4 AMENDED PROJECT DESCRIPTION

4.1 INTRODUCTION

1. This section provides a description of the Amended Project and provides further indicative information on construction methods for the Amended Project.

2. Section 4.2 describes the site and location of the Amended Project. The Amended Project Boundary remains the same as the Original Project Boundary as described in Section 7.2 of the Original ES with the following amendment:

- Amended OfTW Corridor described in Section 1: Introduction.

3. Section 4.3 describes the Amended Project itself. It explains the approach of using a Rochdale Envelope which sets out maximum and minimum parameters within which the final design of the Amended Project will fall. The Original Project description as described in Section 7: Project Description of the Original ES is amended as follows:

- Increase in the footprint of jack-up vessels used during construction of the Wind Farm; and
- Changes to the cable installation timescales for the OfTW.

4. Section 4.3 also expands on the equivalent Section 7: Project Description of the Original ES by including a description of a 'most likely' scenario, as explained in Section 1.6. Tables 4.1A-G present a summary of the Rochdale Envelope for the Amended Project (maximum and minimum parameters) and also present a summary of the 'most likely' scenario. These are a full restatement of the Original Project parameters (as amended) presented in Tables 7.1A-G of the Original ES.

5. Section 4.3.4 provides information on electromagnetic fields (EMF) in response to a request from consultees. This is further to the Original ES.

6. Section 4.4, at the request of consultees, include more indicative detail on construction methods, in particular vessel types, than was contained in the Original ES. It should be noted that, as the type of vessel available at the time cannot be predicted, these descriptions are illustrative so as to aid consultee's understanding. The vessels described provide information as available at the current time.

7. Section 4.5 provides information on the construction programme.

8. Where the Amended Project remains unchanged from the Original Project, this has been stated and this information is not repeated in this Section.

4.2 SITE DESCRIPTION

4.2.1 THE WIND FARM

9. The Wind Farm Site location, description and characteristics remain as described in Section 7.2.1 and 7.2.2 of the Original ES. To summarise, the Wind Farm Site is located approximately 25 km south south-east of Wick, Caithness and is located on the Smith Bank, a bathymetric high in the outer Moray Firth. The Wind Farm Site is, at its closest point, 13.5 km from the coastline (see Figure 1.1).

10. The Wind Farm Site is approximately 19 km in length and 9 km in width at the maximum extents of the site, covering an area of approximately 131.5 km^2.

4.2.2 THE OFTW

11. There has been a minor amendment to the Original OfTW Corridor since the submission of the Original ES. As stated previously in Section 1.4, the amendment to the Original OfTW Corridor was identified as a requirement through ongoing consultation with oil platform stakeholders.

12. The Original OfTW Corridor has been widened in the vicinity of the Beatrice Bravo oil platform. This is to ensure that the subsea cable can be laid a minimum of 1.5 km away from the oil platform, a separation distance identified by the oil platform stakeholders. An additional area of 3.71 km^2 within the Amended OfTW Corridor has been included as a result of this amendment (see Figure 1.3).

13. The Amended OfTW Corridor is approximately 65 km in length and varies between 575 m and 1.6 km in width, running between the Wind Farm Site and Mean High Water Springs (MHWS) at the landfall point. A plan showing the Amended OfTW Corridor is presented in Figure 1.2.

14. The landfall point for the OfTW remains unchanged from the Original ES. The scope of this application ends at MHWS. The onshore cable route from this point landward falls within the application for Planning Permission in Principle submitted to The Moray Council in October 2012 for the Onshore Transmission Works.

4.3 DEFINITION OF THE AMENDED PROJECT

4.3.1 ROCHDALE ENVELOPE

15. As stated in Section 7.3.1 of the Original ES, due to uncertainties associated with offshore construction, it is not possible to define a detailed Project design at this point in the development process. In addition, there are details that cannot yet be finalised in relation to the construction techniques, vessels and methods that will be used during construction and ultimate decommissioning of the Project.

16. In order to ensure that the EIA is sufficiently robust and has taken account of the worst case likely significant effects arising from the Project, a set of parameters were developed for the Original ES. These parameters are collectively referred to as the 'Rochdale Envelope' as defined in Section 3: EIA Process and Methodology of this ES Addendum.

17. The Rochdale Envelope remains largely unchanged from the Original ES and is presented, as updated, in Tables 4.1A-G below. The changes from the Original ES are:

- Increase in the footprint of the jack-up vessels used during construction of the Wind Farm from 30 m^2 per leg footprint to 200 m^2 per leg footprint, assuming a 6 leg vessel as the worst case;
- Alteration to the construction programme and associated timescales for the installation of cables; and

- Amendment to the Original OfTW Corridor.

18. The Original ES presented the footprint for a jack-up vessel which would be used to install the turbines. New information on vessels has since become available and hence the footprint of the jack-up vessel for the Amended Project is 200 m^2 per leg of the vessel. Jack-up vessels have four to six legs; assuming a worst case of six legs, the maximum footprint of the jack-up vessel in the Amended Project is therefore 1,200 m^2.

19. Since the submission of the Original ES, further information has become available relating to the construction processes for the Project. As such, the Rochdale Envelope parameters with regard to the duration of cable installation for the OfTW has been further developed to give a full breakdown of activities and when, throughout the OfTW cable installation campaign, they will occur (Table 4.1G). This scenario presents the worst case (i.e. maximum time period) for the OfTW cable installation based on available information at this time.

20. As per the Original ES, the author of each technical assessment has been advised of the Rochdale Envelope parameters as set out in Tables 4.1A-G. Neither worst case scenario will represent the Final Build Plan, however, as the design of the Amended Project will be within these parameters, the effects of the final design will be no worse, and likely less than those predicted.

21. Each technical assessment section describes which components and construction methods representing the worst case and provides an assessment of environmental effects based on that definition.

22. Following consent and final detailed design, a Final Build Plan (as outlined in the construction method statement) will be provided to Marine Scotland Licensing Operations Team (MS-LOT) for approval. The purpose of this submission will be to:

- Demonstrate compliance with any conditions attached to consents; and
- Ensure that the final design remains within the parameters of the Rochdale Envelope considered in the Original ES as amended by this ES Addendum.

4.3.2 THE 'MOST LIKELY' SCENARIO

23. As described in Section 3.5 of this ES Addendum, in order to assist consultees, this ES Addendum includes a 'most likely' scenario for the development of the Amended Project. This most likely scenario has been used for illustrative purposes throughout this ES Addendum to present the likely environmental effects of what BOWL considers may be a likely representation of the Amended Project in reality.

24. The most likely scenario has been developed through ongoing engineering design which is working towards the concept design for the Amended Project. **This does not represent the final detailed design and hence consent is still sought based on the Rochdale Envelope parameters (presented in this section).**

25. The most likely scenario is presented in Tables 4.1A-G. Key elements are as follows:

4.3.2.1 *Wind Turbines*

26. The detailed design and layout of the site will not be finalised until further engineering design has been undertaken. As such, the indicative layout for the most likely scenario remains as presented in the Original ES. No specific layout is presented for the most likely scenario, however, a most likely spacing between the turbines is presented in Table 4.1A.

4.3.2.2 The most likely scenario is based on the construction of 140 turbines with a maximum tip height of 187.4 m.

4.3.2.3 *Substructures and Foundations*

27. The Rochdale Envelope provided a range of alternative options for substructures and foundations for met masts, offshore substation platforms and turbines. The most likely scenario is based on the use of a tubular jacket substructure with pin pile foundations.

4.3.3 AMENDED PROJECT PARAMETERS

28. Tables 4.1A-G present the Rochdale Envelope and most likely scenario parameters as assessed for the Amended Project throughout this ES Addendum.

Table 4.1A: Amended Project Rochdale Envelope Parameters and Most Likely Scenario (Turbines)

Wind Turbine	**Rochdale Envelope Parameters**			**Most Likely Scenario**		
Description of Component and Nature of Uncertainty	**Range of Components and Key Parameters**	**Utilising the anticipated smallest turbine available**	**Utilising the anticipated largest turbine available**	**Range of Components and Key Parameters**	**Utilising the likely turbine parameters**	**Comments**
Three bladed horizontal axis wind turbine. **These scenarios outline the largest and smallest turbines that would be utilised on site. The final turbine choice will lie within these extents. Each scenario also represents the maximum number of turbines of each size that would be installed. The final number of turbines may be less, but will not exceed those set out in the Rochdale Envelope.**	**Rated Generating Capacity per Turbine**	3.6 MW	7 MW	**Rated Generating Capacity per Turbine**	Not known	Due to the ongoing design both within and outwith BOWL this is not known.
	Maximum number of turbines	277	142	**Likely number of turbines**	140	
	Tip Height Range	132.6 – 140.6 m	190.4 – 198.4 m	**Tip Height Range**	179.4 – 187.4 m	The hub and tip heights relate directly to the blade clearance range. Since this has not yet been finalised, this range cannot be narrowed further at this point in time.
	Hub Height Range	79 m – 87 m	107.9 m – 115.9 m	**Hub Height Range**	102.4 m – 110.4 m	

