6 SITE SELECTION AND CONSIDERATION OF ALTERNATIVES

6.1 INTRODUCTION

1. This Section of the ES describes the approach taken to identify the preferred site for the Project including consideration of alternatives for the Wind Farm and the OfTW. This Section also outlines alternative engineering solutions for the Project that have been considered before and during the EIA and iterative design process.

6.2 LEGISLATION AND POLICY

2. The EIA Directive (85/337/EEC) requires developers to present within their environmental statement; "*where appropriate, an outline of the main alternatives studied by the developer and an indication of the main reasons for his choice, taking into account the environmental effects*" (Article 5, Annex III, para. 2). Alternative sites, layouts, processes and technology considered as part of the Project are considered in this Section.

6.3 THE WIND FARM

6.3.1 SITE SELECTION AND ALTERNATIVE SITES

3. The Marine Renewable Energy and the Natural Heritage: an Overview and Policy Statement (SNH, 2004) and Matching Renewable Electricity Generation and Demand (Scottish Government, 2006) indicated the Moray Firth area was favoured for development of large scale offshore wind farms.

4. In 2007, the Scottish Government asked The Crown Estate to undertake a leasing round for offshore wind in Scottish Territorial Waters. In the summer of 2008 The Crown Estate asked developers to come forward with proposals for offshore wind farm sites anywhere within Scottish Territorial Waters.

5. In response, BOWL identified the Wind Farm Site as a suitable site for offshore wind farm development. There are a number of reasons as to the choice of site location for the Wind Farm. The key points listed below were the driving factors for development in the Moray Firth:

- Existing development, construction and operational experience on the Smith Bank in deep water;
- A favourable wind regime, as identified from five years of wind data from meteorological masts at the Durran Mains onshore wind farm and two years of LIDAR wind data from the Beatrice A platform;
- An existing 1,000 MW Grid Connection Agreement held since 2006;
- Perceived low seascape, landscape and visual sensitivity – based on findings of the SNH (2006) assessment of sensitivity and capacity of the Scottish seascape in relation to wind farms (low to medium sensitivity, moderate to high capacity for development); and
- Perceived low environmental constraints – due to the lack of designated sites and rare or protected species recorded in close proximity to the Wind Farm Site.

6. The Wind Farm Site was determined by the Smith Bank, oil field infrastructure to the south west, planned oil field development to the north west and the 22.2 km (12 NM) Scottish Territorial Waters boundary. Consideration of a range of available turbine technologies and the associated variation in spacings between turbines of different dimensions and generating capacities showed that a Wind Farm generating capacity of 1,000 MW could be achieved within the Wind Farm Site. The final site capacity will be dependent on the site constraints and which Rochdale Envelope parameters are utilised.

7. In February 2009 The Crown Estate announced Exclusivity Agreements with 10 sites including awarding the Beatrice Offshore Wind Farm to BOWL.

8. The suitability of the site was further affirmed in May 2010 with the Scottish Government's publication of the SEA in the Draft Plan for Offshore Wind Energy in Scotland (May 2010) which confirmed that all ten 'short term' (i.e. Scottish Territorial Waters 2009 lease round) sites could be developed between 2010 and 2020 if "appropriate mitigation is implemented to avoid, minimise and offset significant environmental impacts".

9. In March 2011, Blue Seas – Green Energy, A Sectoral Marine Plan for Offshore Wind Energy in Scottish Territorial Waters was published by Marine Scotland. The Final Plan in this document included 6 of the 10 sites initially put forward by The Crown Estate. Kintyre; Forth Array; Bell Rock and Solway Firth were not included in the Final Plan. Beatrice was included in the Final Plan as a short-term site. The six short-term sites within the Final Plan in Scottish Territorial Waters are shown on Figure 6.1.

6.3.1.1 No Development Scenario

10. The 'no development' scenario has been represented as the current baseline situation reported in the topic Sections of this ES. The effects of the Project have been assessed relative to this baseline. It is recognised that aspects of this baseline will not remain static for the lifetime of the Project. In particular, and apart from any changes arising from economic and fisheries policies and economic market considerations, it is predicted that biodiversity and landscape will undergo a level of change as a result of climate change. Due to the complexities and uncertainties inherent in attempting to predict the nature and extent of such changes to landscape and biodiversity during the operational lifetime of the Project, it has been assumed that the current baseline will remain. It is considered that this represents a precautionary and appropriate approach for EIA purposes.

