and onshore to Peterhead. Ultimately, it was decided that the cable route via Fraserburgh was the favoured option over Rattray Bay, the key reasoning for this is as follows:

- Schedule risk and technical risk slightly higher for Rattray approach to shore;
- Greater potential environmental effect along parts of the Rattray-Peterhead onshore route;
- More challenging geological conditions at Rattray;
- Longer offshore cable route for Rattray option leading to increased difficulty for cable burial;
- Rattray onshore cable route has a higher number of ecological sensitivities;
- Less landowner negotiation required for the Fraserburgh onshore export cable route (i.e. in the event that the onshore export cable is located within a disused railway line within the onshore export cable route, 30 % of the Fraserburgh route would be under single ownership of Aberdeenshire Council);
- High number of onshore cable pipelines near Rattray offshore cable route; and
- Higher cost at Rattray due to requirement of directional drilling at the landfall point over trenching. No significant engineering / construction difficulties for the Fraserburgh option.

2.1.6 Landfall Selection

2.1.6.1 Appraisal of the potential landfall sites took into account the physical coastal area, from the perspective of engineering or environmental constraints, but also the offshore approach and onshore exit path. The principal characteristics of an ideal landfall point include:

- Flat sandy beach;
- Avoidance of rocky areas and cliffs;
- Sufficient space for installation infrastructure;
- Good access; and
- Avoidance of key environmental and engineering concerns.

2.1.6.2 An updated single offshore and onshore cable route was finalised; Figure 1.1-4, Volume 6 a details the extent of this route corridor. This is the route that has been taken forward and considered in all impact assessments with this ES. An exact onshore export cable route will be defined prior to submission of the onshore planning application to Aberdeenshire Council.

2.1.7 Offshore DC Hub Connection

2.1.7.1 SHETL has made proposals for an offshore HVDC hub, which would be located to the north east of the MORL Zone. This has not yet received consent but is in development in order to reinforce the network and support renewable energy connections from Caithness and Shetland. The current regulatory regime does not allow MORL to apply for a connection directly to this infrastructure. However, consultation is underway with the relevant regulatory authorities to allow MORL to pursue this connection option.

2.1.7.2 Despite MORLs continued support of the Hub's development, since the Hub is unconsented and un-built and given the high level of uncertainty regarding connection due to the regulatory regime, MORL is unable to treat the Hub as an option at the present time. The Hub option has therefore not been considered further in this ES other than as a development included where relevant (on the basis of the limited information currently available) in the Cumulative Effect chapters in Section 6.

2.1.8 Onshore Substation Location

2.1.8.1 MORL, or the subsequent subsidiary, will be installing two DC onshore converter stations to convert the electricity exported in DC to AC for a suitable connection to the National Grid. These convertor units will be co-located in a single holding close to Peterhead Power Station. An exact location is yet to be decided, but a preferred area has been identified (see Figure 1.1-5, Volume 6 a). Discussions are ongoing with landowners to determine the exact location and layout of the substation(s) on land within the preferred onshore substation area. This will be finalised following production of a masterplan by the owner / operator of the Peterhead Power Station compound which forms part of the preferred area. In the meantime assessments have been carried out based on a location within the Peterhead Power Station compound.

2.1.9 Continued Refinement of Rochdale Envelope

2.1.9.1 Further concept engineering studies and screening sessions gradually refined the Project parameters, balanced by both engineering and environmental considerations, the Project parameters were continuously streamlined with the greater amount of information that was available. Key Project parameter refinements are shown in Table 2.1-3 below.

Table 2.1-3 Key Rochdale Envelope Project Parameter Refinements

Key Rochdale Envelope Refinements	**Reason for Refinement**
Removal of semi submersible moorings as a potential substructure / foundation. Initially removal from purely wind turbine structures, however, this method was eventually screened out for OSP's	• High cost; • High technical risk; and • Concern of Fishing Industry Representatives.
Selection of HVDC transmission over HVAC	Consideration of: • Cable length; and • Voltage stability.
Selection of Fraserburgh Beach as the preferred landfall point	• Potentially simpler landownership; and • Technically favourable landfall approach.
Monopiles removed as potential substructure	• High cost; • High technical risk; and • Noise level.
Reduction of the consideration of 3.6 MW turbines across all three proposed wind farm sites to solely one site (i.e. reducing the overall environmental impact through the requirement of less machines).	• High technical risk; • Increased periods of piling noise due to number of structures required to reach capacity; • Wake effects; • Technological innovation; and • Higher capacity easier to achieve with larger machines.

2.1.9.2 As engineering studies progress the Project detail will continue to be refined and focused. The requests for Information (RFI) / Requests for Proposal (RFP) process and Front End Engineering Design (FEED) process help to develop a single Project, the environmental effects of which will not exceed the effects of the Rochdale Envelope assessed and submitted within this Environmental Statement. This process will be ongoing both during and after the consent determination period.

2.2 Project Description

2.2.1 Rochdale Envelope Approach

2.2.1.1 A Project Design Statement (PDS), which outlines the proposed infrastructure, and the construction, operation and decommissioning methods can assist the EIA process. In the case of offshore wind developments of the proposed scale of the Project, the developer must apply for consents several years in advance of commencing the construction process. At this stage, an extensive amount of engineering design has been carried out. However, much of the infrastructure (i.e. the larger 7 / 8 MW turbine) is still at the concept stage and will not be ready until closer to construction.

2.2.1.2 Detailed engineering will be stepped up again once consents are awarded. This is because of the costs associated with the detailed engineering process and particularly because it allows for further development and trialling of novel techniques and methods which are currently emerging allowing developers to take advantage of this progress. Therefore, the applications for consent will set out a scheme of parameters which is known as a Rochdale Envelope. The range of parameters sets out the maximum and minimum extents of project components that have been assessed. The effects identified in the assessment of these components form the scope of the effects that the proposed Project may give rise to. Therefore, in subsequent phases of the engineering design process, the development must be within the scope of the scope of the assessed effects.

2.2.1.3 The concept engineering for the Project has been completed and the range of concepts suitable for the infrastructure, and construction and operation methodologies identified. This range of concepts was critically assessed, refined and narrowed down to produce the Rochdale Envelope. The Rochdale Envelope for the Project is explained in full in this Project Description. Specific examples of instances where the Rochdale Envelope has been refined can be found in Table 2.1-3 in Chapter 2.1 (Assessment of Alternatives).

2.2.1.4 For the EIA, the realistic worst case scenario based on the options within the Rochdale Envelope has been assessed. The realistic worst case scenario can vary between receptors, therefore, a summary of the parameters relevant to each assessment is provided at the start of each discipline impact assessment.

2.2.2 Rochdale Envelope – Parameter Plan

2.2.2.1 Table 2.2-1 and Table 2.2-2 below provide a summary of the component parameters assessed, which are fully discussed in 2.2.6 and 2.2.7 below.

Table 2.2-1 Wind Farm Parameters

Infrastructure Type	Parameter	Parameter Range
Wind Turbine Generators (WTGs)	Number in Site 1	63 to 139 turbines
	Number in Site 2	63 to 100 turbines
	Number in Site 3	63 to 100 turbines
	*The order of site construction of the Telford, Stevenson and MacColl wind farms will be determined pending further detailed site analysis, accordingly the order of build is flexible. If the 3.6 MW turbine is selected it will only be built out in Site 1.	

Infrastructure Type	Parameter	Parameter Range
Wind Turbine Generators (WTGs) **(continued)**	Rating	3.6 to 8 MW
	Hub height	97 to 118 m
	Rotor diameter	120 to 172 m
	Blade width range	4.2 to 5.8 m
	Max tip height	162 to 204 m
	Minimum air draft (i.e. minimum clearance between blade tip and LAT)	22 m
	Rotational speed range	4 to 15.1 rpm
	Spacing	
	Downwind Crosswind	840 to 1,720 m 600 to 1,376 m
Substructure & foundation for WTG's: **Concrete Gravity Base Foundations with Ballast and a gravel / grout bed**	Work platform size (at base on turbine)	45 x 45 m
	Base width	65 m
	Gravel / grout bed diameter	75 m
	Excavated bed + scour protection diameter	95 m
	Max dredger affected diameter	125 m
	Max bed excavation depth	5 m
	Max gravel bed depth	2.5 m
Substructure & foundation for WTG's: **Steel Lattice Jackets with Pin Piles**	Jacket base width	60 m
	Number of legs / piles	3 to 4
	Max Diameter of piles	2.5 m
	Max Length of piles	60 m
	Max scour protection around each leg plus pile diameter	16 m
Inter–array cabling	Indicative number of strings per site	7 to 12
	Capacity of each string	Up to 36 MW
	Configuration of strings	Branched or looped
	Voltage of cabling	33 or 66 kV
	Entry / exit method to WTGs and OSPs	J tube
	Target burial depth in seabed	1 m

Infrastructure Type	Parameter	Parameter Range
Inter–array cabling (continued)	Protection where burial not achieved	Rock placement, concrete mattresses / concrete tunnels / grout bags, Proprietary steel / plastic ducting / protecting sleeves.
Meteorological Mast	Number to be installed as part of the proposed Project	1
Met–mast style and substructure & foundation: Option 1 – Steel lattice met mast on a monopile	Indicative diameter of monopile	4.5 m
	Mast tip height at LAT	Up to 150 m
Met–mast style and substructure & foundation: Option 2 – Steel lattice met mast on a ballasted concrete gravity base with gravel / grout bed	Dimensions are expected to be no greater than those of the gravity base for a WTG	
	Mast tip height at LAT	Up to 150 m
Met–mast style and substructure & foundation: Option 3 – Steel lattice met mast on a steel lattice jacket with pin piles	Dimensions are expected to be no greater than those of the jacket substructure for a WTG	
	Mast tip height at LAT	Up to 150 m
Met–mast style and substructure & foundation: Option 4 – LIDAR on a floating spar with moorings which are weighted or anchored to the seabed	Indicative spar diameter	1 to 2 m
	Indicative spar height from top to bottom	c. 35 m
	Indicative work platform diameter	3 m
	Indicative height above sea level	10 m

Table 2.2-2 Transmission Infrastructure Parameters

Infrastructure Type	Parameter	Parameter Range
AC OSPs	Number required	3 to 6
	Indicative topside width x length	100 x 100 m
	Indicative maximum height above LAT	70 m
AC / DC OSPs	Max number required	2
	Indicative dimensions are as per AC OSPs above	
Substructure & foundation for OSPs: Concrete Gravity Base Foundations with Ballast and a gravel / grout bed	Base Width	Max 130 m
	Gravel / grout bed diameter	Max 140 m
	Excavated bed + scour protection diameter	Max 160 m
	Max dredger affected diameter	190 m

Infrastructure Type	Parameter	Parameter Range
Substructure & foundation for OSPs: **Concrete Gravity Base Foundations with Ballast and a gravel / grout bed** **(continued)**	Max bed excavation depth	5 m
	Max gravel bed depth	2.5 m
Substructure & foundation for OSPs: **Steel Lattice Jackets with Pin Piles or Suction Caissons** **Or** **Steel Lattice Jack–up with Pin Piles or Suction Caissons**	Jacket base width	Up to 100 m
	Number of legs / piles or suction caissons (Jacket)	Up to 8 legged / 8 piles
	Number of legs / piles or suction caissons (Jack up)	4 legged / 16 piles
	Diameter of piles	3 m
	Length of piles	60 m
	Scour protection around each leg plus pile diameter	16 m
	Diameter of suction caissons	20 m
	Scour protection around each leg plus suction caisson diameter	40 m
Inter–platform cabling	Voltage	220 kV
Peterhead onshore grid connection via Fraserburgh Beach landfall		
Export cabling (offshore)	Cable configuration	2 bundles of 2 cables
	Cable bundle separation distance	4 x water depth (200 to 800 m), as per regulation
	Voltage of cabling	320 kV
	Entry / exit method from OSPs	J tube
	Target burial depth in seabed	1 m
	Protection where target burial not achieved	Concrete mattresses or rock placement
	Cable corridor width	Two x up to 6 m trench
	Cable corridor length	Approximately 105 km
Export cabling (onshore)	Location	Underground
	Route length	Approximately 30 km
	Number of trenches / conduits	1 to 2
	Width of trenches / conduits	Single trench – two 3 m trenches Combined trench – 4 to 5 m trench

Infrastructure Type	Parameter	Parameter Range
Export cabling (onshore) (continued)	Voltage of cable	320 kV
	Target burial depth	1 m
Onshore converter substation(s)	Number of converter units	2
	Compound dimensions	200 x 170 m

2.2.3 Introduction

Wind Farm Sites

2.2.3.1 As previously mentioned, MORL holds a Zone Development Agreement with The Crown Estate for Zone 1 of Round 3, in the Moray Firth. Within the MORL Zone, MORL has phased the development priorities with the first phase of development activities happening in the east of the site, the EDA. MORL holds three Agreements for Lease (AfL) with The Crown Estate for three separate sites within the EDA (Telford / Stevenson / MacColl). Later phases of development will concentrate on the western part of the Zone, the WDA (if less than 1,500 MW is constructed in the EDA). The MORL Zone, EDA and WDA can be seen in Figure 1.1-1, Volume 6 a.