Wind Turbine	**Rochdale Envelope Parameters**			**Most Likely Scenario**		
Description of Component and Nature of Uncertainty	**Range of Components and Key Parameters**	**Utilising the anticipated smallest turbine available**	**Utilising the anticipated largest turbine available**	**Range of Components and Key Parameters**	**Utilising the likely turbine parameters**	**Comments**
	Indicative Nacelle Dimensions (l x w x h)	13 m x 4 m x 4 m	26 m x 16 m x 12 m	**Indicative Nacelle Dimensions (l x w x h)**	15.1 m x 9.1 m x 9.0 m	Including external components such as heli hoist platform
	Blade Clearance above Lowest Astronomical Tide (LAT)	25.4 m – 33.4 m	25.4 m – 33.4 m	**Blade Clearance above Lowest Astronomical Tide (LAT)**	25.4 m – 33.4 m	
	Maximum Rotor Diameter	107.2 m	165 m	**Likely Rotor Diameter**	154 m	
	Maximum Blade Swept Area	9,025.7 m^2	21,382.5 m^2	**Likely Blade Swept Area**	18,627 m^2	
	Revolutions per Minute Range	4.8 – 13	4.8 – 13	**Revolutions per Minute Range**	5-11	The rpm varies depending on the wind speed so this must remain a range
	Minimum Spacing	642 m	990 m	**Minimum Spacing**	985.6 m	

Table 4.1B: Amended Project Rochdale Envelope Parameters and Most Likely Scenario (Meteorological Masts)

Meteorological Masts	**Rochdale Envelope Parameters**			**Most Likely Scenario**		**Comments**
Masts equivalent to turbine height mounted with meteorological monitoring equipment required to monitor wind conditions at the site. **Precise number of masts and mast locations undetermined.**	**Mast Type**	Lattice structure tower mast		**Mast Type**	Lattice structure tower mast	
	Maximum Number of Masts	3		**Likely Number of Masts**	3	
	Minimum Number of Masts	1				
	Minimum Height above LAT	79 m		**Likely Height above LAT**	102.4 – 110.4 m (This varies depending on final hub height so must remain a range)	
	Maximum Height above LAT	115 m				
	Design	Lattice tower structure with equipment on booms at various heights including the top.		**Design**	Lattice tower structure with equipment on booms at various heights including the top.	
	Power Source	Powered by either independent renewable source e.g. small solar panel or connected to wind farm distribution system by inter-array cables.		**Power Source**	Powered by either independent renewable source e.g. small solar panel or connected to wind farm distribution system by inter-array cables.	
	Available Substructure Types	Tubular Jacket	Monotower	**Likely Substructure Types**	Tubular Jacket	
	Available Foundation Types	Pin piles Suction piles	Gravity Base Monopile	**Likely Foundation Types**	Pin piles	
	Location	Likely to be located on the outer edges of the Wind Farm.		**Location**	Likely to be located on the outer edges of the Wind Farm.	

Table 4.1C: Amended Project Rochdale Envelope Parameters and Most Likely Scenario (Substructures)

Substructure	Rochdale Envelope Parameters			Most Likely Scenario				Comments
Structure that connects the above sea level structure with the foundation. Will be used for turbines, meteorological masts and OSPs. **Substructure type not yet known.** **Dimensions of substructure types unknown.**	**Substructure Type**	Tubular Jacket	Monotower	**Substructure Type**	Tubular Jacket			
	Design	Tubular steel lattice structure with up to 4 'legs'	Single cylindrical steel or concrete tube	**Design**	Tubular steel lattice structure with 4 'legs'			
	Dimensions	Unknown - will vary based on water depth and foundation type		**Dimensions**	Water Depth: up to 40m Base diameter : 22.8m Top diameter: 12m Height: 61.5m	Water Depth: up to 50m Base diameter : 24.9m Top diameter: 12m Height: 71.5m	Water Depth: Over 50m Base diameter : 26m Top diameter: 12m Height: 76.5m	
	Applications	Suitable for turbines, meteorological masts and OSPs	Suitable for turbines and meteorological masts	**Applications**	Suitable for turbines, meteorological masts and OSPs			
	Possible Foundation Types	Pin piles, suction piles or gravity bases for turbines, meteorological masts and OSPs	Conical gravity base with turbines. Conical gravity base or monopile for meteorological masts	**Foundation Type**	Pin piles			

Table 4.1D: Amended Project Rochdale Envelope Parameters and Most Likely Scenario (Foundations)

Foundations	**Rochdale Envelope Parameters**					**Most Likely Scenario**		**Comments**
Element that fixes the substructure to the seabed. **Will be used for turbines, meteorological masts and Offshore Substation Platforms (OSPs).**	**Foundation Type**	Pin Piles	Suction Piles	Gravity Base	Monopile	**Foundation Type**	Pin Piles	
	Applications (Substructure)	Tubular Jacket	Tubular Jacket	Tubular Jacket Monotower	Monotower	**Applications (Substructure)**	Tubular Jacket	
	Applications (above sea level components)	Turbine, OSP and Meteorological Mast	Turbine, OSP and Meteorological Mast	Turbine, OSP and Meteorological Mast	Meteorological Mast	**Applications (above sea level components)**	Turbine, OSP and Meteorological Mast	
	Primary Materials	Steel	Steel	Concrete or steel	Steel	**Primary Materials**	Steel	
	Brief Description	Steel pins on each leg of Tubular Jacket driven into the seabed. Maximum blowforce of 2300 kJ. Vibropiling which is currently an untested technique may be used if feasible.	Upturned bucket style design on each leg of Tubular Jacket sunk into the seabed using vacuum pumps.	Cast structure that sits on flat sea bed and relies on the weight of the structure for stability.	Cylindrical tube driven into the seabed.	**Brief Description**	Steel pins on each leg of Tubular Jacket driven into the seabed. Likely maximum blowforce of 2300 kJ. Vibropiling which is currently an untested technique may be used if feasible.	The maximum blow force will be further defined when further geotechnical information is available; it is possible a lighter hammer will be used.

Foundations	**Rochdale Envelope Parameters**					**Most Likely Scenario**		**Comments**
	Foundation Type	Pin Piles	Suction Piles	Gravity Base	Monopile	**Foundation Type**	Pin Piles	
	Dimensions / Depth (Dependent on number of piles and sea bed conditions)	Each turbine pile up to 2.4 m diameter. Each OSP pile up to 3 m diameter. Approximately 20 m – 80 m in length.	Each pile 5 m – 15 m diameter. Approximately 8 m – 30 m penetration depth.	50 m – 65 m in diameter for turbines. 50 m – 100 m for OSPs. Sits on seabed.	Approximately 5 m diameter. Up to approximately 80 m in length	**Dimensions / Depth (Dependent on number of piles and sea bed conditions)**	Turbine piles: Likely to be 1.8m diameter. Seabed penetration depth: 32m – 42m Length Range: 36m – 51m OSP piles: Either 8 × 1.8m piles or 4 × 2.4m piles Likely seabed penetration depth: 25 - 43 m	Pile lengths will vary depending on the geotechnical conditions at the turbine site in question, hence the remaining range in lengths

Foundations	Rochdale Envelope Parameters						Most Likely Scenario		Comments
	Associated Operations		Seabed obstructions survey. Drilling operations. Piling operations. Cement grouting. Use of jack-up vessel.	Seabed obstructions survey. Use of jack-up vessel.	Seabed obstructions survey; Seabed preparation using jetting tool and dredging up to 5 m below starting seabed level; Ballasting operations. Use of jack-up vessel.	Seabed obstructions survey. Piling. Grouting. Use of jack-up vessel.	**Associated Operations**	Seabed obstructions survey. Drilling operations. Piling operations. Cement grouting. Use of jack-up vessel. Vibro piling.	
Dependent on final turbine and substructure selection. **Different combinations of turbine, substructure and foundation type will have different zones of influence.**	**Zone of Influence – Per Turbine**	**Maximum Footprint (areas of seabed in direct contact with structure)**	14 m²	707 m²	3,318 m²	N/A	**Likely footprint (areas of seabed in direct contact with structure)**	11 m²	Areas are for most likely scenario of 1.8m piles and largest jacket of 26m diameter base
		Shadow (area of seabed over which structure is sited)	6,145 m²	8,636 m²	3,318 m²	N/A	**Shadow (area of seabed over which structure is sited)**	2,153 m²	Areas are for most likely scenario of 1.8m piles and largest jacket of 26m diameter base
		Maximum Temporary Zone of Influence	9,272 m²	17,449 m²	20,867 m²	N/A	**Likely Temporary Zone of Influence**	4,134 m²	Areas are for most likely scenario of 1.8m piles and largest jacket of 26m diameter base

Foundations	Rochdale Envelope Parameters						Most Likely Scenario		Comments
		Maximum Permanent Zone of Influence	7,644 m^2	15,186 m^2	18,385 m^2	N/A	**Likely Permanent Zone of Influence**	3,073 m^2	Areas are for most likely scenario of 1.8m piles and largest jacket of 26m diameter base

Table 4.1E: Amended Project Rochdale Envelope Parameters and Most Likely Scenario (Inter-Array Cables)