6.3.2 LAYOUT DESIGN

11. As discussed in Section 4: EIA Process and Methodology of this ES, a Rochdale Envelope approach has been adopted for assessment purposes. The detailed design of the site will therefore not be finalised until after consent. There are however a number of fixed constraints within which the site layout will ultimately be developed and these are described in Section 7: Project Description of this ES.

12. The crosswind and downwind spacing between the wind turbines is dependent on the wind regime. Following wind resource assessment, a decision was made by BOWL that the distance between each wind turbine within the site will be no less than six times its rotor blade diameter. Any distance smaller than this was dismissed due to the reduction in efficiency of generation. The distance between turbines will therefore be dependent upon which wind turbine is utilised.

13. A wind turbine layout design option of arranging the wind turbines in curved rows was considered in the early design stages. Through consultation with shipping and sailing stakeholders, and the local fishing fleet, this design concept was dismissed on the basis of navigational risk and therefore also safety. Straight rows of wind turbines are considered much safer and more straightforward to navigate through or around and straight rows therefore form a key design element of the Wind Farm layout. However, while the wind turbines will be arranged in straight rows where possible, irregular spacing may be used between the rows within the Wind Farm site e.g. the further downwind within the site the wider the spacing between rows.

6.3.3 WIND TURBINES

14. There are a large range of wind turbines currently available and in development with various sizes and capacities that may be suitable for use at the Wind Farm. Any wind turbines with a generating capacity of less than 3.6 MW were dismissed. This is a commercial decision, made as a result of the greater number of turbines which would have to be procured, installed and maintained to meet the target Wind Farm capacity of 1,000 MW. Similarly, an upper generating capacity of 7 MW was set and any wind turbines with a capacity above this were dismissed. The offshore wind turbine market is developing rapidly and new turbine designs with generating capacities of greater than 7 MW are in development. However, these new turbines will require testing prior to being placed into production and the likely longer timescales for their availability for deployment on the Wind Farm are such that they are not considered to be a viable option.

6.3.4 SUBSTRUCTURES AND FOUNDATIONS

15. The substructures and foundations connect and secure the wind turbine to the seabed. There are a range of substructure and foundation types available for use on offshore wind developments. An engineering appraisal was undertaken on these options taking into account environmental, safety, economic and technical considerations. The appraisal criteria prepared to assess all of the combined foundation and substructure types were as follows:

- Safety – including fabrication and assembly; lifting and loadout; transportation onshore; transportation offshore; installation and construction; operations and maintenance; decommissioning and disposal;
- Costs – including fabrication and assembly; lifting and loadout; transportation onshore; transportation offshore; installation and construction; operations and maintenance; decommissioning and disposal;

- Schedule – including design; fabrication and assembly; lifting and loadout; transportation onshore; transportation offshore; installation and construction; operations and maintenance; decommissioning and disposal;
- Technical – including variability of ground conditions; variability of water depths; established processes; weight; number of welds; complexity of joints; complexity in transportation, lifting and installation; number of offshore operations; requirements for scour protection; requirements for corrosion protection; complexity in access; and complexity in decommissioning;
- Environmental – including environmental effects, sustainability; transportation movements; area of disturbance to seabed; demolition and disposal options; and
- Reputation – including tried and tested methods; design failures; tried and tested construction and installation methods; operational failures; maintenance intervention; tried and tested decommissioning methods.

16. The substructures and foundation types that were considered are summarised in Table 6.1 which also identifies those which were dismissed at an early stage in the design process.