2.2.3.2 MORL is applying for three consents for the three offshore wind electricity generating station sites within the EDA of the MORL Zone. The sites Telford, Stevenson and MacColl, which are shown previously in Figure 1.2-2, Volume 6 a and the area of each site is provided in Table 2.2-3 below. The sites are on the Smith Bank in the outer Moray Firth, approximately 22 km (12 nm) from the Caithness coastline. The water depths are between 38 to 57 m (21 to 31 ftm).

Table 2.2-3 Maximum capacities of Telford, Stevenson and MacColl

	Telford	Stevenson	MacColl	EDA
Area	93 km^2	77 km^2	125 km^2	295 km^2
Maximum capacity	500 MW	500 MW	500 MW	1,500 MW

2.2.3.3 Within the Zone, MORL aims to establish wind power generation to a capacity of 1,500 MW and holds a grid connection agreement for this output. The three proposed wind farm sites within the EDA, which are the subject of this Project description, will be developed ahead of any sites identified for the WDA. Maximum capacity within each individual wind farm site is 500 MW. The EDA is large enough to allow the entire Project capacity of 1,500 MW to be developed within its boundaries. If the full 1,500 MW is not constructed within the EDA then the WDA could potentially be progressed up to a maximum of 500 MW (but within the overall 1,500 MW capacity for MORL Zone).

2.2.3.4 The infrastructure associated with the three proposed wind farms will comprise of the following:

- Turbines and associated substructures and foundations;
- Inter–array cabling; and

- Offshore met mast (within one site only but location to be confirmed) in addition to the offshore met mast which has already been consented (see 2.2.8 below for further details).

2.2.3.5 Details of the proposed wind farm infrastructure are provided in 2.2.6 below.

Offshore Transmission Infrastructure Owner (OFTO)

2.2.3.6 The three proposed offshore wind farm sites will be connected to the National Grid using transmission infrastructure (see 0 below). Although this will be operated by an OFTO, MORL intends to consent and potentially construct the infrastructure.

Transmission Infrastructure

2.2.3.7 A grid connection agreement is in place with the National Grid at the existing Peterhead substation (Figure 1.1-4, Volume 6 a). The transmission infrastructure that would be required to connect the three proposed wind farms to the Peterhead substation would include:

- AC offshore substations platforms (OSPs);
- AC to DC converter platforms (AC / DC OSPs);
- Cabling between the AC OSPs and AC / DC OSPs;
- DC export cable from the AC / DC OSPs to the onshore DC to AC converter substation at Peterhead (including export cable landfall);
- Onshore DC to AC converter substation(s); and
- Cabling between onshore converter substation and onshore AC collector station.

2.2.3.8 The proposed export cable route and boundary in which transmission infrastructure will be located can be found in Figure 1.1-4, Volume 6 a. It is possible that two of the OSPs will be located within a 2 km buffer area from the site boundary within the offshore export cable route. This buffer area is indicated by the dark green section in Figure 1.1-4, Volume 6 a.

2.2.3.9 Plate 2.2-1 below provides a visual summary of the division of ownership boundaries between the offshore wind farm infrastructure from that of the transmission infrastructure and that of the National Grid (NGET).

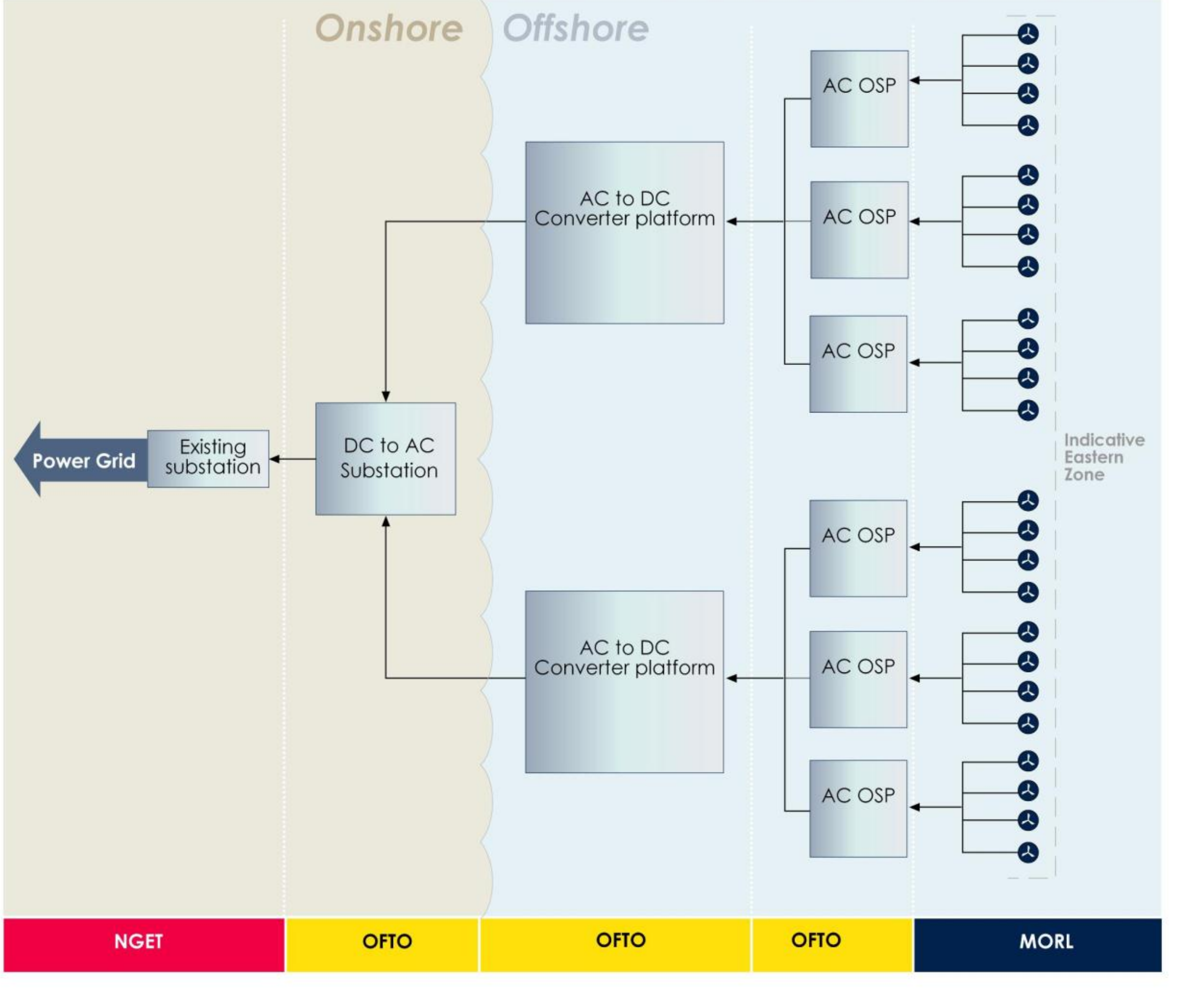

Plate 2.2-1 Diagram of Ownership of the Required Infrastructure Assuming a Connection at Peterhead[3]

2.2.4 Wind Resource

2.2.4.1 A preliminary assessment of the wind conditions at the EDA has been carried out using a hindcast calculation procedure (Plate 2.2-2 below). The operational Numerical Weather Prediction Model, IRIE, has been run over a ten year hindcast period. The hindcast has been made with an input of a four daily analysis from a boundary model field GFS. The wind conditions at the site have been analysed for the period 01/01/2000 to 01/01/2010. The weather conditions over Moray Firth are generally ruled by low pressures moving from the Atlantic on a track between Scotland and Iceland towards northern Scandinavia. The area is dominated by westerly flow, giving windy and unsettled weather with frontal passages most of the year, this westerly direction is dominant most of the year. During the months of April and May the most marked anomaly appears as a pronounced SE component due to high pressure.

[3] NOTE: Electrical design is indicative only and actual layout will be subject to detailed design optimisation

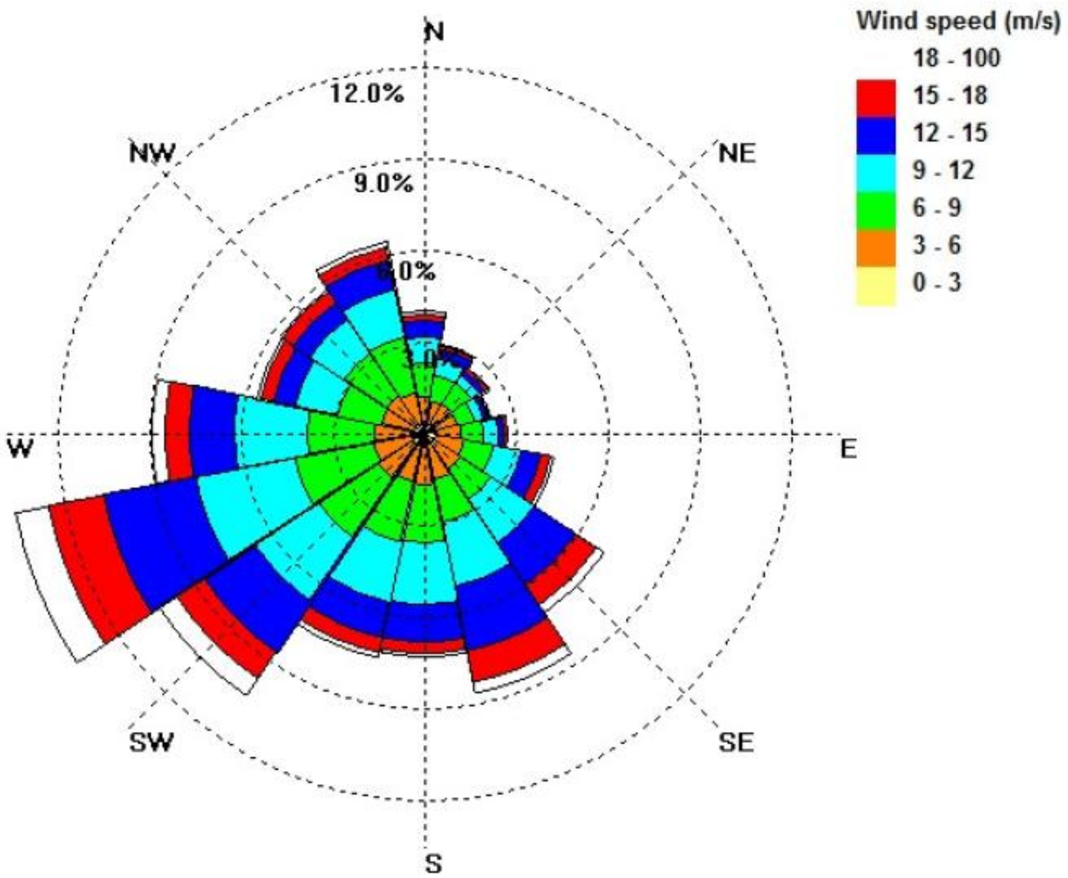

Plate 2.2-2 Results of Hindcast Calculation in Moray Firth

2.2.5 Construction Schedule

2.2.5.1 An indicative construction schedule for the three proposed wind farms and the transmission infrastructure is shown in Plate 2.2-3 below. The order in which the sites will be constructed has not yet been determined.