Inter-Array Cables		Rochdale Envelope Parameters			Most Likely Scenario		Comments
Cables linking turbines and substations. **Current unknowns are; routing of cables; location in terms of being above or below the sea bed and protection measures required in either case. The length of cable required will be dictated by these issues.** **There is a presumption in favour of burial or protection where feasible, however, the full extent of this is currently unknown pending further technical studies.**	**Indicative Cross Sectional Area**	185 mm^2	400 mm^2	800 mm^2	**Indicative Cross Sectional Area**	240 - 630 mm^2	The variation is due to the use of multiple cable diameters. Cables carrying higher current require larger cables areas and diameters.
	Outer Diameter	113 mm	129 mm	157 mm	**Outer Diameter**	135 - 157 mm	
	Weight (kg/m)	21	28.1	48.9	**Weight (kg/m)**	24.4 – 43.2	
	Possible Voltage Range	33 – 66 kV AC			**Likely Voltage**	33 kV AC	
	Maximum Total Length of Cabling	350 km			**Likely Total Length of Cabling**	260 km	
	Maximum Length of Buried Cabling	325 km			**Likely Length of Buried Cabling**	230 km	
	Minimum Length of Buried Cable	0 km					
	Minimum Burial Depth	On seabed surface			**Likely Burial Depth**	1.0 m	
	Maximum Burial Depth	2.5 m					
	Minimum Zone of physical disturbance from trench	1.5 m			**Likely zone of physical disturbance from trench**	3 m	Cannot be refined further at this time due to likely installation method not being finalised
	Maximum Zone of physical disturbance from trench	3 m					

Inter-Array Cables		Rochdale Envelope Parameters				Most Likely Scenario			Comments
	Cable Protection Measure Options	Concrete blanket/ matressing	Rock Net/ gabion	Rock Placement	No Protection	**Likely cable protection measures**	Concrete blanket/ matressing	Rock Placement	
	Maximum extent of cable protection	0.48 km^2				**Maximum extent of cable protection**	0.48 km^2		
	Installation techniques for buried cables	**Ploughing** Involves a blade cutting through the seabed and the cable laid behind. Plough will be pulled by either Surface vessel or Remote Operated Vehicle (ROV).	**Jetting** Involves the formation of trenches through the use of a water jet to displace sediment. The jet is usually attached to an ROV and is either free swimming, on ski-like skids or active tracks (e.g. caterpillar).	**Trenching** Involves the excavation of a trench by a caterpillar tracked vehicle temporarily placing the excavated sediment adjacent to the trench.		**Likely installation techniques for buried cables**	**Ploughing** Involves a blade cutting through the seabed and the cable laid behind. Plough will be pulled by either Surface vessel or Remote Operated Vehicle (ROV).		**Jetting** Involves the formation of trenches through the use of a water jet to displace sediment. The jet is usually attached to an ROV and is either free swimming, on ski-like skids or active tracks (e.g. caterpillar).

Table 4.1F: Amended Project Rochdale Envelope Parameters and Most Likely Scenario (Offshore Substation Platforms)

Offshore Substation Platforms (OSPs)		**Rochdale Envelope Parameters**		**Most Likely Scenario**
OSPs collect electricity from the turbines via Inter-Array Cables and convert the voltage to a suitable current for export via the OfTW.	**OSP Type**	AC Transmission	DC Transmission	AC Transmission
	Maximum Number of OSPs	2 AC OSPs	2 AC OSPs and 1 DC OSP	2 AC OSPs
	Maximum dimensions (l x w x h)	40 m x 40 m x 30 m	115 m x 55 m x 42 m	Topsides structure alone: 42 x 30 x 19m 33 x 20 x 16m
	Maximum Weight	2,300 t	16,000 t	45m LAT Jacket – 1985 t 55m LAT Jacket – 2150 t
	Maximum height from Lowest Astronomical Tide (LAT)	20 m	20 m	20 m
	Available Foundation Types	Pin Piles (excluding pre-driven piles) (3 m pin piles) Suction Piles		Pin Piles Likely pile diameter: 1.8 m or 2.4 m
	Available Substructure Type	Tubular Jacket		Tubular Jacket
	Access Facilities	Boat landing and helipad		Boat landing and helipad

Table 4.1G: Amended Project Rochdale Envelope Parameters and Most Likely Scenario (Offshore Transmission Works)

<table>
<tr><th>Offshore Transmission Works (OfTW)</th><th></th><th colspan="3">Rochdale Envelope Parameters</th><th colspan="2">Most Likely Scenario</th></tr>
<tr><td rowspan="15">The OfTW comprises cables transmitting electricity from the OSPs to the Substation element of the Onshore Transmission Works.

Transmission may be alternating current (AC) or direct current (DC).
Number of cables and trenches.
Routing of trenches.
Cable protection measures.</td><td>Number of Cable Trenches</td><td colspan="3">Up to three cable trenches required on the seabed.</td><td colspan="2">3</td></tr>
<tr><td>Maximum Width of Cable Trench</td><td colspan="3">3 m</td><td colspan="2">3 m</td></tr>
<tr><td>Maximum Depth of Cable Trench</td><td colspan="3">2.5 m</td><td colspan="2">1.7 m</td></tr>
<tr><td>Maximum Number of cables per trench</td><td colspan="3">3</td><td colspan="2">1</td></tr>
<tr><td>Maximum distance between trenches</td><td colspan="3">Approximately four times water depth.</td><td colspan="2">Approximately four times water depth.</td></tr>
<tr><td>Maximum water depth along cable route corridor(s)</td><td colspan="3">Approximately 100 m</td><td colspan="2">Approximately 100 m</td></tr>
<tr><td>Minimum water depth along cable route corridor(s)</td><td colspan="3">38 m</td><td colspan="2">38 m</td></tr>
<tr><td>Maximum slope of cable plough</td><td colspan="3">15 degrees</td><td colspan="2">15 degrees</td></tr>
<tr><td>Maximum slope of sea level in route corridor(s)</td><td colspan="3">3 degrees</td><td colspan="2">3 degrees</td></tr>
<tr><td>Installation techniques for installation</td><td>Ploughing</td><td>Jetting</td><td>Trenching</td><td>Ploughing</td><td>Jetting</td></tr>
<tr><td>Typical Dimensions of Drilling Equipment (l x w x h)</td><td>9 m x 4 m x 3.5 m</td><td>8 m x 4 m x 2.5 m</td><td>12.6 m x 10 m x 6.1 m</td><td>9 m x 4 m x 3.5 m</td><td>8 m x 4 m x 2.5 m</td></tr>
<tr><td>Cable Protection Measure Options</td><td>Concrete blanket/ matressing</td><td>Rock Net/ gabion</td><td>Rock placement</td><td colspan="2">Rock placement</td></tr>
<tr><td>Maximum length of cable protection (i.e. maximum length of surface laid cable)</td><td colspan="3">45% of total cable length</td><td colspan="2">10.7 km</td></tr>
<tr><td>Maximum extent of cable protection</td><td colspan="3">0.26 km^2</td><td colspan="2">0.26 km^2</td></tr>
</table>

Table 4.1G: Amended Project Rochdale Envelope Parameters and Most Likely Scenario (Offshore Transmission Works) contd

Definitions: **For the construction activity in question:** **The 'Total Time' is the entire time that all operations related to the activity in question are likely to take.** **The 'seabed contact time' is the time duration – out of the total time – where there is contact with the seabed.**	**Maximum total duration of cable laying operations (based on one cable in each of three trenches i.e. 3 cables total)**	**Year 1 Campaign – 1 Cable installed**		**Likely durations of all cable laying operations, broken down by activity (based on one cable in each of three trenches i.e. 3 cables total).** **The likely scenario presented here is 2 cables installed in Year 1, and 1 cable installed in Year 2.**	**Year 1 Campaign – 2 export cables installed**	
		Pre-lay ROV survey and boulder clearance: Total survey time: Seabed contact time:	 20 days 5 days		Pre-lay ROV survey and boulder clearance: Total survey time: Actual seabed contact time:	 26 days 3 days
		Pre-Lay Grapnel Run: Total grapnel run time: Seabed contact time:	 20 days 15 days		Pre-Lay Grapnel Run: Total grapnel run time: Actual seabed contact time:	 22 days 16 days
		Cable Installation: Total time including transit, loadout, transport and installation: Seabed contact time (cable jointing included):	 100 days 70 days		Cable Installation: Total time including transit, loadout, transport and installation: Seabed contact time (cable jointing included):	 139 days 104 days
		Total duration of all activities Year 1: Total seabed contact time for all activities Year 1:	140 days 90 days		Total duration of all activities Year 1: Total seabed contact time for all activities Year 1:	187 days 123 days
		Year 2 Campaign – 1 cable installed			**Year 2 Campaign – 1 cable installed**	
		All elements have identical installation durations to year 1 (above)			Pre-lay ROV survey and boulder clearance: Total survey time: Seabed contact time:	 13 days 1.5 days
		Year 3 Campaign – 1 cable installed			Pre-Lay Grapnel Run: Total grapnel run time: Seabed contact time:	 11 days 8 days
		All elements have identical installation durations to Year 1 (above)				

					Cable Installation: Total time including transit, loadout, transport and installation: Seabed contact time (cable jointing included):	 76 days 52 days
					Total duration of all activities Year 2: Total seabed contact time for all activities Year 2:	100 days 61.5 days
	Total duration of cable protection operations (based on one cable in each of three trenches i.e. 3 cables total)	**Year 1 Campaign – 1 cables installed**		**Likely durations of all cable protection operations, broken down by activity (based on one cable in each of three trenches i.e. 3 cables total)** **The likely scenario presented here is 2 cables installed in Year 1, and 1 cable installed in Year 2.**	**Year 1 Campaign – 2 cables installed**	
		Jet Trenching including pre and post trench survey: Total time: Seabed contact time:	 60 days 50 days		Jet Trenching including pre and post trench survey: Total time: Seabed contact time:	 86 days 62 days
		Rock placement: Total rock placement time: Seabed contact time:	 30 days 10 days		Rock placement: Total rock placement time: Seabed contact time:	 42 days 8 days
		Year 2 Campaign – 1 cable installed			**Year 2 Campaign – 1 cable installed**	
		All elements have identical installation durations to Year 1 (above)			Jet Trenching including pre and post trench survey: Total time: Seabed contact time:	 43 days 31 days
		Year 3 Campaign – 1 cable installed All elements have identical installation durations to Year 1 (above)			Rock placement: Total rock placement time: Seabed contact time:	 21 days 4 days

4.3.4 ELECTROMAGNETIC FIELDS (EMF)

29. The Original ES generated some comments from consultees requesting more information relating to EMF associated with the Project. The following section provides background to EMF and its context with regard to the Amended Project.