Table 6.1 Substructures and Foundations Considered

Project Element	Description	Dismissed After Appraisal?	Main Reasons for Dismissal
Substructure Type			
Monotower	A large steel tube which links the base of the wind turbine with a foundation component. Only feasible for use with met masts. Described further in Section 7: Project Description.	Yes, for wind turbine and OSP. Not dismissed for met masts.	Noise constraints associated with piling. Very thick steel sections required at this water depth.
Guyed monopole	A steel pole which connects between the base of the wind turbine tower and the seabed. This pole then has a number of steel guy cables which fan out from the pole and secure into the seabed.	Yes	Due to the long length of mooring lines they can have a large zone of influence which can have a greater impact on commercial fishing and shipping/sailing when compared to other options.
Tripod	Described further in Section 7: Project Description.	No	n/a
Quadrapod	Described further in Section 7: Project Description.	No	n/a
Jacket	Described further in Section 7: Project Description.	No	n/a
Pyramatrix	Much lighter than steel	Yes	Currently unproven

Project Element	Description	Dismissed After Appraisal?	Main Reasons for Dismissal
	this concept is a modular 'space frame' technology weaving composite material into lattices of reinforcing pyramids.		technology for wind turbines.
Semi-submersible	Obtains its buoyancy from ballasted, watertight pontoons located below the ocean surface. The wind turbine tower would connect to this and the pontoon would be anchored to the seabed by a number of steel guy cables.	Yes	The long length of mooring lines can have a large zone of influence which can have a greater impact on commercial fishing and shipping/sailing when compared to other options. Currently Unproven technology for wind turbines. More suitable for deeper water applications than that of the Wind Farm site. Significant tonnages of steel are required therefore unlikely to be an economic solution for the Wind Farm.
Tension leg platform	As with a semi-submersible but the tethering to the seabed is by securing an anchor point below the platform and connecting the two with steel cables under high tension.	Yes	Currently unproven technology for wind turbines. More suitable for deeper water applications than that of the Wind Farm Site.
Spar buoy	As with guyed monopole concept but the pole does not touch the seabed and 'floats' in the water column.	Yes	The long length of mooring lines can have a large zone of influence which can have a greater impact on commercial fishing and shipping/sailing when compared to other options. More suitable for deeper water applications than that of the Wind Farm site.
Jack-up structure	This is a structure which could be floated out to site and when in	Yes	A high level of maintenance is required for complex

Project Element	Description	Dismissed After Appraisal?	Main Reasons for Dismissal
	position a set of 'legs' would be lowered to the seabed. Can only be coupled with a bearing foundation.		mechanical system. The jack-up system is expensive and would only be used once. Potential for significant footing penetration across the site due to the varying seabed conditions.
Foundation Type			
Drag Anchor	Drag anchors can be deployed with mooring lines to secure semi-submersible or floating (e.g. spar buoy) substructures. Anchor can be embedded or gravity loaded.	Yes	Inflexible - only suitable for semi-submersible or spar buoy substructures which have been dismissed.
Monopile	Described further in Section 7: Project Description.	No	n/a
Multiple piles	Described further in Section 7: Project Description.	No	n/a
Suction piles	Described further in Section 7: Project Description.	No	n/a
Gravity base foundation	Described further in Section 7: Project Description.	No	n/a
Bearing foundation	This is a structure which is effectively a rigid mat which sits on the seabed, onto which a jack-up structure's legs will be placed to spread the bearing load.	Yes	Only suitable for jack-up substructure which has been dismissed. Potential penetration of seabed.

6.4 OFFSHORE TRANSMISSION WORKS

17. The route of the OfTW Corridor and OnTW cable is largely dependent on the location of the onshore substation location.

18. A 1,000 MW grid connection offer for a connection to the existing substation at Blackhillock, near Keith in Moray was made to BOWL in 2006 based on available capacity and connectivity into the wider Grid.

19. Although a connection at Blackhillock was already agreed, cable routes from the Wind Farm to alternative substations, as well as alternative routes to Blackhillock were considered by BOWL. This consideration of alternatives was undertaken to

ascertain the likely technical and environmental effects of the link to Blackhillock relative to other potential grid connection locations, and to ensure that a connection at Blackhillock is the optimum location.

20. A site selection process and appraisal exercise was therefore undertaken and performed as follows:

- Identification of onshore substations located around the coastline of the Moray Firth and identification of potential routes from the Wind Farm;
- Appraisal of route options and landfall locations against environmental and technical constraints; and
- Appraisal of routes for the OfTW between the Wind Farm and the optimal landfall, and identification of a preferred option.