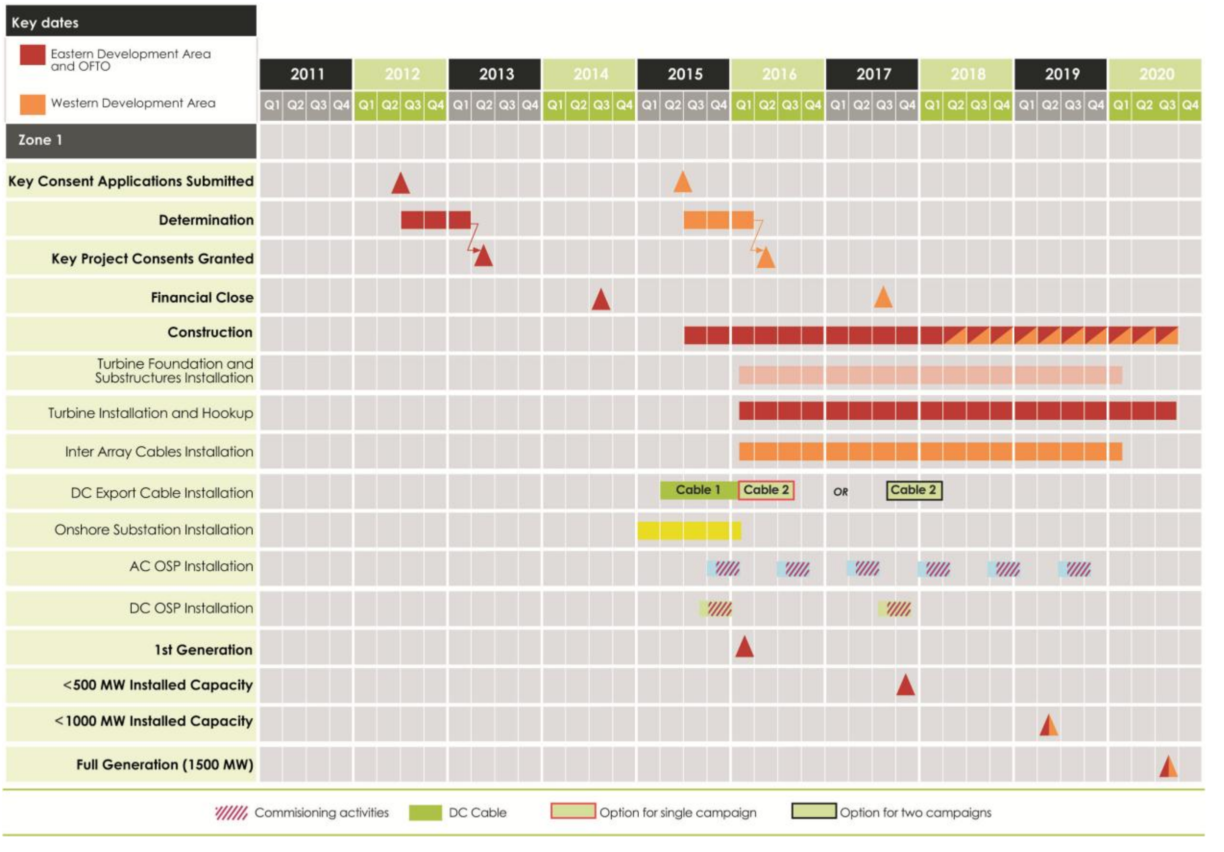

Plate 2.2-3 Indicative Installation Programme

*Date against key project consents granted is indicative, assuming 9 month consent determination period.

2.2.5.2 Construction of the three proposed wind farms and the transmission infrastructure is expected to take six years from commencement of the transmission infrastructure works to final commissioning of the wind farms. Construction of each single wind farm site could take up to two years with construction of the first site commencing in 2015, with the installation of the first AC OSP, and the completion of the third site in Q3 2020. The construction schedule will be 24 hours a day, 365 days a year.

2.2.5.3 The six year schedule is based on three key assumptions:

- The sites are constructed sequentially, but there is likely to be overlap in the construction between one site finishing and the next commencing construction;
- Each site has a maximum capacity of 500 MW made up of a maximum of 339 turbines over the three proposed wind farm sites (based on the overall limit of 1.5MW within the EDA). It should be noted that only one wind farm site could have maximum of 139 x 3.6 MW turbines (site 1) the other two sites will have 100 turbines or less and the specific site order has not been determined yet; and
- First generation of electricity will begin early in 2016, with full generation by 2020 upon completion of the installation of the third site.

2.2.5.4 Therefore, if a higher rated turbine is used in a site (and therefore less turbines are required) or a decision is taken to build a lower target capacity (see Table 2.2-3 above) or two or three sites are constructed concurrently, the construction programme could potentially decrease in duration. To accelerate the construction programme, MORL is considering the possibility of having six piling vessels working simultaneously to install foundations and substructures. This option may be required in the instance where separate project entities own the three projects and as such their programme inter–dependence will be decoupled. In this instance installation duration will decrease.

2.2.5.5 Up to six AC OSPs are anticipated to be installed at intervals between 2015 and 2019. The actual installation period is anticipated to take less than a month per substation.

2.2.5.6 The installation of the transmission works will commence in 2015 and offshore cabling works and AC / DC OSP installation will be completed either in 2016 or by mid 2018, depending on whether the total capacity is installed in one or two phases. The construction of the onshore converter substation(s) and the onshore export cable laying will commence in 2015 and will be completed by early 2016 to allow for first generation. Onshore export cable laying will ideally be undertaken during the summer months. In areas where there are no obstacles such as watercourses or roadways, it is estimated that between 200–1,000 m of cable can be laid per day, depending on the installation method.

2.2.6 Offshore Generating Station

2.2.6.1 The paragraphs under this heading outline the range of concepts for each category of infrastructure required for the three proposed wind farm sites. At the current time, the range of concepts is the same for each site. However, where there will be differences in the infrastructure within sites because of the timing of construction this has been clearly indicated. The specific infrastructure required for each site will be determined following further detailed engineering.

Wind Turbine Generators

2.2.6.2 Wind turbine generators (WTGs) are classified by turbine rating, which indicates the maximum electricity in megawatts production possible from the infrastructure. The models of wind turbine generators for the Telford, Stevenson and MacColl sites are expected to be of a rating between 3.6 to 8 MW. A specific manufacturer of wind turbine generator has not yet been identified because the market is currently undergoing significant changes in maximising the efficiencies of machines and developing and testing higher rated machines. At the current time, the 3.6 MW turbine is used extensively in the offshore wind industry and therefore is the most technically proven option. However, the 8 MW turbine category is the highest rated and largest wind turbine that is expected to be commercially and technically feasible within the Project timescales.

2.2.6.3 Any wind turbine model selected will be of proven technology and will conform to the standard design of a horizontal axis wind turbine with three blades attached at the hub to a nacelle, which houses the generator and other operating equipment, and a turbine tower. Table 2.2-4 below provides the range of dimensions associated with the turbine models currently on the market or in development. For the purposes of the Project description and impact assessments these categories correspond with the minimum and maximum ratings expected within each site. Plate 2.2-4 below illustrates a potential 7 and 8 MW turbine.

Table 2.2-4 Dimensions of the Four Generic Models of Turbine Proposed for the Telford, Stevenson and MacColl Sites

Rochdale Envelope Parameter	Dimension Ranges
Approximate hub height range	97 to 118 m
Rotor diameter range	120 to 172 m
Maximum blade width range	4.2 to 5.8 m
Maximum tip height @ LAT range	162 to 204 m
Minimum Air draft at HAT	22 m
Range of rotational speeds required for electricity generation	4 to 15.1 rpm

2.2.6.4 It should be noted that the turbine parameters presented for the 5, 7 and 8 MW generic turbine design represent the rotor diameters of current model designs. The parameters may change as the technology develops but is expected to remain within the presented Rochdale Envelope.

2.2.6.5 The colouring, markings, lighting and foghorn requirements for the wind turbines within the sites will be agreed with the appropriate authorities (e.g. Northern Lighthouse Board, Civil Aviation Authority).

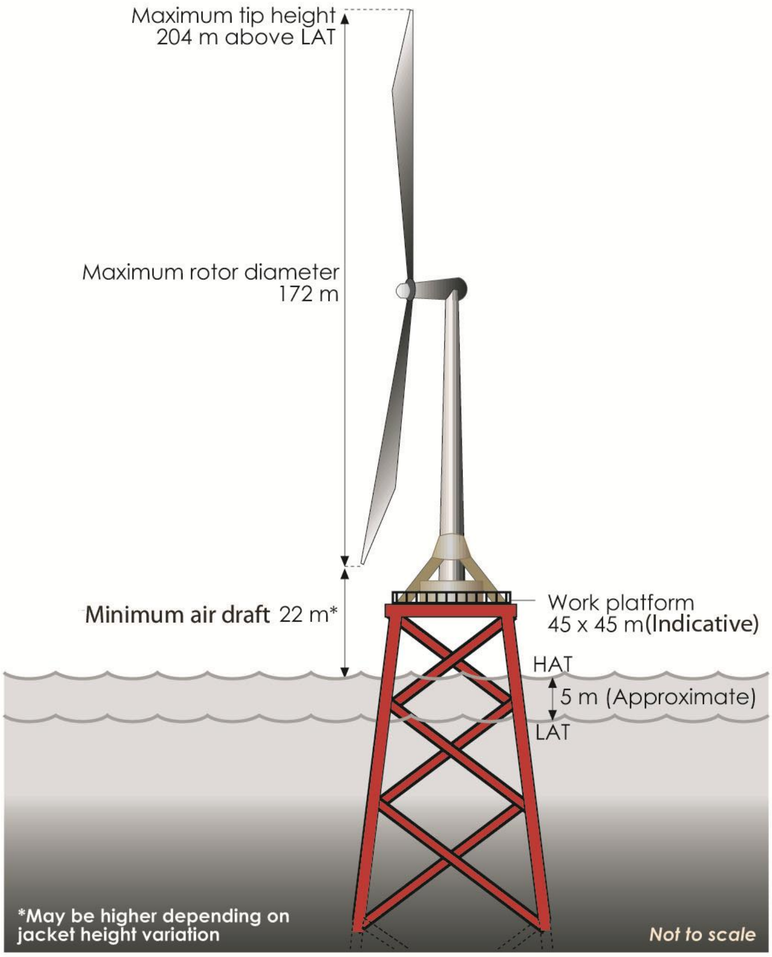

Plate 2.2-4 Illustration of an Indicative 7 / 8 MW Turbine

Turbine Numbers and Site Layout

2.2.6.6 Only one rating of turbine will be used within each site, however, different ratings of turbines may be used in different sites. This will allow the project to take advantage of advances in technology as the programme progresses. Table 2.2-5 and Table 2.2-6 below present the various build-out scenarios for the sequential development of sites, which gives an indication of the lowest and highest number of turbines, the installation of which would give rise to the full scope of potential effects for each site. Each site has a maximum capacity of 500 MW and the order of the build-out is not yet known. Site numbers refer to the order in which the sites will be constructed and do not correspond to a particular named site (e.g. Telford, Stevenson or MacColl).

2.2.6.7 Impact assessments were completed based on a Parameter Plan which contemplates between 63 and 139 turbines for each site. The maximum level of installed capacity for which consent is sought within each site is 500 MW although some of the combinations in the tables below appear to result in a higher capacity than this cap. This is due to rounding up the number of turbines required to assess the 500 MW capacity (e.g. 71 turbines x 7 MW only equals 497 MW installed capacity, therefore the number of turbines assessed was 72; and 62 turbines x 8 MW only equals 496 MW installed capacity, therefore the number of turbines assessed was 63). This ensures that there is no under assessment of the environmental effects of installing up to the maximum 500 MW capacity on each site. However, it should be clear that the number of turbines actually installed will not exceed installed capacity cap of 500 MW on each site.

Table 2.2-5 Build–out Scenario Using the Greatest Number of Turbines for 1,500MW

	Expected Year for Construction to Start	Turbine Rating	Number of Turbines Required	Maximum Capacity
Site 1	2016	3.6 MW	139	500 MW
Site 2	2017 / 2018	5 MW	100	500 MW
Site 3	2019	5 MW	100	500 MW
EDA			339	1,500 MW

Table 2.2-6 Build–out Scenario Using the Least Number of Turbines for 1,500MW

	Expected Year for Construction to Start	Turbine Rating	Number of Turbines Required	Maximum Capacity
Site 1	2016	7 / 8 MW	72/63	500 MW
Site 2	2017 / 2018	7 / 8 MW	72/63	500 MW
Site 3	2019	7 / 8 MW	72/63	500 MW
EDA			216/189	1,500 MW

2.2.6.8 The final site layout within the boundaries for Telford, Stevenson and MacColl are yet to be determined. However, the information below provides a summary of the factors which influence the site layout.