4.3.4.1 EMF Background Information

Electric Fields (E)

30. An energised cable with a voltage across it will create an electric field (denoted E) which is proportional to the magnitude of the voltage and stored charge rather than the current flowing in the cable. Higher voltage circuits (i.e. a 66 kV as opposed to 33 kV) would therefore create a larger electric field.

Magnetic Fields (B)

31. Both AC and DC cables will produce an electric field when a voltage is applied and a magnetic field when power is flowing in the cable. If the current is DC, the current is constant and therefore so is the magnetic field (denoted B). If the current is AC, then the magnetic field will also alternate. B is proportional to the magnitude of the current and permeability of the surrounding material and is inversely proportional to the distance from the conductor.

Induced Electric Fields (E_i)

32. An induced electric field (denoted E_i) is produced due to the varying magnetic field, B, which results in an opposing electric field (E) forming. As only AC cables produce a changing magnetic field (B) then the assumption could be made that only AC cables will produce an induced electric field.

33. However, in the submarine environment, there is still the possibility of an induced electric field for DC cables. This is due to the fact that although the magnetic field remains constant, marine creatures or moving water will pass through this static field. This has the same result as a moving field and a static object; therefore an induced electric field will be created.

34. It should be noted that very small induced electric fields (E_i) are already naturally created by tidal streams or fast moving fish passing through the earth's static magnetic field.

4.3.4.2 EMF Emissions

35. Within a three-phase AC cable there are three separate cores, each of which is shielded by an insulation screen and contained within the cables outer metal armour. The use of insulation screens and cable armouring confines most of the directly generated electric field (E) within the cable and the design of the three cores are arranged within the cable in such a way as to have a cancelling effect on each other and further reduce the total field strength outside the cable. It cannot be said, however, that the screens shield all EMF emissions. As a result, there is residual electric field (E) and unshielded magnetic fields (B) outside the cable which radiate into the surrounding medium in which the cable is located (CMACS, 2003).

36. Although there is no three core cancelling effect for single core subsea or DC cables, again, the armour, and in the case of higher voltage cables the metallic sheath, will be designed to provide a shield against the main electric field (E) as per the design specification standard IEC 60502. Provided the armour has a robust grounding arrangement the electric field (E) will be blocked and hence contained within the cable core. However, if this was not the case, any leakage of E would be negligible when compared to E_i.

37. It should also be noted that the strength of the EMFs decreases rapidly both horizontally and vertically from the source.

4.4 INDICATIVE CONSTRUCTION INFORMATION

38. The detail from the Original ES provided information on the likely installation techniques, vessels and construction timescales. Feedback from consultees on the Original ES requested further information on the construction programme and details of vessels movement and installation durations.

39. The following sub-sections provide further detail of the most likely vessels and construction activities. It should be reiterated here that the specific vessels and construction programme cannot be determined and hence the following information is for illustration only. The availability of vessels, both in terms of design, and commercial availability will not be known until nearer the construction date. Similarly the construction will depend on the actual design of the Amended Project, and factors such as the weather and metocean conditions.

4.4.1 WIND TURBINE INSTALLATION

4.4.1.1 Transportation and Installation Process

40. At the time of writing, the specific vessel for installing the wind turbines has not been selected. It is however likely that a jack-up vessel will be used (See Plate 4.1 for an image of a jack-up vessel). These vessels are expected to have the capacity to carry between two and seven wind turbines dependent on the specific vessel and wind turbine type. Due to this variation in vessel capacity, the choice of vessels will have an impact on the turbine construction programme.

41. A representative example of one of these vessels is the Seafox 5[1] (not yet built). The vessel statistics are as follows:

- Length: 151 m
- Breadth: 50 m
- Design Draught: 6.0 m
- Depth: n/a
- Propulsion: 10 knots, Dynamic Positioning (DP)

[1] This is not the vessel shown in the image (Plate 4.1), as it has not yet been built. However, it is considered to provide realistic specifications of a jack-up vessel which could be used on the Amended Project.

Plate 4.1: Leviathan Jack-up Installation Vessel (Source: SSE)

42. Most jack-up vessels have four to six legs which have varying sizes of leg base footprint. The leg bases on existing jack-up vessels vary in size from 100 m^2 to 200 m^2. The most likely scenario would be a leg base area of 150 m^2 on a six legged vessel, equating to a footprint of 900 m^2.

43. The indicative wind turbine installation process using a heavy lift jack-up vessel is:

- Jacking and preload in harbour;
- Loading of wind turbine onto vessel;
- Preparation for sea transport;
- Transfer to site;
- Positioning/jacking/preparation for lifting;
- Installation of wind turbine tower;
- Installation of wind turbine nacelle;
- Installation of wind turbine blades;
- Jack down and relocate;
- Repeat utilising all turbines on board; and
- Transfer to port and re-load.

4.4.1.2 Construction Programme

44. There are many variables which will influence the turbine installation process and timelines, as such, the turbine construction timetable is not available at this time.

The following information provides a representative example for the installation of the most likely scenario, a wind farm with 140 turbines.

45. Installation is likely to be carried out over a three year period, predominantly April through September. The installation of one turbine including positioning of the vessel and jacking up, lifting/installation, jacking down and moving to the next location is likely to take 30 – 90 hours. Technical issues, mechanical breakdown and weather influence can greatly impact the actual time, but installation time is likely to be within this range. It is expected the number of turbines to be installed per week is between two and five.

Table 4.2: Construction Summary Most Likely Scenario: Wind Turbines

Vessel	Jack-up (e.g. Seafox 5)
Wind Turbine Installation Time (per turbine)	30 – 90 hours
Turbines installed per week	2 - 5
Jack-up Vessel Seabed Contact Time (per turbine)	30 – 90 hours
Seabed Contact Area (per turbine)	900 m^2
Total Installation Period	3 years

4.4.2 FOUNDATION AND SUBSTRUCTURE INSTALLATION

46. The substructure for the most likely scenario is a tubular jacket secured to the sea bed using pin pile foundations. Section 4.4.2.1 describes foundation installation and Section 4.4.2.2 describes substructure installation.

4.4.2.1 Foundation Transportation and Installation: Pin Piles

47. Pin piles will be transported from their manufacturing location to the Wind Farm Site. There are several options for the transfer of piles to the Wind Farm Site:

- Option 1: Pile installation vessel collects piles from manufacturing location and travels direct to the Wind Farm Site to commence installation; or
- Option 2: A separate transit vessel takes piles to a harbour near the Wind Farm Site where it is joined by the installation vessel. The piles are transferred to the installation vessel, which travels to the Wind Farm Site and commences installation; or
- Option 3: As Option 2, except that the vessels meet within the Wind Farm Site to transfer the piles.

48. In both Options 2 and 3, the transit vessel would then return to the pile manufacturer to collect a new load of piles.

49. The transit vessel type has not yet been decided. A representative example is a North Sea barge and anchor handling tug (AHT).

50. A North Sea barge is a rectangular, shallow draught vessel (cargo barge) which is transported by towing using one or multiple tugs. It is likely each barge will carry up to three jackets. The specification of a typical vessel is:

- Length: 90 -140 m
- Breadth: 30 – 40 m
- Draught: n/a
- Depth: n/a
- Propulsion: n/a

51. There are several vessel types under consideration for performing the pin pile installation. The most likely vessel types are:

- Heavy cargo vessel (HCV) (Plate 4.2); or
- Heavy lift vessel (HLV) (Plate 4.3).

52. A representative example of a HCV is the Jumbo Javelin (Plate 4.2). The vessel statistics are as follows:

- Length: 144.21 m
- Breadth: 26.70 m
- Draught: 7.9
- Depth: n/a
- Propulsion: 17 knots DP.