6.4.1 ONSHORE SUBSTATION OPTIONS AND ONSHORE CABLE ROUTE

21. As the location of the OSPs is yet to be decided, for the purposes of the consideration of alternative OfTW cable routes the location of the start of the OfTW cable route is taken as the closest point of the Wind Farm boundary to the onshore substation at which the Wind Farm would be connected to the grid.

22. All available substations on the mainland within approximately 40 km of the coastline of the Moray Firth were identified as potential grid connection points. This identified the following five potential onshore substation grid connection options (Figure 6.2):

- Blackhillock substation;
- Peterhead substation;
- Rothienorman substation;
- Dunbeath substation; and
- Mybster substation.

23. Scottish Hydro Electric Transmission Ltd (SHETL) is planning a HVDC connection to provide a high capacity electricity connection between the Grid and renewable energy projects on Shetland. As part of the submarine portion of the connection, an offshore hub is being considered which may have the potential to allow the offshore wind farms in the vicinity to utilise a single connection to the transmission network. This hub would likely be located in vicinity to the Wind Farm Site if it proceeds. However, this option has not yet been consented or built and BOWL is therefore unable to replay this as a valid option at the EIA and consent submission stage. The offshore hub option has therefore not been considered further in this ES.

24. A route appraisal workshop was held in July 2010 attended by BOWL's development team, project engineers and EIA consultants. The workshop identified 14 potential route options linking the Wind Farm to the six substation locations (Figure 6.2). Each route option was appraised taking into account a variety of environmental and engineering constraints mapped using a Geographic Information System (GIS). For the purposes of this ES, and the identification of a suitable landfall and OfTW cable route, the optimum option identified was a direct route to the agreed grid connection point at Blackhillock, as other options were

more constrained by route length, environmental designations and grid connection constraints.

25. The offshore hub option was appraised as having very few environmental or technical constraints. However, this option has not yet been consented or built and BOWL is therefore unable to rely solely on this as a valid option at the EIA and consent submission stage. In addition, the hub will need to be connected to the grid and its capacity may be constrained. The offshore hub option has therefore not been considered further in this Section.

6.4.2 CABLE LANDFALL

26. The landfall options were largely determined by the selection of the preferred grid connection and onshore substation location, identified as Blackhillock.

27. Five potential landfall locations for a connection to Blackhillock were identified following screening out of constrained sites, including consideration of high level technical, economic or environmental factors consisting of the distance from Blackhillock, technical suitability, and avoiding designated sites where possible (see Figure 6.3). The landfall locations identified included:

- Portgordon West (Approximate National Grid Reference (NGR): NJ 391 643);
- Portgordon East (Approximate NGR: NJ 399 645);
- Portlessie Bay (Approximate NGR: NJ 447 670);
- Sandend Bay (Approximate NGR: NJ 556 662) ; and
- Cullen Bay (Approximate NGR: NJ 500 677).

28. The landfall locations were assessed not only in terms of the landfall site, but also the route the cables would take to the grid connection point at Blackhillock. Following an environmental review of the terrestrial route options, in the majority of cases the landfall locations were rejected on the grounds of the resultant OnTW route to Blackhillock rather than significant issues at the landfall itself.

29. The preferred landfall location and corridor to Blackhillock was identified as Portgordon West. This decision was largely due to the suitability of the corridor from the landfall onto Blackhillock. The route is also the shortest to Blackhillock, with minimal environmental and engineering constraints along the route.

30. Following a civil engineering site visit, extents for the cable landfall were identified within the Portgordon West landfall (between NGR: NJ 38614 64277 and NJ 37525 64629), the outcomes of the assessments in this EIA will help to determine a specific landfall between these extents.

31. Following consultation, SNH has recommended that directional drilling should be used to create a cable route under the Spey Bay Site of Special Scientific Interest (SSSI). Directional drilling will likely be undertaken under the landfall location, to avoid disturbing the Spey Bay SSSI. The nearshore approach is characterised by very gentle slopes, at Portgordon, the 10 m water depth isoline is situated approximately 1.8 km from the coast. Therefore, the directional drilling is likely to start at this location or beyond so that the cable does not interfere with offshore/onshore/alongshore sediment movement. The cable will then exit

onshore sufficiently far enough back so that the coastline retreat would not expose the cable on the beach in its expected operational lifetime. This will therefore avoid any interaction between the cable and the SSSI. The landfall has been assessed in more detail in the OfTW assessments within this EIA, and also within the application for the OnTW due to the overlap in the consenting jurisdictions, to identify embedded development design and mitigation solutions to minimise effect upon the Spey Bay SSSI.