2.2.6.9 The layout of a wind farm site is dependent on several factors including:

- The prevailing wind direction, as turbine rows must be orientated into the dominant wind direction;
- The rotor diameter of the turbine within the site, as this influences the spacing required between adjacent turbines;
- Distance from adjacent turbines to minimise wake losses;
- Seabed geological conditions;
- Seabed bathymetric conditions;
- Seabed obstructions (micro–siting constraint);
- Physical and spatial constraints; and
- Environmental issues (micro–siting constraint).

2.2.6.10 The final spacing between the turbines is dependent on detailed analysis of the wind resource, the rotor diameter of the final turbine type selected, technical constraints and the effects on these features from the spatial "micro–siting" constraints associated with the seabed. Micro–siting constraints are those features of the sea environment which prevent the installation of a turbine in a particular position.

2.2.6.11 The standard downwind spacing is expected to be between 7 and 10 times the turbine rotor diameter and the crosswind spacing will be between 5 and 8 times the turbine rotor diameter. The minimum downwind spacing will therefore be 840 m, while the maximum will be 1,720 m. With crosswind spacing, the minimum will be 600 m and the maximum 1,376 m. Plate 2.2-5 and Plate 2.2-6 below provide an illustration of the potential configuration of the turbines in relation to each other. The patterns being considered for the three sites are a regular grid pattern (where turbines are aligned along both the downwind and crosswind axes) and a diamond pattern (where turbines are only aligned along the downwind axis). Only one pattern will be used across the three proposed wind farm sites.

2.2.6.12 It should be noted that, following more analysis of the wind resource, it may be that some rows of turbines are "removed" from the array layout or individual turbines removed or re–positioned. This is to ensure that each wind turbine is working at maximum efficiency and the influence of wake losses from turbines "upstream" is minimised.

2.2.6.13 Plate 2.2-5 and Plate 2.2-6 below show indicative turbine layout patterns.

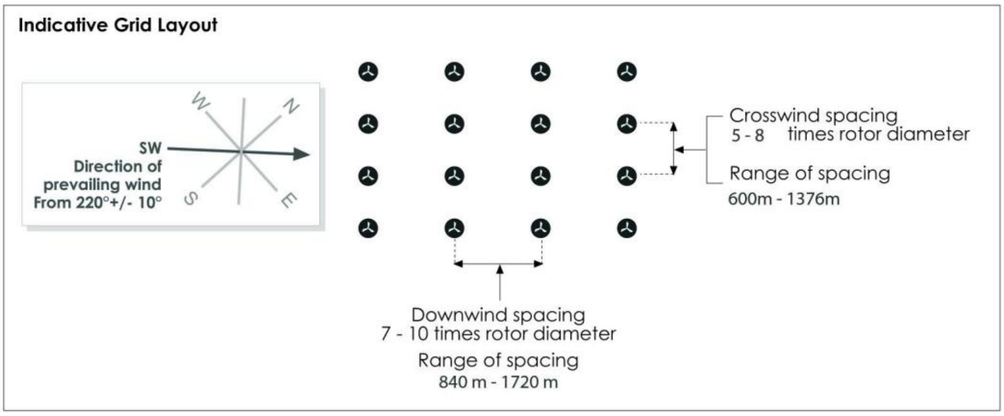

Plate 2.2-5 Indicative Grid Layout

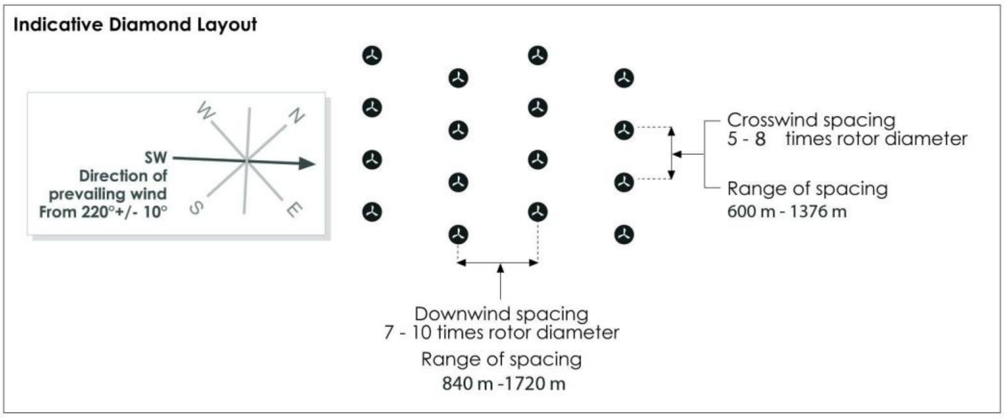

Plate 2.2-6 Indicative Diamond Layout

Foundations and Substructures for Wind Turbine Generators

2.2.6.14 The WTGs will be supported by substructures and foundations which hold the machine in place on the seabed. There is an access deck platform between the turbine tower and the substructure, which allows personnel access into the turbine tower.

2.2.6.15 Two main foundation and substructure concepts, the Gravity Base Structure (GBS) on a gravel bed and the Jacket Structure with pin piles, are proposed to be used within the three proposed wind farm sites; it should be noted that there are multiple variations within these two broad concepts. These variations are covered within the assessment of the two main concepts as both of them have been defined and assessed as worst case scenario. The choice of which concept is more appropriate within a site is dependent upon the turbine model selected and the ground conditions within the particular site. As a result, there may be a mix of GBS and Jacket Structures across the three sites or even within a site.

Gravity Base Structures

2.2.6.16 There are many variations of the GBS. The main differences are related to the GBS geometry / shape. The foundation can be a square, cross, circular or hexagonal and the side view geometry can be a cone shape, a monotower or even a lattice structure (jacket). An indicative figure is presented below to illustrate some of these different geometries (Plate 2.2-7 below). These sub–concepts of a GBS are mainly composed by a concrete base, ballast material and a hollow concrete / steel tower or a steel lattice structure (jacket). For the purpose of the EIA, MORL has defined a generic cone shape GBS to represent the worst case scenario and cover all the GBS sub–concepts.

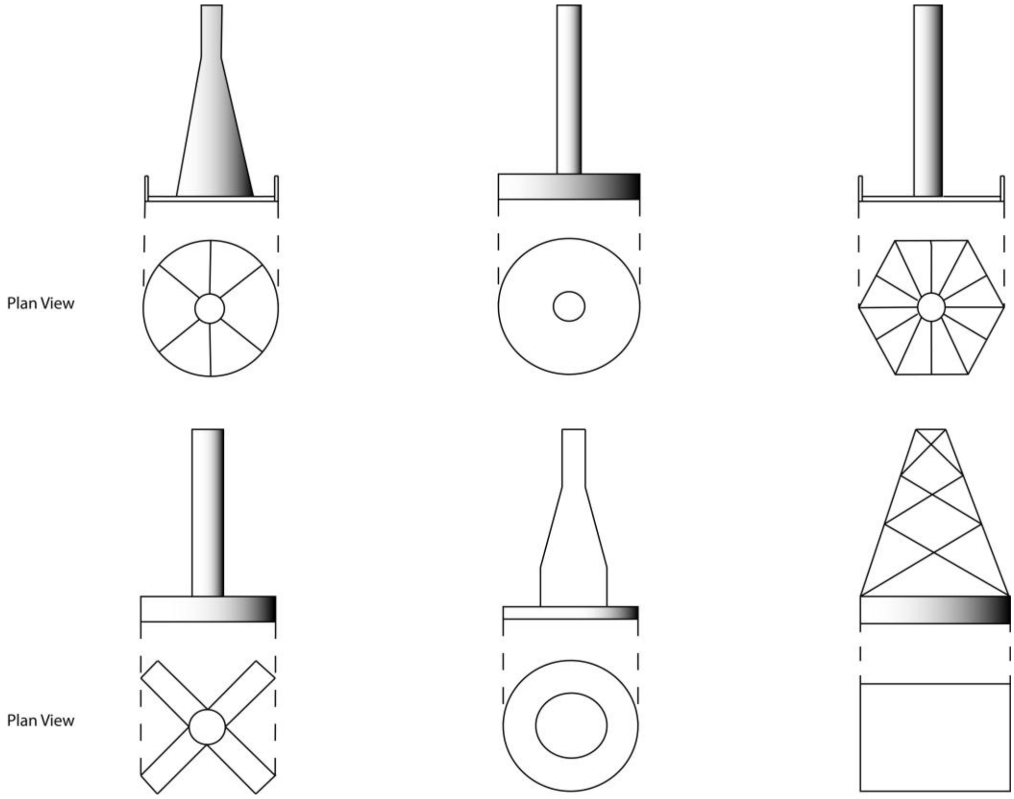

Plate 2.2-7 Indicative Geometry / Shape of GBS Concepts

*All concepts are covered within the GBS worst case scenario outlined in Plate 2.2-8 below.

2.2.6.17 The generic GBS is composed of a hollow concrete base, which is filled with ballast for stability, and a steel monopole top–piece (Plate 2.2-8 below). The GBS may have a steel "skirt" which penetrates the seabed. The concept requires the preparation of the seabed, which involves an area of seabed being dredged to allow the installation of a flat gravel bed to provide a stable foundation for the GBS. It is expected that the area of seabed which is excavated will be greater than the final area of the laid gravel bed. In some cases, grouting injected under the GBS may be a suitable alternative to the gravel bed foundation. Scour protection (graded rock placement, concrete mattress or scour mats) are likely to be used around the concrete base. Corrosion protection will be required for the steel tower / top–piece and for the secondary steel work (boat landings and leaders) of the substructure. This is likely to take the form of cathodic protection, painting and mechanical removal of deposits. There is also potential for the use of corrosion inhibitors chemicals inside the J tubes. An assessment of the requirement for corrosion protection and management of deposits on the substructures will be made later.

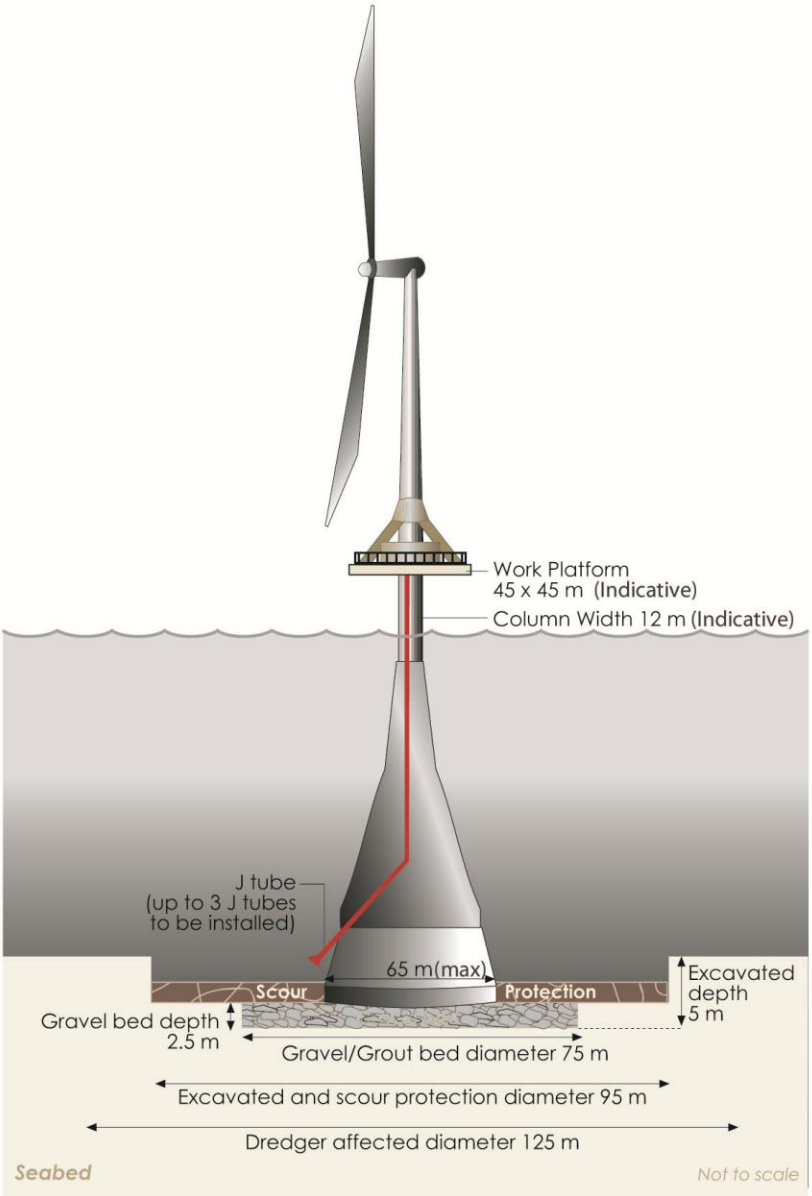

Plate 2.2-8 Diagram of a Typical GBS Substructure and Gravel Bed Foundation

Jacket Structures

2.2.6.18 Jackets are steel structures with three or four legs, each of which is fixed to the seabed using a steel "pin" pile (Plate 2.2-9 below). Jacket structures can assume different configurations. As with the GBS, this concept has various sub–concepts including braced monopods, tripod structures and three or four legged lattice structures. For the purpose of the EIA, MORL has defined a generic 4–legged lattice structure to represent the worst case scenario and cover all the jacket concepts. Scour protection (e.g. scour mats or rock) will be used around each leg. Corrosion protection will be required for the steel top–piece of the substructure. Similar to the GBS this is likely to take the form of cathodic protection, painting and mechanical removal of deposits. There is also potential for the use of corrosion inhibitors chemicals inside the J tubes.