Plate 4.2: Jumbo Javelin HCV (Source: www.marinetraffic.com[2])

53. A representative example of a HLV used for pin pile installation is the Stanislav Yudin (see Plate 4.3). It would be equipped with a pile driving hammer as illustrated in Plate 4.4. The vessel statistics are as follows:

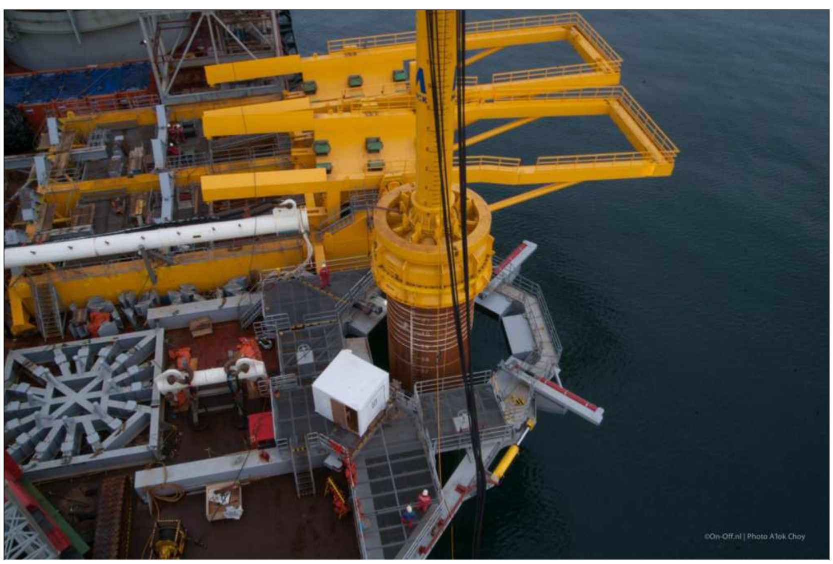
- Length: 183 m
- Breadth: 40 m

[2] Web Reference: http://www.marinetraffic.com/ais/showallphotos.aspx?imo=9243837#top_photo (accessed 14/02/2013)

- Draught: 6.5 m
- Depth: n/a
- Propulsion: 5.6 knots.

Plate 4.3: Stanislav Yudin HLV (Source: www.marinetraffic.com[3])

Plate 4.4: Pile Driving Hammer (operating on a monopile, not a pin pile) (Source: Subsea 7)



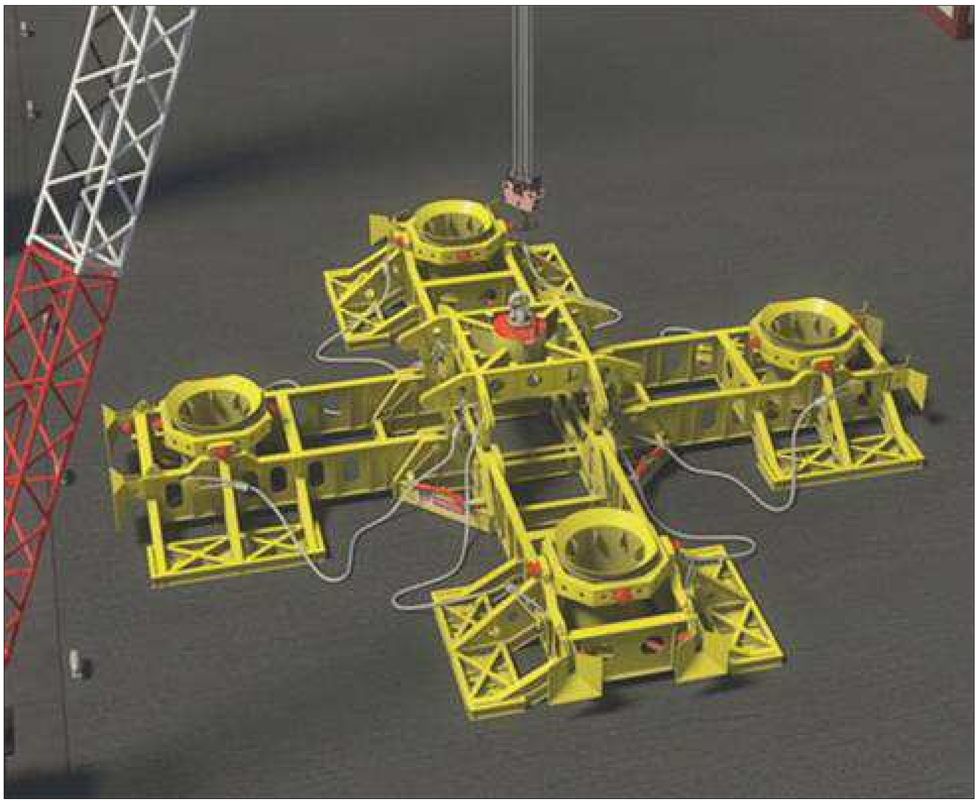
54. It is likely that the pin piles will be 'pre-piled' i.e. they will be installed in the ground prior to the jacket being placed on the seabed. Pre driven piles normally require the use of a pile installation template structure. This is to ensure that the piles will be installed within the tolerances required ready for jacket installation. A basic pile installation template for the jacket footprint is expected to weigh

[3] Web reference: http://www.marinetraffic.com/ais/showallphotos.aspx?imo=8219463 (accessed 14/02/2013)

approximately 300-400 t. A representative pile installation template is shown in Plate 4.5. The cross beam length (i.e. distance between pile guide holes) will vary depending on the jacket footprint. The height of the structure is likely to be up to 10 m. Employment of certain types of noise mitigation technology could change the template dimensions.

Plate 4.5: Representative Pile Drive Template

(Reference: SSE internal report BEA-REP-CON-SS7-153)



55. The pin piles will be driven into the seabed, a length of the pile will remain protruding from the sea bed. This protrusion is known as the 'stick-up'. The pile stick-up is likely to be up to 9 m from the seabed. The jacket is then lowered onto the stick-up from the jacket installation vessel as described in Section 4.4.2.2, and secured.

56. The following sequence outlines the pin pile installation process for the most likely scenario:

- Piles are collected and loaded to the transport vessels, transported to the handover point and transferred to the installation vessel;
- The installation vessel travels to the Wind Farm Site and uses DP;
- The installation vessel arrives at the first pile location and positions using DP ready for deployment of the Remotely Operated Vehicle (ROV);
- The piling template is lifted overboard and placed on the seabed;
- The first (of four) piles is lifted into position and hammer readied for piling;
- Pile driving;

- The hammer is recovered and returned to the cradle;
- The process is repeated for the hammering of the remaining three piles in the template;
- The pile template is recovered; and
- The installation vessel transits to the next jacket location.

57. The pile is lowered vertically onto the seabed. The weight of the pile usually causes the pile to penetrate the upper surface depending on the conditions. The pile is gripped with an alignment tool to ensure it remains vertical during piling. The pile hammer used to drive the pile will be hydraulic or air driven suspended from the crane (see Plate 4.4).

58. The maximum blow force, based on geotechnical information available at the time, of the hammer to be used for driving the substructure piles for the turbines and the OSPs is 2,300 kJ (2,300 kNm), weighing 240 tonnes.

Construction Programme

59. A summary of the duration for the pin pile installation is provided in Table 4.3.

Table 4.3: Construction Summary Most Likely Scenario: Pin Pile Foundations

Vessel	Heavy cargo vessel (Jumbo Javelin)/ HLV (Stanislav Yudin)
Pile Hammering (average blow count per pile)	4,000
Pile Hammering (average blows per minute)	45
Pile Driving (total duration per pile)	3-5 hours (including soft start, piling, monitoring and adjustment)
Time Spent on Site at one Template Foundation (includes time repositioning and piling)	30-38 hours
Piling Time per Foundation (4 piles)	12-20 hours
Total Time on Site per Piling Trip*	12 – 16 days
Foundations Installed per week (4 piles per foundation)	2 – 5 foundations
Vessel Seabed Contact Time (per foundation)	0
Seabed Contact Area (per jacket location)	0
Total Installation Period	See Table 4.5. (construction summary)

* This is the time that the vessel is on site before it needs to leave and restock.

60. It is likely that pile driving will be able to continue year round, however, this cannot be conclusively determined. Table 4.4 presents four indicative piling schedules to illustrate the range of options which could realistically be implemented. At this stage, Scenario 1 can be considered the most likely scenario, although all the other scenarios remain under consideration.

Table 4.4: Indicative Piling Campaign Scenarios

Example wind turbine pile installation schedules for 4 scenarios		
Scenario 1 1 vessel piling over a continuous installation programme	Year 1	Vessel starts piling in autumn and continues until finished. The entire installation campaign could be expected to be completed in around 1 year or slightly less.
	Year 2	No piling activity unless year 1 over-runs/OSP installation schedule requires it.
	Year 3	No piling activity unless OSP installation schedule requires it.
Scenario 2 2 vessels piling over a continuous installation programme	Year 1	Two installation vessels start piling at around the same time (although are likely to be on-site together for only a limited time due to the staggered vessel scheduled i.e. one vessel collects while the other installs and vice versa). The start month could be at any time. The entire installation campaign could be expected to be complete in around 6-9 months.
	Year 2	No piling activity unless OSP installation schedule requires it.
	Year 3	No piling activity unless OSP installation schedule requires it.
Scenario 3 1 vessel piling over 3 discreet installation campaigns	Year 1	The installation vessel piles for around 4-6 months. The starting time in unknown, but piling is likely to start prior to the jacket installation programme, and therefore will probably start in the winter months and continue into spring/summer.
	Year 2	The installation vessel piles for around 4-6 months as above.
	Year 3	The installation vessel piles for around 4-6 months as above.
Scenario 4 1 vessel piling over 2 discreet installation campaigns	Year 1	6-9 months piling. Start month could be at any time prior to the jacket installation start.
	Year 2	6-9 months piling.
	Year 3	No piling activity unless OSP installation schedule requires it.

4.4.2.2 Substructure Transportation and Installation: Tubular Jacket

61. The type of vessel likely to be used to transport the jackets from the manufacturing location to the Wind Farm Site is a standard North Sea barge (as described in Section 4.4.2.1).