6.4.3 OFFSHORE TRANSMISSION WORKS CABLE ROUTE

32. Following the identification of the preferred substation and landfall, a joint study (JP Kenny Renewables, 2011) was undertaken by BOWL, SHETL and MORL to discuss offshore transmission works cable route options that may affect each party. All three projects are in close proximity to each other within the Moray Firth and collaboration was undertaken to identify a preferred solution for all parties.

33. A direct route from the Wind Farm to the preferred landfall at Portgordon West would cross the MORL Western Development Area, therefore consultation with MORL was undertaken to minimise the potential impact on their development, and the need for any export cables to cross a number of inter-array cables and the associated risks to each project arising from this. A similar issue exists with the consented SHETL route from Shetland to the Moray Coast, which also crosses the MORL Western Development Area.

34. The objective of the joint study was to undertake a desk-based route assessment of the potential OfTW cables routes through and/or around the MORL Development Zone to the planned landfall at Portgordon West. All aspects of routing issues were considered, including seabed and ground conditions, engineering constraints, third party interactions, environmental and physical constraints, and restricted zones.

35. Five route options for the OfTW were developed (Figure 6.4) as follows:

- Option 1 - Direct route (62.9 km) - this is the most direct route from the Beatrice Offshore Wind Farm to the landfall at Portgordon;
- Option 2 - MORL passage route (63.8 km) - this route follows the passage between the Eastern and the Western development sites of the MORL Zone and then straight south to the landfall at Portgordon;
- Option 3 - Workshop route (64.9 km) - envisaged as a compromise between routing around and through the MORL Zone, the route follows the northern boundary of the MORL Zone. At the point where it reaches the 3.7 km (2 NM) turbine exclusion zone enforced around the Beatrice A offshore platform, the route turns south and exits the turbine exclusion zone passing through the MORL site towards Portgordon West;
- Option 4 - West Route (73.8 km) - this route goes to the west of the Beatrice Oil Field and avoids all related infrastructure e.g. pipelines and power cables; and
- Option 5 - East Route (99.7 km) - this route follows the MORL boundary to the east and then south to Portgordon West.

36. To minimise disturbance with the MORL Development Zone and to ensure cable lengths are not excessive, Option 3 was identified as the preferred OfTW route, by

BOWL, SHETL and MORL. Therefore Option 3 is the OfTW route described and assessed in this ES. The water depth in the Moray Firth is not considered to be a problem for the installation of large power cables; the typical strength of an armoured HVDC or HVAC cable is comfortably sufficient to withstand its self-weight plus the laying tension, at a laying depth in excess of 100 m. Up to three individual power export cables will run parallel to each other with a separation distance (between cables) of approximately four times water depth. The OfTW corridor therefore varies in width between 575 m and 1.54 km. The OfTW corridor is described in more detail in Section 7: Project Description of this ES.

6.5 SUMMARY

37. The site selection process for the Wind Farm included consideration of alternative sites and layouts, and the development of the Wind Farm Rochdale Envelope has included consideration of a range of available technologies and construction processes. Detailed environmental and technical appraisals of the options available for the grid connection point and OnTW route, the landfall and the OfTW route have been undertaken. The OfTW route chosen has been assessed in this ES.

38. The OnTW and OfTW can be summarised as:

- The onshore substation and grid connection, to be located at Blackhillock;
- The landing point at Portgordon West;
- The OnTW route running from Portgordon West to Blackhillock; and
- The OfTW route from Portgordon West to the Wind Farm site (Figure 1.1).

6.6 REFERENCES

39. DECC (2011) *National Policy Statement for Renewable Energy Infrastructure (EN-3)*

40. JP Kenny Renewables (2011) Moray Firth Cable Routing Options Appraisal

41. SNH (2004) *Policy Statement 04/01 Marine Renewable Energy and the Natural Heritage: an Overview and Policy Statement*

42. Scottish Government (2006) *Matching Renewable Electricity Generation and Demand*