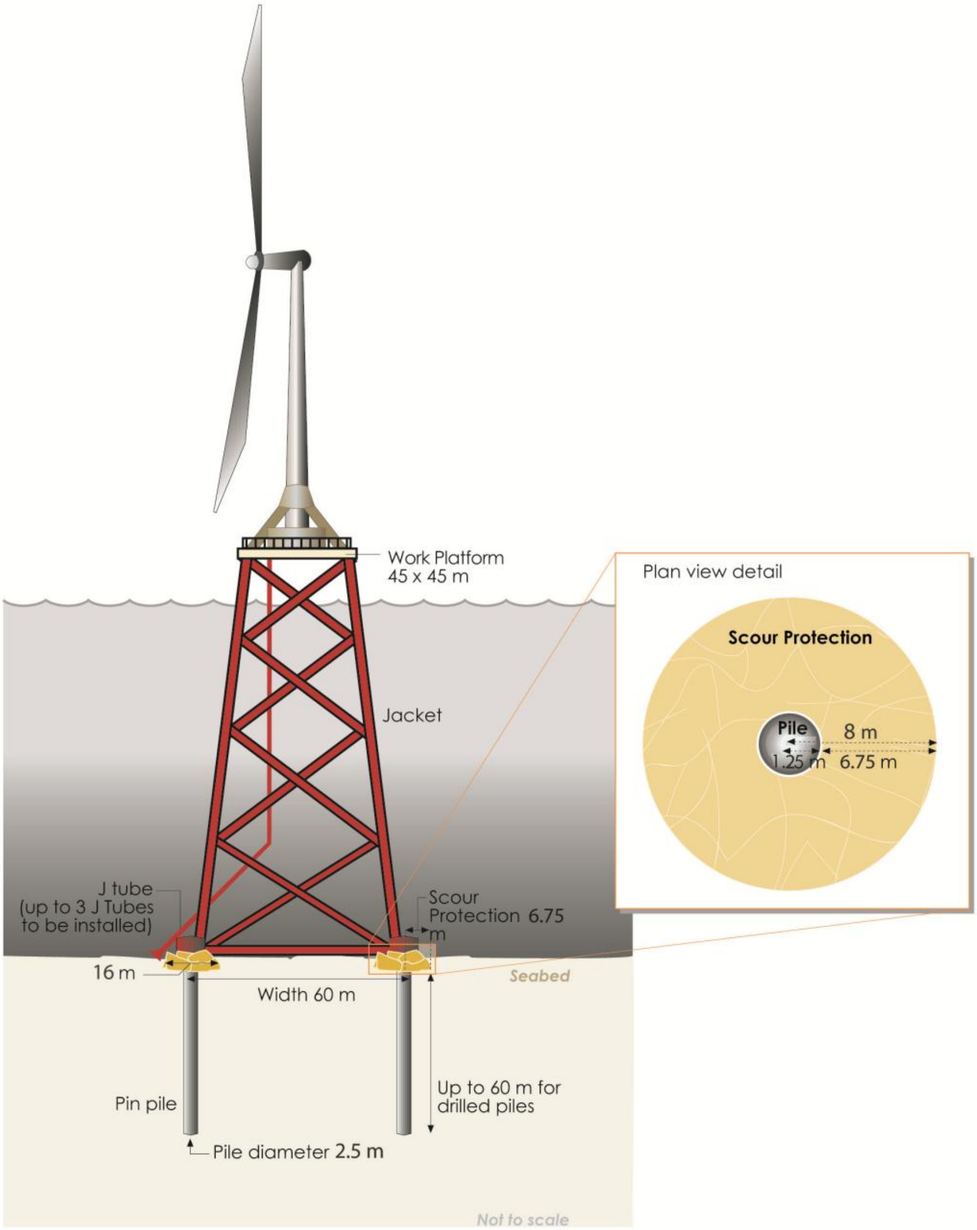

Plate 2.2-9 Diagram of a Typical Jacket Substructure with Pin Piles

Inter–Array Cabling

2.2.6.19 Inter–array cabling will run between each turbine in strings and connect each string to an offshore AC OSP. Typically, depending on detailed design, up to 36 MW of turbines will be connected on a cable "string" (e.g. ten 3.6 MW turbines or seven 5 MW turbines). There would indicatively be 7 to 12 strings within each site. The cabling will be between 33–66 kV. The configuration of the turbines on the strings is expected to be either a branched radial or looped arrangement.

2.2.6.20 Plate 2.2-10 and Plate 2.2-11 below are schematic of a typical looped and branched radial inter–array string configuration.

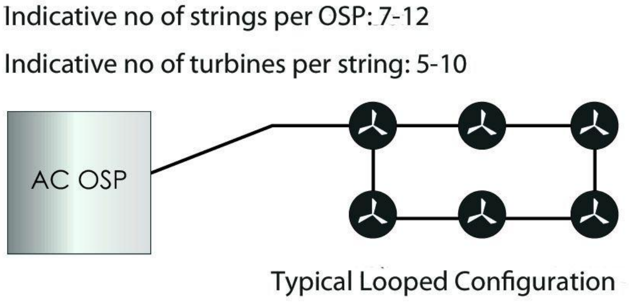

Plate 2.2-10 Typical Looped Configuration

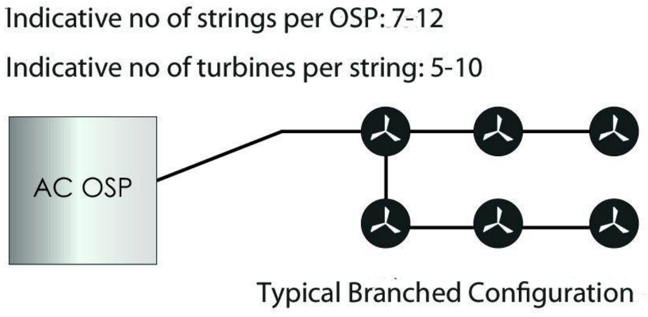

Plate 2.2-11 Typical Branched Configuration

2.2.6.21 Inter–array cabling entry to a turbine or substation is facilitated using a J tube, a steel tube structure which guides the cable from the inside of the turbine into the sea environment (Plate 2.2-9 above). Array cables would normally be installed in trenches for protection but close to each WTG the cables will be laid on the seabed for entry to the J tubes. After installation the exposed cables will be protected. Typically the length will extend up to 100 m out from the base of the WTG. Each WTG will have up to four J tubes each with a cable. Protection of the exposed cables will be used, such as pre–formed concrete mattresses consisting of concrete block sections linked together by webbing so that they may drape flexibly over the cable and seabed. Alternatively controlled rock placement using a fall pipe monitored by ROV (Remotely Operated Vehicle) may be used. It is also a possibility that concrete tunnels and grout bags, and propitiatory steel / plastic ducting or protecting sleeves could be utilised to protect the cable.

2.2.6.22 Further analysis will be carried out of the site 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 site specific ground conditions. It is normally expected that 1 m will be targeted for burial depth. However, this 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.

2.2.7 Transmission Infrastructure

2.2.7.1 This section outlines the range of concepts for each category of infrastructure required for the offshore transmission infrastructure (OfTI). A geophysical and geotechnical survey campaign was carried out in 2011 to identify appropriate areas for installation of cables and platforms. The extent of the surveyed areas can be seen in Figure 1.1-4, Volume 6 a (purple section). All OfTI infrastructure will be located either in the wind farm sites or within a 2 km buffer within the offshore export cable route. This is indicated by the dark green section in Figure 1.1-4, Volume 6 a.

AC Offshore Substation Platforms

2.2.7.2 Between 3–6 alternating current (AC) offshore substation platforms (OSPs) will be required to collect the power generated by the three wind farms. The exact locations of the OSPs are not currently known but it is anticipated that the substations could be located either within the wind farm sites or a maximum of 2 km from the boundary within the export cable route surveyed area. This is highlighted in green in Figure 1.1-4, Volume 6 a. The AC OSPs are enclosed structures housing heavy electrical equipment such as transformers, switchgear and control systems. The function of the AC OSPs is to transform the electricity generated by the turbines from voltages of 33–66 kV to 220 kV for export to the AC / DC OSPs. Table 2.2-7 below provides the maximum dimensions of the AC and AC / DC OSPs. Please note that the AC / DC OSPs will be part of the offshore transmission infrastructure but are included for comparison in this section.

Table 2.2-7 Dimensions of the AC and AC / DC OSPs

Platform Parameter	Dimensions	
	AC Platform	AC / DC Platform
OSP 'topside' max width x length	100 m x100 m	100 m x100 m
Topside max height above LAT	70 m	70 m

2.2.7.3 It is highlighted that it may be possible to combine the AC and AC / DC OSPs. This would allow fewer substations to be installed offshore. The dimensions presented for the foundations and topsides applicable for either the individual or combined substation options.

AC / DC Offshore Converter Substation Platforms

2.2.7.4 Up to two AC / DC OSPs will be required to convert the AC electricity generated by the turbines to high voltage DC electricity. The exact locations of the AC / DC OSPs are yet to be decided, however, they will be located either in the wind farm sites or within a 2 km buffer area from the site boundary within the offshore export cable route. This buffer area is indicated by the dark green section in Figure 1.1-4, Volume 6 a.

2.2.7.5 The AC / DC OSPs are enclosed structures housing heavy electrical equipment including AC–DC converter equipment, switchgear, transformers and control systems. The AC / DC OSPs would also contain transformer coolant systems that would use liquid coolant and also a diesel generator for emergency auxiliary supply only.

2.2.7.6 Other components of the AC / DC OSPs may include a helideck, crane, fire fighting equipment, lighting and a SCADA (Supervisory Control and Data Acquisition) system. As a backup to the SCADA system data may be communicated using microwaves. MORL will be in discussion with OFCOM to ensure there is no interference with existing microwave links. Table 2.2-7 above provides the dimensions of the AC / DC OSPs.

2.2.7.7 As highlighted previously, it may be possible to combine the generating station AC OSPs with the offshore AC / DC OSPs.

Foundations and Substructures for AC and AC / DC OSPs

2.2.7.8 The AC and AC / DC OSPs will be supported by substructures and foundations, of which there are five concepts identified as suitable for the three sites:

- GBS with a gravel bed foundation;
- Jacket with pin piles;
- Jacket with suction caissons;
- Jack–up with pin piles; and
- Jack–up with suction caissons.

2.2.7.9 The choice of which concept is more appropriate within a site is dependent upon the ground conditions within a particular site.