62. The most likely options available for transferring the jackets from the barge deck for installation are:

- Option 1: Transporting the jackets to the Wind Farm Site on the barge for transfer to the jacket installation vessel; or
- Option 2: Transport the jackets and the installation vessel to a sheltered near shore location close to the Wind Farm Site where the jackets are transferred to the installation vessel.

63. There are several vessel types under consideration for performing jacket installation. The most likely options are:

- HLV; or
- Jack-up installation vessel.

64. A representative example of a HLV is the Oleg Strashnov (see Plate 4.6). The vessel statistics are as follows:

- Length: 183.0 m
- Breadth: 47.0 m
- Draught: 13.5 m
- Depth: n/a
- Propulsion: 14 knots DP

Plate 4.6: Oleg Strashnov HLV (Source: Subsea 7)

65. A representative example of a jack-up vessel is the Seafox 5 as described in Section 4.4.1.1.

66. The following sequence outlines the jacket installation process utilising a HLV. The vessel in question will use DP and does not require anchors:

- Jackets delivered on the transportation barge;
- The HLV also transits to the Wind Farm Site;
- The vessels transit to the first jacket installation location, moor alongside each other and prepare for jacket transfer;
- All but one of the jackets are lifted on to the HLV deck from the barge using the HLV crane;
- The one remaining jacket on the barge deck is lifted from the cargo barge deck;
- The jacket is then lowered until positioned over the pre installed piles;
- Final positioning is attained with the help of a ROV (see Plate 4.7 for observation and help in accurate jacket placement). The ROV would operate from the HLV;
- The jacket is lowered onto the piles;
- The ROV checks the positioning;

- The HLV crane is disconnected from the jacket;
- The barge and tug leave to return to the manufacturing location for another load of jackets;
- The HLV is prepared for transit; and
- The HLV transits to next installation location.

67. The HLV would repeat these steps, until all jackets are installed.

Plate 4.7: Example ROV (Source: SSE internal report BEA-REP-CON-SS7-095)

68. A jack-up installation vessel could also be used for the jacket installation. The jack-up installation process would differ from the HLV process in that the vessel would jack-up out of the water on its legs prior to installation. With jack-up complete, the lifting and installation process would then proceed similarly to the HLV described above.

Construction Programme

69. The approximate timescales for the jacket installation process are summarised in Table 4.5.

Table 4.5: Construction Summary Most Likely Scenario: Jacket Substructure

Vessel	Jack-up (e.g. Seafox 5)/HLV(e.g. Oleg Strashnov)
Installation of jacket (per jacket)	16 – 40 hours
Jackets installed per week	2 – 5
Jack-up Vessel Seabed Contact Time (per jacket)	30 – 90 hours
Seabed Contact Area (per jacket location)	900 m^2
Total installation period	3 years

Ancillary Jacket Installation Activities

70. The jacket installation process includes some activities which may be carried out by a smaller construction support vessel (CSV) (see Plate 4.8). For pre-piled jacket installation, the pre-installed piles may require cleaning prior to jacket installation to remove marine growth from the inside of the piles and present a clean surface for the jacket-pile grouted connection. The CSV, using a ROV may also remove soil

plugs from the piles. This is the act of suctioning excess soil accumulation from within the piles to allow a good grouting connection to be achieved.

71. Grout is required to be injected around each pin-pile and pile sleeve to secure the jacket in place. This activity is likely to be performed by the CSV. Grouting could occur some time after the completion of the jacket installation.

Plate 4.8: Example CSV (Source: www.ottocandies.com[4])

72. ROVs have been developed to attach to grout connectors located on the pile sleeves and allow direct grouting to be achieved. If used, the ROVs would be operated from the CSV.

73. The specifications of a typical CSV are:

- Length: 89.25 m
- Breadth: 18 m
- Draught: 5.0 m
- Depth: 7.4 m
- Propulsion: 13 knots DP

4.4.2.3 New Vessel Options

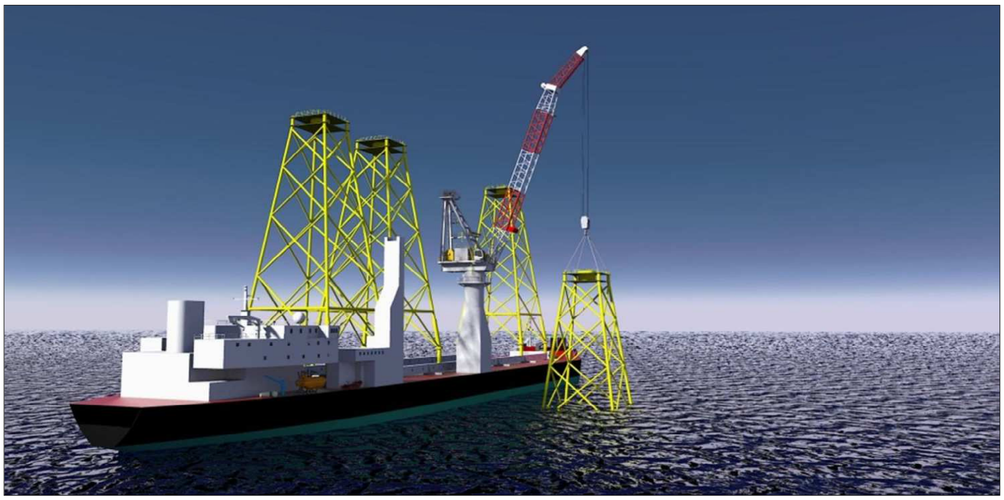
74. Some new vessels are now available, or at the concept stage, which could potentially be used for both piling and jacket installation by the time of commencing construction of the Wind Farm. An example is the Teekay/A2Sea vessel (Plate 4.9) which is currently under development, which utilises an oil tanker converted for use in the offshore wind market. This example is given for illustrative

[4] Web reference: http://www.ottocandies.com/specs/grant.pdf (accessed 14/02/2013)

purposes only, to demonstrate the range of potential vessel installation options available. The final decision on the vessels to be used will be determined nearer to commencement of construction based on vessels on the market, and their availability to supply the Amended Project. The vessels described throughout this Section provide information as available at the time of writing.

Plate 4.9: Teekay/A2Sea: Example of a Future Installation Vessel Solution

(Source: www.teekay.com[5])



4.4.3 INTER-ARRAY CABLE INSTALLATION

4.4.3.1 Transportation and Installation Vessels

75. There are several vessels required for the installation of inter-array cables. These are:

- Cable laying vessel (CLV) (Plate 4.10);
- Trenching vessel (Plate 4.11);
- Workboat – used for the transfer of personnel between the CLV and the wind turbine foundation during installation. There are many workboats available on the market suitable for personnel transfer during inter-array cabling works. An example of a typical workboat accessing a turbine is shown in Plate 4.12; and
- Service vessel – similar specifications to trenching vessel.

76. The specifications for these vessels are:

- CLV e.g. Seven Sisters (Plate 4.10):

Length:	104 m
Breadth:	20 m
Draught:	5.7 m
Depth:	n/a
Propulsion:	11 knots DP

[5] Web reference: http://www.teekay.com/Theme/TeekayCorp/files/doc_presentations/2012/1%20-%20TKC%20I-Day%20Presentation%20%20vFINAL_v001_t55cf5.pdf (accessed 14/02/2013)

- Trenching vessel e.g. Grand Canyon (Plate 4.11):

Length:	130 m
Breadth:	25 m
Draught:	7.5 m
Depth:	n/a
Propulsion:	14 knots DP
Trenching Machine:	T1200 (Plate 4.13)

- Service vessel, similar to Grand Canyon described above;

- Workboat, generic workboat (Plate 4.12):

Length:	Approximately 17m
Breadth:	Approximately 6 m
Draught:	Approximately 1.2 m
Depth:	n/a
Propulsion:	Up to about 30 knots

Plate 4.10: Seven Sisters CLV (Source: Subsea 7)

Plate 4.11: Grand Canyon Trenching / Servicing Vessel
(Source: www.bergengroup.no[6])

Plate 4.12: Example Workboat
(Source: SSE internal report BEA-REP-CON-SS7-160)

[6] Web reference: http://www.bergengroup.no/publish_files/BN89_GrandCanyon_4s.pdf (accessed 14/02/2013)

77. The combinations of vessels which could be used for the inter-array cable installation are outlined below. Three representative scenarios are presented. These are provided as examples only; the final installation approach may differ from those described here.

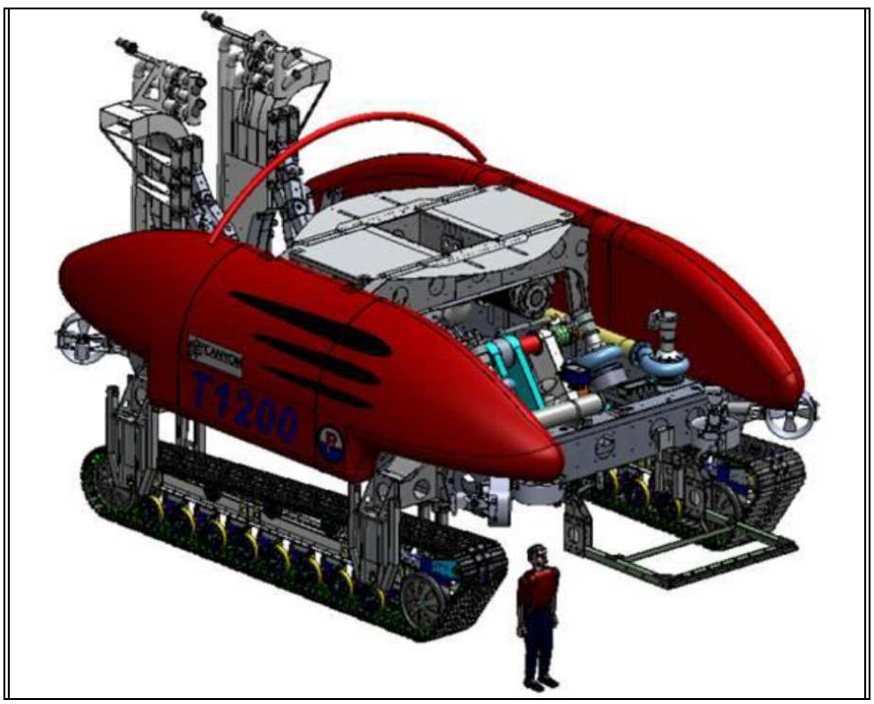
- Scenario 1: CLV; Workboat (at the Wind Farm); Trenching vessel;
- Scenario 2: CLV; Workboat (based in a local port); Trenching vessel; or
- Scenario 3: CLV; Service vessel; Trenching vessel.