Gravity Base Structures

2.2.7.10 Similar to the GBS for wind turbines, the proposed GBS are composed of hollow concrete bases, which are filled with ballast for stability and requires the preparation of the seabed which involves a flat gravel bed being laid to provide a stable foundation for the GBS. Scour protection (Graded rock placement, concrete mattress or scour mats) will be used around the concrete base.

2.2.7.11 The GBS required to support the OSP would be significantly larger than that of the GBS for a wind turbine and a range of design options will be considered, including but not limited to:

- Four GBSs of the maximum size used for turbines, located close together;
- Two larger GBSs side by side; and
- One very large GBS.

2.2.7.12 Plate 2.2-12 below provides a plan view of the seabed to show the maximum area affected by the GBS structure.

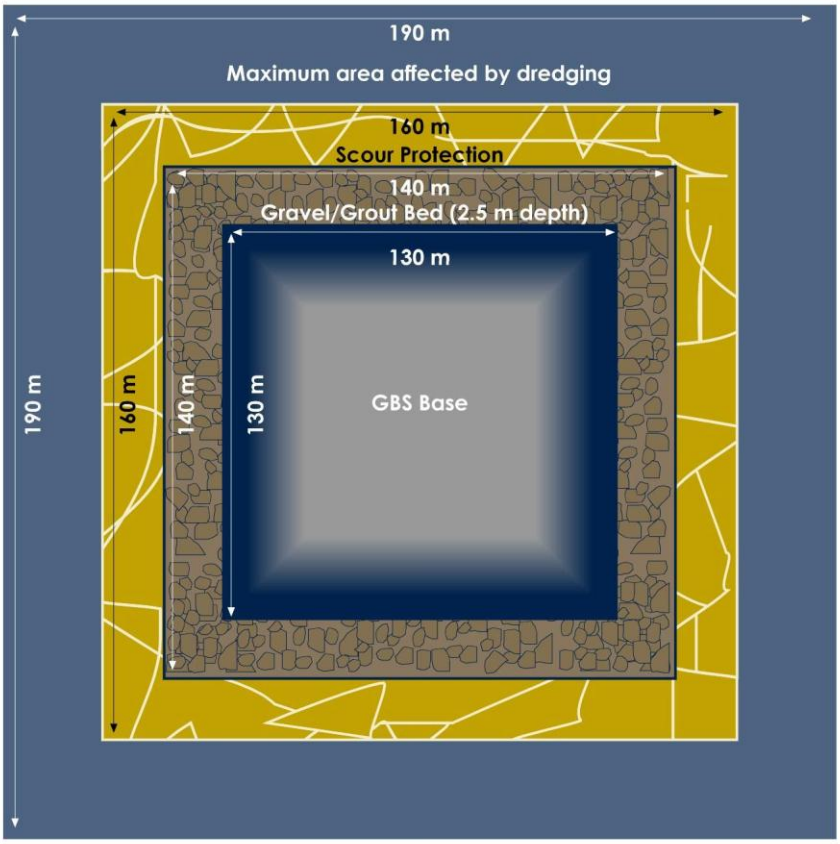

Plate 2.2-12 Plan View of the Seabed, Showing Area Affected by the Platform GBS Substructure and Gravel Bed Foundations*.

*Plate is a representation of dimensions; it may not ultimately be square in shape.

Jackets with Pin Piles or Suction Caissons

2.2.7.13 The jacket substructure with pin pile foundations is similar to that of a wind turbine described in 2.2.6 above. However, the jacket structure required to support an AC OSP will have up to 6 legs, an AC / DC OSP will have up to 8 legs. The alternative suction caisson foundation would be an open–ended steel cylinder up to 20 m diameter attached to each leg (see Plate 2.2-14 below). The principle is that water is sucked out of the cylinder which then embeds itself in a sandy seabed to a depth of up to 20 m. This option cannot be used in many locations across the three sites because only 10 % of the seabed in this area is suitable for this concept.

2.2.7.14 An illustration of an OSP with jacket substructure and pin pile foundations is shown below in Plate 2.2-13 and with suction caisson foundations in Plate 2.2-14.

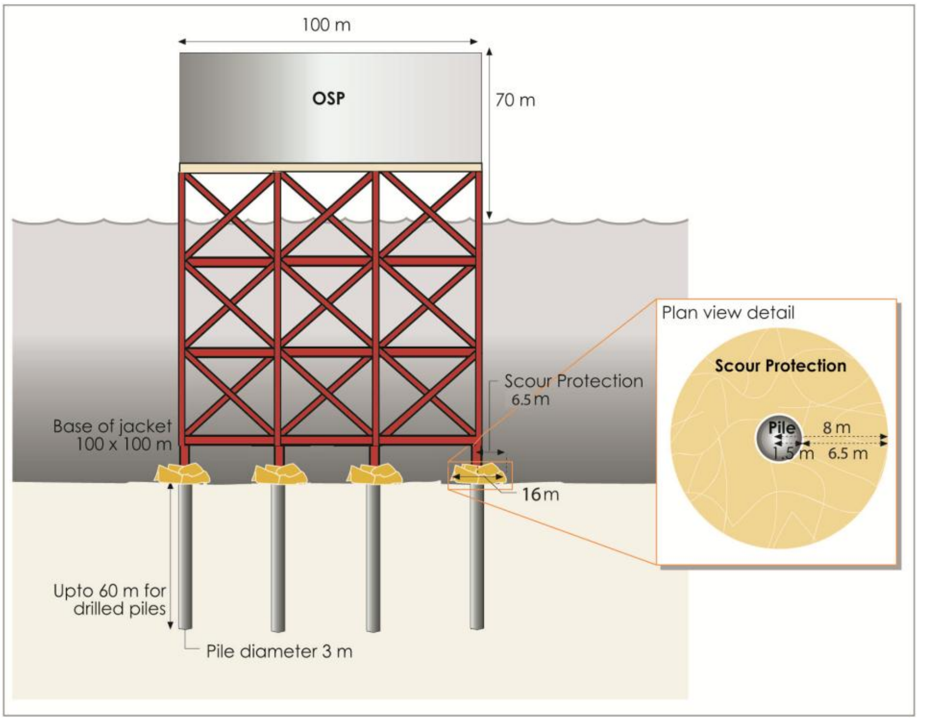

Plate 2.2-13 Pin Pile Foundations

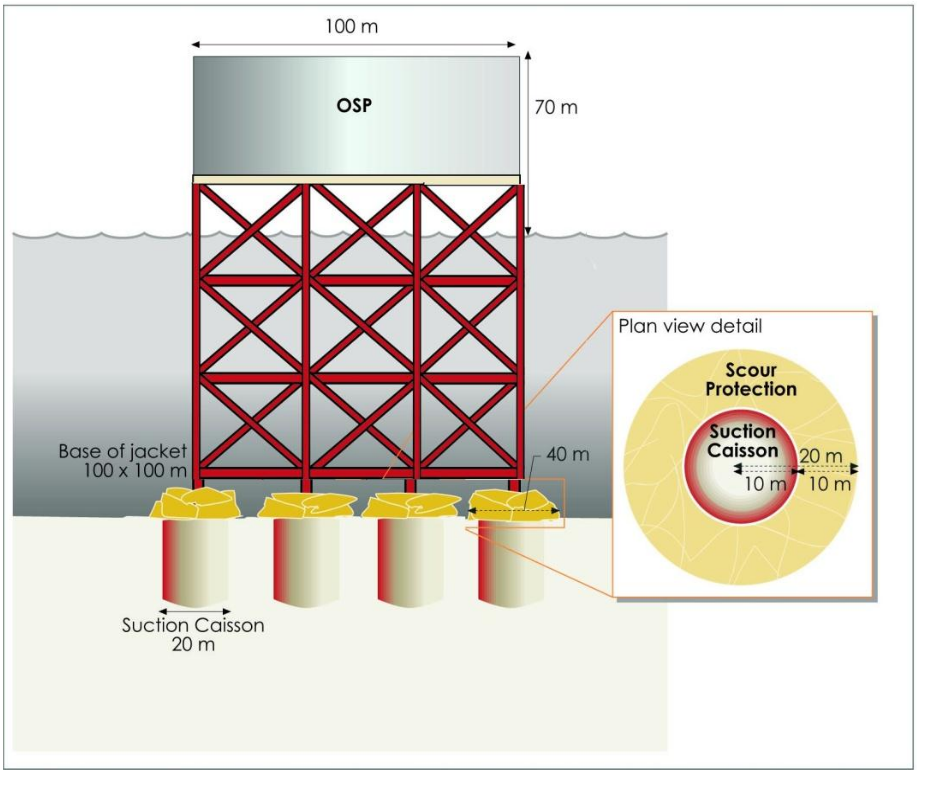

Plate 2.2-14 Suction Caisson Foundations

Jack–ups with Pin Piles or Suction Caissons

2.2.7.15 The jack–up concept will have either pin pile or suction caisson foundations similar to those described in 2.2.6 above. The jack–up substructure consists of a topside box with four support legs that can be raised or lowered using a powerful jacking system operating between each leg and the hull. Water ballast is taken by the jacking system to ensure the legs are fully loaded and secure in the seabed. At the base of each leg a 'spud can', such as a steel cone which penetrates the seabed, may be fitted. For long–term stability it may be necessary to install a pin pile up to 3 m diameter at each leg. Alternatively a suction caisson of 20 m diameter can provide stability. The area around the legs will require scour protection. Corrosion protection is likely to take the form of cathodic protection, painting and mechanical removal of deposits, there is potential for use of corrosion inhibitor chemicals inside the J tubes. An assessment of the requirement for corrosion protection and management of deposits on the substructures will be made later.

Inter–Platform Cabling

2.2.7.16 Cabling at 220 kV will be required to connect the AC OSPs to the AC / DC OSPs. Cables will be buried or protected in the same way as the inter–array cables (2.2.6 above). Where the AC and AC / DC OSPs are combined (see paragraph 2.2.7.7), the cabling would be contained within the platform infrastructure, rather than installed sub–sea.

Export Cable

2.2.7.17 HVDC export cables will be required to connect the DC OSPs to the chosen grid connection point. Two, 320 kV export cables per DC OSP will be required resulting in a total of four export cables. For the majority of the route, these cables will be bundled (i.e. two bundles of two cables). However, there may be short sections where cables are unbundled and laid as single cables. There will be up to two trenches with a maximum trench affected width of 6 m in the offshore section and similar two 3 m trenches onshore; if it is feasible to place the onshore cable bundles in a single trench, the maximum trench affected width will be 5 m. There will be a maximum of one bundled cable (two single cables) in any one trench. Therefore, there will be two export cable bundles in total to export the production of up to 1,500 MW of electricity.

Export Cable Route

2.2.7.18 For the Peterhead connection, the AC / DC OSPs would be expected to be located to the south or east and within 2 km of the zone boundary or within the MacColl site. The site selection work for the cable route identified Fraserburgh Beach as the preferred landfall option, which would allow the export cable to be taken onshore to the final connection point at Peterhead. Figure 1.1-4, Volume 6 a details the extent of the offshore and onshore export cable route. The width of the surveyed offshore export cable route, within which the export cables and potential AC / DC OSPs will be located, is variable depending on the water depth, seabed conditions and seabed features, ranging between 1 and 5.8 km. The width of the onshore export cable route ranges between 1 and 2 km, within this the onshore cables and lay–down areas will be located. Within this corridor area an optimised cable route location will be selected prior to the submission of the onshore planning application.

2.2.7.19 For the subsea portion of the route, the DC cable bundles would be buried to a target depth of 1 m based on site–specific seabed conditions. Where adequate burial cannot be achieved alternative protection methods, such as mattresses or rock placement will be used.

2.2.7.20 The cables or cable bundles will be spaced apart to reduce the potential for damage by unexpected activities such as anchor drag, and to allow safe repair of adjacent cables. The distance between the cables or cable bundles is expected to be four times the water depth, based on current industry best practice. From the bathymetric conditions found in the surveyed area this will result in a cable separation of approximately 200 to 800 m. In the intertidal zone at the landfall point and onshore, both cables may be accommodated in the same trench or conduit. The onshore sections of the export cable route will also be buried to a target depth of 1 m. No overhead sections of the route are planned and the entire cable length will be buried.

Onshore Converter Substation(s)

2.2.7.21 Two direct current (DC) 750 MW + / – capacity onshore converter units will be required to convert the DC electricity transmitted by the AC / DC OSPs back to high voltage AC electricity in order for it to be connected to the onshore grid network. These two converter units will be co–located within a single compound onshore in close proximity to Peterhead Power Station and AC collector substation. The substations may be housed separately or within one building. The compound for this substation will cover an area of approximately 200 x 170 m. It has an indicative height of 25 m and potentially requires a 100 x 100 m laydown area.

2.2.7.22 In addition to the DC converter equipment located in the compound there will be HVAC switchgear, harmonic filters, HVAC cables, liquid cooled transformers, 33 kV auxiliary supply equipment including distribution transformers and switchgear. There will be control room facilities, including SCADA protection and control systems for the unmanned site located either within the converter building or within a separate building within the substation compound.

2.2.7.23 It is highlighted that in order to complete the grid connection for the wind farms, an onshore collector substation will be required to facilitate a final connection to the high voltage AC system owned by SHETL and operated by NGET. A connection between the OFTO assets and the SHETL assets located in a separate compound will be made using 400 kV cables. These will be installed by MORL on behalf of the OFTO. Any works associated with this onshore collector substation will be consented and constructed by SHETL.

SHETL Offshore Hub Connection

2.2.7.24 SHETL have made a proposal for an offshore hub connection, described in detail in 2.1.7 above. This has not yet received consent and the current regulatory regime does not allow MORL to apply for a connection directly to this infrastructure, therefore this option is not part of the Project. Consultation regarding this connection is on–going. MORL is applying for a marine licence and will apply for planning permission to install a connection to the grid through the offshore / onshore export cable route through landfall at Fraserburgh to the onshore substation(s) at Peterhead.

2.2.8 Offshore Meteorological Mast(s)

2.2.8.1 MORL has consent and will be installing a metrological mast in Q3 2012. The mast will we located 510571E 6449002N (UTM Zone 30 North with WGS 84 datum.

2.2.8.2 MORL and BOWL intend to use the wind speed data collected from the met mast to enable robust resource calculations and yield estimates for their wind farm designs.

2.2.8.3 The meteorological mast is a permanent structure that is intended to remain on site for the life span of the wind farm.

2.2.8.4 The met mast will consist of;

- The subsea foundation structure, which will be a tapered monopole (approximately 4.5 m diameter) and will provide the seabed attachment up to a stable platform structure at approximately 16 to 22 m above Lowest Astronomical Tide (LAT);
- An access / impact protection structure;
- The lattice type met mast structure itself, which will be approximately 84 to 88 m tall above its platform attachment; and
- The maximum height of the structure will be 110 m LAT.

2.2.8.5 An indicative diagram of the met mast is shown in Plate 2.2-15 below.

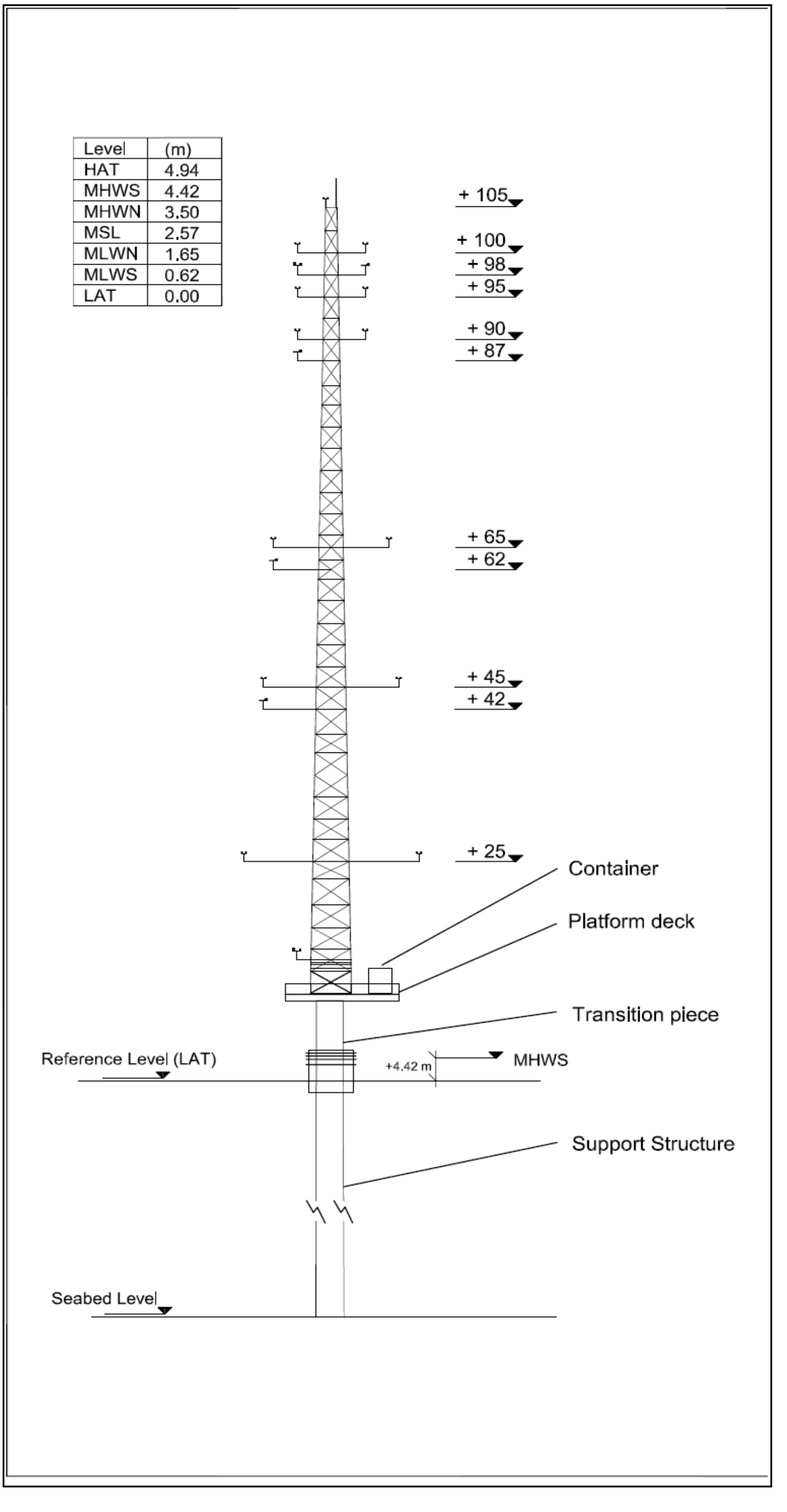

Plate 2.2-15 Diagram to Show Indicative Dimensions of the Proposed Met Mast

2.2.8.6 MORL are planning to install a second meterological mast to assist in long term wind resource monitoring and wind farm performance. The exact location of this has not yet been determined, it will be in one of the three proposed wind farm sites.

2.2.8.7 This met mast will be one of two broad concepts:

- **Floating Lidar** – the floating lidar system will consist of a buoy or floating substructure (spar–buoy) designed to collect, process and transmit meteorological, oceanographic, directional wave, water quality and currents data with near–real time communications capabilities which will be used to assess the offshore wind resource assessment at the site. The system is the ideal wind and environmental assessment data collection device for extreme marine weather conditions. The buoy platform or floating substructure (spar–buoy) chosen is well proven, designed specifically for long–term deployments in deep, extreme, marine conditions. The main components of the system will be:
  - Floating platform (buoy) or floating substructure (spar–buoy);
  - Chain moorings;
  - Position monitoring and navigational aids;
  - Measurement instrumentation: Lidar and oceanographic sensors;
  - Power supply; and
  - Data acquisition and transmission system.
- **Non–lidar** – Latice tower, transitional piece and platform supported by a foundation substructure. Within this there are various options for structural foundations:
  - Monopile (same as the first MORL met mast;
  - Gravity Base Structure; and
  - Jacket with pinpiles or suction caissons.

2.2.8.8 The non–lidar structure itself will be no different to the first MORL met mast in that it will be a lattice structure of similar dimensions of design to that shown in Plate 2.2-15 above. Its maximum height will be 150 m above LAT.

2.2.9 Offshore Installation

2.2.9.1 The following section describes the installation procedures likely to be utilised for installation of the three proposed wind farms and offshore transmission infrastructure. Final installation methods are subject to detailed engineering design and may be adapted based on the technology selected and technical advances.

Foundations and Substructures

2.2.9.2 The descriptions in the following section apply both to wind turbines and platforms foundation and substructure installation, as relevant to the application.

Gravity Base Structures

2.2.9.3 Prior to installing the GBS, a gravel bed foundation must be prepared to provide a flat surface. The seabed preparation will require of excavation of the site using a technique such as trailer suction hopper dredging. The dredged material will be transported or disposed of locally under licence. The excavated site will then be filled in with suitably graded rock using a technique such as a flexible fall pipe system from a vessel guided by ROV observation.

2.2.9.4 There are two potential methods for installing the GBS onto the gravel bed foundation. The first method would be for the substructure to be floated from the transport barge, or if practical, from the fabrication site, to the installation location. A heavy lift vessel will then lower the substructure into place. The second method would be to transport the GBS in two or more sections on a barge, with each section being installed by a crane.

2.2.9.5 Grouting may be required to provide extra stability to the substructure foundation, or to replace the gravel bed foundation entirely. In both cases, grout would be pumped in through entry points in the skirt.

2.2.9.6 The GBS then needs to be ballasted internally with suitable material which is durable in a marine environment. Specialist vessels and equipment are available for this task.

2.2.9.7 Finally, a layer of scour protection material will be installed around the perimeter of the GBS. This is likely to be graded rock delivered by fall pipe from a specialist rock placement vessel under ROV observation, concrete mattresses or scour mats.

Jacket with Pin–Piles or Suction Caissons

2.2.9.8 A jack–up barge or other suitable lift vessel would be used to transport the jackets to site and a crane would be used to install the substructure. Where pin–piles are used as the foundation technique, the piles may be installed before (pre–piling) or after (post–piling) the jacket is installed. For pre–piled foundations, a template is placed on the seabed to ensure the piles are installed in the correct locations. The template is then removed and moved to the next location and the jacket is landed onto the piles. For post–piling, the piles are installed through pile sleeves located at each corner of the jacket.

2.2.9.9 Impact piling is the most common method of installing piles, using a piling hammer from a suitable vessel (e.g. jack–up). In some cases, it may be possible to drill the post–hole. However, this method is not currently commercially viable for large–scale use and is currently only expected to be used in exceptional circumstances. Another option would be to combine the two techniques in a drive–drill–drive pattern. This is usually used in areas with very hard geological strata and it is not currently expected to be used within any of the three sites unless piling alone has been unsuccessful.

2.2.9.10 Suction caissons may also be used as the foundation of the jacket legs. These may be installed either by pushing the caisson into the seabed or by creating a negative pressure within the skirt by "sucking the water out" which secures the caisson to the seabed.

2.2.9.11 Where required, grout will be used to provide a strong connection between jacket and pile. The grout will be installed using the pile sleeve and ROV observation. After grouting, scour protection may need to be installed around each leg / pile depending on local conditions. This may be controlled rock placement, concrete mattresses or anti–scour matting.

Jack–up Concept

2.2.9.12 The concept of using a jack–up to support an OSP offers the advantage that the entire jack–up including the topsides equipment box can be built in a shipyard. Once complete the hull of the jack–up, which is essentially a water tight steel box containing the equipment can be floated out of dry dock at the shipyard to the site with the four legs fully extended above the hull.

2.2.9.13 The principle of the jack up is that the support legs can be raised or lowered using a jacking system operating between each leg and the hull. On arrival at site the legs would be jacked down to contact the seabed, then the full weight of the hull plus water ballast would be taken by the jacking system to ensure the legs are fully loaded and secure in the seabed. After this the hydraulic jacking system would elevate the hull up the legs to its intended elevation. At the base of each leg a 'spud can' would be fitted, typically a steel cone.

2.2.9.14 To ensure stability over the operational life of the platform, it may be necessary to install a pin pile at the foot of each leg. This would be grouted to secure the connection to the leg structure. The J tubes for the OSP cable entries / exits will be positioned after the jacking operation is complete. Alternatively a suction caisson would be utilised as an alternative seabed fixing method, installed using similar methodology as described in 0 above.