78. The most likely option is currently considered to be a Scenario 1.

79. Jet trenching is the most likely method of installing the inter-array cables. A jet trenching vehicle uses nozzles mounted on jet swords to inject water at high pressure which fluidises the seabed allowing the cable to sink under its own weight. The equipment to be used for the jetting has not yet been selected. However, the trenching is likely to require a stand alone vessel equipped with a suitable jet trencher (see example in Plate 4.13).

Plate 4.13: Canyon T1200 Jet Trencher

(Source: SSE internal report BEA-REP-CON-SS7-160)



80. If there are seabed sections where jet trenching is not possible, cable ploughing may be adopted. An example is the Sea Stallion cable plough shown in Plate 4.14. Generally, cable ploughs operate in a simultaneous 'lay and trench' operation (i.e. the cable is trenched at the same time as it is laid), although post cable-lay plough options are also available. The plough could be operated from the CLV, or from a separate vessel. It is not possible to clarify further on these decisions at the current time. If a separate vessel were used for the cable ploughing, it is likely to have a

similar specification to the trenching vessel (Plate 4.11). The CLV would also be similar to the Seven Sisters (Plate 4.10).

Figure 4.14: Sea Stallion Cable Plough (Source: Subsea 7)

81. Cables are installed from spools or reels located on the CLV. In the most likely scenario, the trenching tool (e.g. Canyon T1200, Plate 4.13) is deployed from the trenching vessel.

82. If burial is not possible, the most likely method of cable protection for the inter-array cable is rock placement. The vessels used for the rock placement would be similar to the fall pipe vessel (Plate 4.19) described in Section 4.4.4.2.

Construction Programme

83. An indicative duration for the installation of one cable between each turbine is 24 hours. The total duration of the inter-array cable laying is not yet known, however, it is likely to occur over a two to three year cable laying campaign with the majority of the work occurring in the summer months (April to September).

84. Indicative total inter-array cable installation durations for a Wind Farm are provided in Table 4.6 below.

Table 4.6: Construction Summary Most Likely Scenario: Inter-Array Cables

Vessel	CLV	Workboat	Trenching Vessel
Total Project Duration (days)*	192	190	90
Duration within Wind Farm Site (days)	129	190	62

*Duration of all activities including laying, trenching, other protection activities etc

4.4.4 OFTW CABLE INSTALLATION

4.4.4.1 Transport and Installation Process

85. The most likely scenario for the export cable is 3 trenches each containing 1 export cable. The following sequence outlines the OfTW cable installation process for the most likely scenario:

- Horizontal Directional Drilling (HDD) works at landfall including transition pit construction (this activity is covered by the onshore application for Planning Permission in Principle submitted to The Moray Council in October 2012 and is described in the accompanying ES to the onshore application);
- Pre-lay survey and route clearance;
- Pre-lay grapnel run;
- Cable transportation;
- Cable laying;
- Cable burial and protection;
- Cable as-built survey; and
- Terminations and testing.

86. Details of these activities and the vessels involved are provided in the following sections.

Pre-Lay Survey and Route Clearance

87. A light construction vessel with a crane and an ROV is likely to be used to survey the export cable route and remove any boulders. The ROV will move along the export cable route, allowing boulders to be located. The crane vessel can then be directed to lift the boulders using the onboard crane and grab. The ROV survey and boulder clearance work is likely to be completed approximately 3 months before cable laying.

88. Various vessels are under consideration for this task, but representative vessel statistics are:

- DP light construction / surveying support vessel:

Length:	65m – 95 m
Breadth:	20 m
Draught:	7 m
Depth:	n/a
Propulsion:	Approximately 14 knots DP
Crane:	30 tonne crane with boulder grab
Equipment:	ROV

Pre-Lay Grapnel Run

89. The pre lay grapnel run involves dragging a rake (grapnel) along the seabed of the export cable route. This clears away any debris which may hinder OfTW cable installation and trenching. This work is likely to be completed one to two months before cable laying commences. The types of vessels which may be used for this task are as follows:

- Small AHT(see Plate 4.15) or DP Multicat (see Plate 4.16):

Length:	26m
Breadth:	11m
Draught:	2.3m
Depth:	n/a
Propulsion:	Varies
Equipment:	Winch and grapnel

Plate 4.15: Example AHT (Source: www.fairplay-towage.com[7])

Plate 4.16: Example DP Multicat (Source: www.briggsmarine.com[8])

Cable Transportation

90. The likely case is that a CLV will transit to the cable manufacturing port to load the cable. The vessel will then return to the export cable route and commence installation. The likely case is two return trips per export cable.

[7] Web reference: http://www.fairplay-towage.com/en/fleetlist/oceangoing-tugs/ (accessed 14/02/2013)
[8] Web reference: http://www.briggsmarine.com/marine/vessel-charter/multicats/forth-trojan/ (accessed 14/02/2013)

Cable Laying

91. There are 3 main options for the installation of the export cable. These are:

- Option 1: Installation of all cable by barge;
- Option 2: Installation of all cable by shallow draught DP vessel; or
- Option 3: Installation of shallow near shore section by barge and deep water section by deep draught DP vessel.

92. Possible vessel types and their usage are provided in the following sections.

HDD Work / Shallow Water Cable Vessels

93. The HDD would previously have been completed (from onshore) and the HDD duct installed. This is likely to be completed approximately 1 year prior to the occurrence of the activities below.

94. The installation of the cable from the HDD receiving site is likely to commence with the following operations:

- The OfTW cable installation vessel (not yet selected) would be positioned at a suitable distance from the end of the HDD receiving site;
- Typically, a shallow water dive team is used to support the installation, as (ROV's do not operate well in the shallow water experienced closer to shore at HDD receiving site); and
- The dive team would prepare the HDD receiving site, clear obstructions, monitor and perform other support tasks. The dive team would require a dive support boat, which is likely to be a small boat, similar in size to a fishing vessel.

95. The vessel selection for performing the HDD pull in and laying of the cable in the shallow water section has not yet been made. The two most likely options for this section of the export cable are a cable laying barge (CLB) (see Plate 4.17) or a shallow draught cable laying ship (see Plate 4.18). The specifications of these vessels are as follows:

- CLB e.g. Eide Barge 28 (see Plate 4.17):

Overall Length:	92 m
Breadth:	28 m
Draught:	5 m
Depth:	n/a
Propulsion:	Towed by an AHT(s)

- Shallow draught cable laying ship e.g. Stemat Spirit (see Plate 4.18):

Overall Length:	90 m
Breadth:	28 m
Draught:	5 m
Depth:	n/a
Propulsion:	10 knots maximum (DP)

96. An anchored CLB would also require the support of one to three tugs (for positioning and manoeuvre) and would have an ROV on board.

Plate 4.17: Eide Barge 28 CLB (Source: www.vsmc.nl[9])

Plate 4.18: Stemat Spirit DP cable laying ship (Source: www.stemat.com[10])

Deeper Water Cable Laying

97. A deep draft CLV, as described in Section 4.4.3.1, is likely to be used for the export cable lay in deeper water sections of the export cable route. An example of this type of vessel is the Seven Sisters (Plate 4.10). These vessels have DP and would not require support from tugs.

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[9] Web reference: http://www.vsmc.nl/bin/ibp.jsp?ibpZone=S94_Eide32bargespreadb&ibpDisplay=view&ibpPage=S94_FocusPage&ibpDispWhat=zone& (accessed 14/02/2013)

[10] Web reference: http://www.stemat.com/uploads/media/Stemat_Spirit.pdf (accessed 14/02/2013)

98. It is not yet known whether the export cable will be installed in sections. However, if a cable joint is required, it would be likely to be performed on the deck of a DP CLV.

Cable Burial and Protection

99. As with the inter-array cable, the most effective form of protection is burial using jet trenching and/or ploughing.

100. The description of the jetting and ploughing processes and equipment for the export cables is the same as for the inter-array cables described in Section 4.4.3.1.

101. In locations where ground conditions prevent jet trenching or ploughing, the cable is likely to be protected using rock placement. This involves installing a layer of rock on top of the cable to provide a barrier against fishing equipment and anchors. Rock placement also provides stability to the cable against movement.