2.2.9.15 Dimensions of the jack up concept would be within the envelope described for the jacket substructures.

Wind Turbine Generators

2.2.9.16 Following installation of the substructure and foundations, the turbines will be lifted into place using a crane on a construction vessel, such as a jack–up or heavy lift vessel. Two installation methods may be used:

- **Single lift** - Wind turbines would be assembled onshore and transported to site. The entire turbine (tower, nacelle, hub and blades) would be lifted into position on the pre–installed substructure. This method involves a bespoke vessel which is not currently available at this time on a commercial scale; and
- **Multiple lift** - The turbine generator is transported to site as separate components. The tower is installed first in two or three sections which are bolted together. This is followed by the rotor–nacelle assembly which would be installed separately (nacelle followed by hub then the blades one at a time) or using the "Bunny Ear" method (the rotor–nacelle assembly complete with two blades is lifted into place followed by the third blade).

Offshore Substation and Converter Platforms

2.2.9.17 Where the AC or AC / DC OSPs have a gravity base or jacket substructure, the platform topsides are installed independently of the substructure themselves. The topsides will be transported to site and lifted into position using a crane from a heavy lift vessel. The topsides may be installed as a single unit or in separate modules.

Offshore Cabling

2.2.9.18 The following section describes cabling installation relevant to the wind farms and offshore transmission infrastructure where the cables are installed offshore (i.e. from the intertidal area to the wind turbines).

Cable Burial

2.2.9.19 Cable lay vessels are used to lay and bury inter–array, inter–platform and offshore export cables. Further analysis will be carried out on the site 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 wind farm and export cable corridor site specific ground conditions. The target burial depth is 1 m. For most of the 105 km offshore export cable route it is expected that the cables will be in trenches for protection. However, for the 24 km section leading to shore the seabed contains areas of rock at, or close to the surface which is potentially unsuitable for trenching, so cables may be laid on the seabed. Where this occurs the cable will be protected by graded rock placement, concrete mattresses or other suitable protective coverings.

2.2.9.20 The available techniques for creating the cable trenches are ploughing, jetting, jet–assisted plough, tracked devices or mechanical cutting. The technique used is chosen so it is suitable for the seabed conditions. A short technical description of these techniques is detailed below:

2.2.9.21 **Ploughing** – A cable plough is a device towed behind a vessel. The plough sits on the seabed and as it is pulled forward, curved steel plough blades are driven into the seabed creating a trench.

2.2.9.22 **Jetting** – Jetting is performed by a remotely operated vehicle which sits on the seabed on a tracked wheel system. The jetting vehicle receives power and control signals via an umbilical from a surface vessel. The jetting vehicle lowers jetting swords into the seabed, fluidising the substrate with high pressure water jets into the swords. The vehicle drives itself along the cable route using its tracked wheel system with the swords and the water jets creating a trench as it travels forward.

2.2.9.23 The operation itself may take one of two forms:

- Combined lay and bury: where the cable trench is created and immediately after the cable is laid in the trench using the same tool and therefore in the same operation; and
- Post–lay burial: where the cable is laid on the seabed in one continuous operation. Upon completion of this a second operation is done to create the trench into which the cable will fall through gravity.

2.2.9.24 **Jet assisted plough** – This technique is basically a hybrid method incorporating ploughing and jetting. Cable ploughs are towed by a vessel and at the surface specialised nozzles introduce water at the soil interface, fluidising the substrate, reducing the stresses involved in this process.

2.2.9.25 **Tracked devices** – These have tracks (like bulldozers) and are deployed on the seabed and usually powered by an umbilical from a vessel. The tracked vehicle can carry a range of equipment for trenching such as mechanical rock cutters or jetting equipment.

2.2.9.26 **Mechanical cutting** – Is used to cut a trench through rock or very stiff clay. It would be deployed on a tracked device and consist of rotating cutting heads.

2.2.9.27 Each cable laying operation is expected to be done continuously without the requirement for splicing. The maximum speed of progress is in the range 300 to 500 m / hr. In difficult conditions (e.g. very stiff clay or rocky sea beds), progress will be slower.

2.2.9.28 For either method used, the degree to which the trench naturally back–fills depends on the nature of the seabed and local metocean conditions or scour protection will be laid where cables cannot be buried to the target depth.

2.2.9.29 Where the cable has to cross existing infrastructure, such as other cables, 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. The new cable 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 owner / operators where relevant.

2.2.9.30 The export cables will typically be laid starting at the landfall and finishing at the offshore site. It is likely that the export cable bundle from the first DC OSP will be installed separately from the second DC export cable (i.e. there will not be two vessels working in parallel). The second cable lay operation may be done directly after completion of the first cable, or a number of years after the first installation is complete dependant on the capacity phasing of the wind farm.

2.2.9.31 The route would be aligned parallel with the first cable route but sufficiently separated to avoid damage.

Cable Pull–in

2.2.9.32 At each turbine it is necessary to pull in one, two or three cables depending on the position of the turbine in the array. Typically a system using messenger wires and cable guides allows pull–in to proceed without diver intervention. Once the cable is pulled in and secured, any exposed areas may be protected (e.g. by mattresses or rock dumping).

2.2.9.33 At OSPs the number of J tubes and pull–ins is much greater and typically a row of J tubes will be pre–installed along sides of the substructure to accept the cable from each of several array strings.

Export Cable Landfall

2.2.9.34 The techniques which could be used for the export cable landfall and intertidal area include open cut trenching, ploughing, dredging, mechanical cutters and horizontal directional drilling (HDD).

2.2.9.35 Open cut trenching consists of excavating a trench across the landfall location and down below low tide level to a point where marine vessels and equipment can operate and continue trenching. Construction of a temporary causeway across the beach and down 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.

2.2.9.36 In the case of sandy beaches, it may be possible to locate a marine trenching plough above high tide connected to the cable installation vessel lying near to shore. The vessel can then pull the trenching plough down the beach and out to sea installing the cable in the foot of the trench as it goes.

2.2.9.37 If rocky conditions are encountered, it may be possible to use a mechanical cutter which uses a rotary cutting wheel to excavate a narrow trench. Such machines may operate above or below water.

2.2.9.38 HDD may be used to avoid cutting an open trench. This involves drilling a hole from the landward side of the landfall to a point below low tide where marine equipment can operate. The diameter of the hole is sized to take a conduit through which the cable(s) are pulled. The maximum distance of cable pull depends on the design strength of the cable. For standard cables, the limit of pull and, therefore, of the HDD approach is 500 m. However, specially strengthened cable can be used to extend this distance to 1 km in exceptional circumstances.

2.2.9.39 If the export cables are laid in two operations separated over a significant period of time, the HDD operation could install a conduit sufficiently large to allow the second DC cable bundle to be pulled through to sit alongside the first at a later stage. Similarly, any trenches cut through the landfall section would be used to accommodate a conduit for the second cable.

Construction Phase Safety Zones

2.2.9.40 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 for Telford, Stevenson and MacColl. In order to minimise disruption to navigation by users of the sea, safety zones are expected to be established around such areas of the total site 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 site as construction work is undertaken. The exact locations are to be determined at a later stage and would be notified to mariners. Safety Zones in place on the Project will be implemented and communicated though standard protocol (i.e. Notice to Mariners).

Transport to Site

2.2.9.41 It is anticipated that most infrastructure elements will be transported to site or the construction port by sea although some elements may be transported via road before transfer to a vessel. The construction port has not yet been identified, although it is expected to be based on the eastern coast of Scotland or northern England.

2.2.10 Onshore Installation

Cabling

2.2.10.1 The final construction location is expected to be 20 to 30 m wide to allow access to the trenches by excavators and cable–drum trucks etc. The trench will be excavated using a digger (e.g. JCB) or possibly a cable plough. The cable plough has an indicative rate of installation of 1,000 m / day, while the open trench method has an indicative rate of 300 m / day.

2.2.10.2 There is the possibility of a single or double installation campaign, i.e. all cables laid in one operation (all four cables separately or bundled, or installation of two cables initially with the remaining cable being laid at a later date). The maximum trench width for the single operation will be 5 m. If cables are laid in two separate campaigns then each trench width will be maximum 3 m, but ultimately still within a maximum 30 m working corridor.

2.2.10.3 Excavated material will be stored within the construction corridor temporarily and used later to fill in the trench and bury the cable. The cables will either be laid in separate trenches or in bundles within the same trench. The trench will be lined with sand for the cable to rest on and depending on the properties of the excavated material; a thin layer of sand may also be used to cover the cable.

2.2.10.4 Where crossings of sensitive watercourses are required HDD would be used. The depth and length of the small sections of HDD would be agreed prior to construction with SEPA (Scottish Environment Protection Agency). Road crossings will most likely involve excavation of the road surface, cable laying and reinstatement of pavement and road.

2.2.10.5 Periodically along the cable route there will be the requirement for jointing pits which will be wider than the cable trench but within 8–10 m of the trench. These are needed where two lengths of cable are joined together and require larger areas for workers and equipment to manoeuvre. The total number of and distance between jointing pits is determined by the size of the cable drums and the feasibility of transporting them to the construction site. Typically, lengths of hundreds of metres are manageable.

2.2.10.6 There should not be any need to establish permanent access tracks, however depending on the route and specific equipment selected, there may be a need for some temporary access tracks for construction, although the nature and location of these has not been determined.

Onshore Convertor Substation(s)

2.2.10.7 Construction of the converter substation(s) compound is likely to comprise of two principal activities: construction of an access road and construction of the compound itself. In both cases, the site will undergo initial preparation works (e.g. removal of vegetation and soil stripping, installation of drainage, where required, installation of fencing and introduction of a capping layer to provide temporary road and compound areas where necessary etc.). Civil engineering works would include procedures such as the construction of foundations for the structures and buildings, construction of plant buildings and installation of equipment and cabling. Discussions are ongoing with landowners to determine the exact location and layout of the substation(s) on its land within the preferred onshore substation area. This will be finalised following production of a masterplan by the owner / operator of the Peterhead Power Station compound which forms part of the preferred area.

2.2.10.8 A full construction management plan and traffic management plan would be prepared in advance of construction commencing.

2.2.11 Operation and Maintenance

2.2.11.1 Operational activities, such as monitoring of turbine activity, will either be carried out primarily from a shore base or from an offshore location.

2.2.11.2 Maintenance activities will include the following types of activities:

- Major interventions include overhauls of turbines or OSP equipment which may be required periodically in the 25 year life. Unplanned failures within turbines, OSP equipment or cables may also require major repairs, which require the use of equipment and methods originally used to install the relevant infrastructure;
- Preventive maintenance comprising scheduled activities including plant and equipment scheduled maintenance, necessary safety inspections and testing of safety related equipment, inspections of primary and secondary structures, scheduled overhauls;
- Corrective maintenance to address equipment failures, primary alarms, or actions arising from results of inspections; and
- Opportunistic maintenance in cases where maintenance personnel and access vessels are available at site and some precautionary inspections or preventive maintenance can usefully be carried out.

2.2.11.3 The types of vessels that will be used during operation are yet to be decided but further details will be provided within the appropriate EIA chapters.

Operational Safety Zones

2.2.11.4 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 wind turbine tower. Depending on the safety case, a larger area may be requested in the application to DECC.

2.2.12 Repowering and Decommissioning

2.2.12.1 A decision as to whether the sites will be repowered will be taken in approximately 15–20 years after operation has commenced. This would most likely involve the replacement of turbines and if necessary, associated cabling, which by then will be near the end of their design life. Depending on the scale and nature of the works, a new consent application with supporting Environmental Statement would need to be submitted.

2.2.12.2 Under the Energy Act (2004), a wind farm and associated transmission infrastructure must be decommissioned at the end of their lifetimes. Guidance is currently available on decommissioning liabilities and standards (DECC, 2011) and a preliminary decommissioning programme has been prepared to support the Section 36 consent application. However, the decommissioning programme would be updated in accordance with relevant legislation and guidance available at the time of decommissioning.

2.2.12.3 Decommissioning will most likely include the removal of non buried–elements (e.g. turbines and OSPs) and associated substructures and onshore substations. Buried elements such as foundations and cables may be removed or left depending on regulatory and Project aims at the time.

2.2.13 References

DECC (2011). Decommissioning of offshore renewable energy installations under the Energy Act 2004: Guidance notes for industry. January 2011 – revised. Available from https://www.og.decc.gov.uk/EIP/pages/files/orei_guide.pdf.