102. Rock placement will be done using a fall pipe vessel. This involves sending the rock from the vessel down a vertical pipe to deposit it on the cable on the seabed. Fall pipe systems are relatively high accuracy as the pipe end can be controlled by the vessel position, with thrusters or an ROV and sonar monitoring system. The specifications of an example vessel are:

- Fall Pipe Vessel e.g. Van Oord Nordnes (see Plate 4.19):

Length:	166.70 m
Breadth:	26.00 m
Draught:	10.51 m
Depth:	n/a
Propulsion	14 knots

103. In shallow waters where it is not possible to use a fall pipe vessel, a side dump vessel maybe used. Rock placement is the preferred method of cable protection. It is also possible rock mattresses will be used but this would replace rock placement and therefore would not change the number of vessel present at any one time.

104. Rock placement is likely to be performed after trenching is complete, although the activities may overlap if required.

Plate 4.19: Van Oord Nordnes Fall Pipe Rock Placement Vessel

(Source: www.offshore-mag.com[11])

4.4.4.2 Additional Vessel Requirements

105. Guard vessels may be required during some parts of the construction period.

106. Post installation activities such as the as-built survey and terminations and testing are likely to be supported by a crew boat in place for the OSP cable connection. The number of crew boats is unknown, although two to three are likely. These boats are likely to be based on-site or at a local port. The specifications of an example vessel are:

- Crew Vessel e.g. Windcat 101 series or similar (see Plate 4.20):
  Length: 27 m
  Breadth: 9 m
  Draught: 2 m
  Depth: n/a
  Propulsion: 31 knots max.

[11] Web reference: http://www.offshore-mag.com/articles/print/volume-70/issue-9/flowlines-__pipelines/new-vessel-designs-facilitate-offshore-pipelay.html (accessed 14/02/2013)

Plate 4.20: Windcat 101 Crew Vessel
(Source: www.windcatworkboats.com[12])

107. It is possible that a 'hotel' vessel is used as accommodation for crews during terminations and testing (durations unknown). The specifications of an example vessel are:

- Vessel: Likely to be a converted ferry or similar (e.g. MS ARV1; Plate 4.21):

Length:	141m
Breadth:	20m
Draught:	6m
Depth:	n/a
Propulsion:	Unavailable

[12] Web reference: http://www.windcatworkboats.com/PR_01062011-WindCat101.pdf?tempFilter=%5Bobject+Object%5D (accessed 14/02/2013)

Plate 4.21: MS ARV1 Hotel Vessel
(Source: www.marinetraffic.com[13])

4.4.4.3 *Construction Programme*

108. The installation of the export cable is likely to take place through the summer months (April to September) as the operations require good weather. The most likely scenario is that the installation would occur over two summer seasons with no winter work.

109. There may be a requirement for one to two joints to be made in each export cable which would require four to ten days work per joint. The process involves retrieval of the two ends of the pre-laid cables on to the deck where the work is performed.

110. Indicative timescales for the export cabling installation activities, assuming the most likely scenario of three export cables, are provided in Table 4.7.

[13] Web reference: http://www.marinetraffic.com/ais/shipdetails.aspx?MMSI=255803650 (accessed 14/02/2013)

Table 4.7: Construction Summary Most Likely Scenario: Export Cable

Pre-lay Survey and Route Clearance	Vessel	DP light construction/ surveying support vessel
	Cable survey	2 weeks per cable (6 weeks total)
	Rock clearance seabed contact time	1.5 days per cable (4.5 days total)
Pre-lay Grapnel Run	Vessel	DP Multicat or small AHT
	Grapnel run	11-12 days per cable (5 weeks total)
	Seabed contact time	8 days per cable (24 days total)
Dive Support Vessel	Time on site	2 - 3 weeks per cable (6-9 weeks total)
Cable Installation including transit, load out, transportation and installation	Vessels	HDD Pull In: CLB or Shallow draught cable laying ship; Deep water cable laying: Deep Draft CLV;
	Cable laying activities including transport	76 days per cable (215 - 228 days total over two years)
	Seabed contact time	Cable laying excluding jointing: 45 days per cable (135 days in total) Cable laying including jointing: 52 days per cable (156 days in total)
Jet Trenching*	Vessel	DP vessel
	Seabed contact time	31 days per cable (93 days in total)
Rock Placement	Vessel	Fall pipe vessel
	Total rock placement activities	21 days per export cable (9 weeks in total). Completed over a 2 year period
	Seabed contact time	4 days per export cable (12 days in total)
Guard Boats	Vessels	Requirement TBC
	Duration of activity	Dependent on construction contractor requirements
Terminations and Testing	Vessel	Crew boats: 2 – 3 crew boats (e.g. Windcat 101) Hotel Vessel: Converted ferry (e.g. MS ARV1)
	Duration of activity	4 weeks per export cable (12 weeks total)

*whilst ploughing maybe required, trenching is the preferred method and hence has been used for the construction timings.

4.5 CONSTRUCTION PROGRAMME AND LOGISTICS

4.5.1 VESSELS

111. The Original ES (Section 7.13) provided an indicative construction programme for the Original Project. Comments on the Original ES requested further clarification regarding construction, in particular relating to the vessels likely to be present at the site at any time. The Sections above have provided detailed information on the likely vessels to be used for the construction of the Amended Project, and their roles in the construction activities and programme. This Section provides a summary of the vessels which may be on site at a given time in the construction process, utilising three scenarios, typical, busy and quiet construction activities. This is an indicative guide based on the most likely scenario. The most likely scenario, the vessels utilised and the exact timetabling is subject to change due to advancements in the design, weather and availability of vessels.

112. The following examples are based on experience of other offshore wind farm projects. In addition to the key vessels described so far in this section and below, it is likely these vessels will be accompanied by smaller support vessels on an ad hoc basis, for example, for transfer of personnel.

113. During turbine commissioning, there may also be a 'hotel' vessel (for example the MS ARV1 as described in Section 4.4.4.3 and shown in Plate 4.21), which will house the personnel performing commissioning duties. During this time additional turbine access vessels may be required; these will be smaller vessels whose details are not known at the current time.

4.5.1.1 Typical Construction Period

114. Table 4.8 presents a scenario of the typical vessel numbers to be expected present within the Wind Farm Site when piling and jacket installation are occurring concurrently. This may occur during the summer months of April to September with fewer vessels on site during the winter.

Table 4.8: Indicative Vessels within the Wind Farm Site for a Typical Construction Period (Summer Months Only)

Concurrent Activity	Vessels on Site
Piling	Piling vessel
	Support vessel with ROV
Jacket Installation	Survey vessel (pile cleaning / grouting) with ROV
	Barge
	Tug
	Jacket installation vessel
Other	Guard vessel requirement TBC
TOTAL	Approximately 8 vessels

4.5.1.2 Busy Construction Period

115. Table 4.9 presents one of the busiest possible construction periods across the Wind Farm Site and Amended OfTW Corridor. This is expected to be a rare case, and not typical of the average vessel numbers and would only occur during summer if the weather permitted and all vessels were available.

Table 4.9: Indicative Vessels within the Wind Farm Site for a Busy Construction Period (Summer Months Only)

Concurrent Activity	Vessels on Site
Turbine Installation	Turbine installation vessel
	Support vessel with ROV
Turbine / OSP Commissioning	1 hotel vessel
	3 crew vessels
Jacket Installation	Survey vessel (pile cleaning / grouting) with ROV
	Barge
	Tug
	Jacket installation vessel
Inter-Array Cable Installation	CLV
	Trenching vessel
	Rock placement vessel
	Workboat
	Guard vessel requirement TBC
OfTW Cable Installation	CLB for shallow water sections
	Deep draught CLV
	Guard vessel requirement TBC
TOTAL	Approximately 20 vessels

4.5.1.3 Quiet Construction Period

116. During the winter months, far fewer construction activities can be carried out, hence the number of vessels on the Wind Farm Site will be reduced. An example scenario for the quiet winter construction period is presented in Table 4.10.

Table 4.10: Indicative Vessels within the Wind Farm Site for a Quiet Construction Period (Winter Months Only)

Concurrent Activity	Vessels on Site
Piling	Piling vessel
	Support vessel with ROV
Other	Guard vessel requirement TBC
TOTAL	Approximately 4 vessels

4.5.2 AMENDED PROJECT CONSTRUCTION PROGRAMME

117. The Amended Project construction programme is expected to cover a period of three to five years. No date is yet available for commencement of construction, but it will be no earlier than 2014.

118. Table 4.11 provides an indicative construction programme for the Amended Project. Construction activities may take place all year round, 24 hours a day, seven days a week (although dependent on weather conditions and scheduling). It should be appreciated that the construction programme must currently maintain a high level of flexibility in order to accommodate unforeseen events, including but not limited to: variations in ground conditions and constraints and delays in logistics and supply chain.

119. It is anticipated that the export cable laying will take approximately nine months to construct. Each cable will be laid as a non-stop activity from one end to the other and installation works will be undertaken 24 hours a day. Both the OfTW and OnTW require to be installed to allow the Wind Farm to be connected to the National Electricity Transmission System.

Table 4.11: Indicative Offshore Construction Programme

Construction Activity	Year 1				Year 2				Year 3				Year 4				Year 5				Year 6			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Transmission Works																								
Install templates and piles																								
Install turbine substructures																								
Lay inter-array cables																								
Install and commission OSPs																								
Install and hook up turbines																								

4.6 REFERENCES

121. CMACS (2003) A baseline assessment of electromagnetic fields generated by offshore windfarm cables. COWRIE 2003.