CONTENTS, SECTION 3

3 *PROJECT DESCRIPTION - THE OFFSHORE COMPONENTS*

3.1 *INTRODUCTION*

The offshore elements of the project are described in this section and these comprise:

- 30 wind turbines;
- subsea cables between the turbines;
- subsea cables from the wind farm to the shore;
- the cable landfall;
- the substation option offshore (the onshore substation option is described in *Section 4*); and
- two meteorological masts.

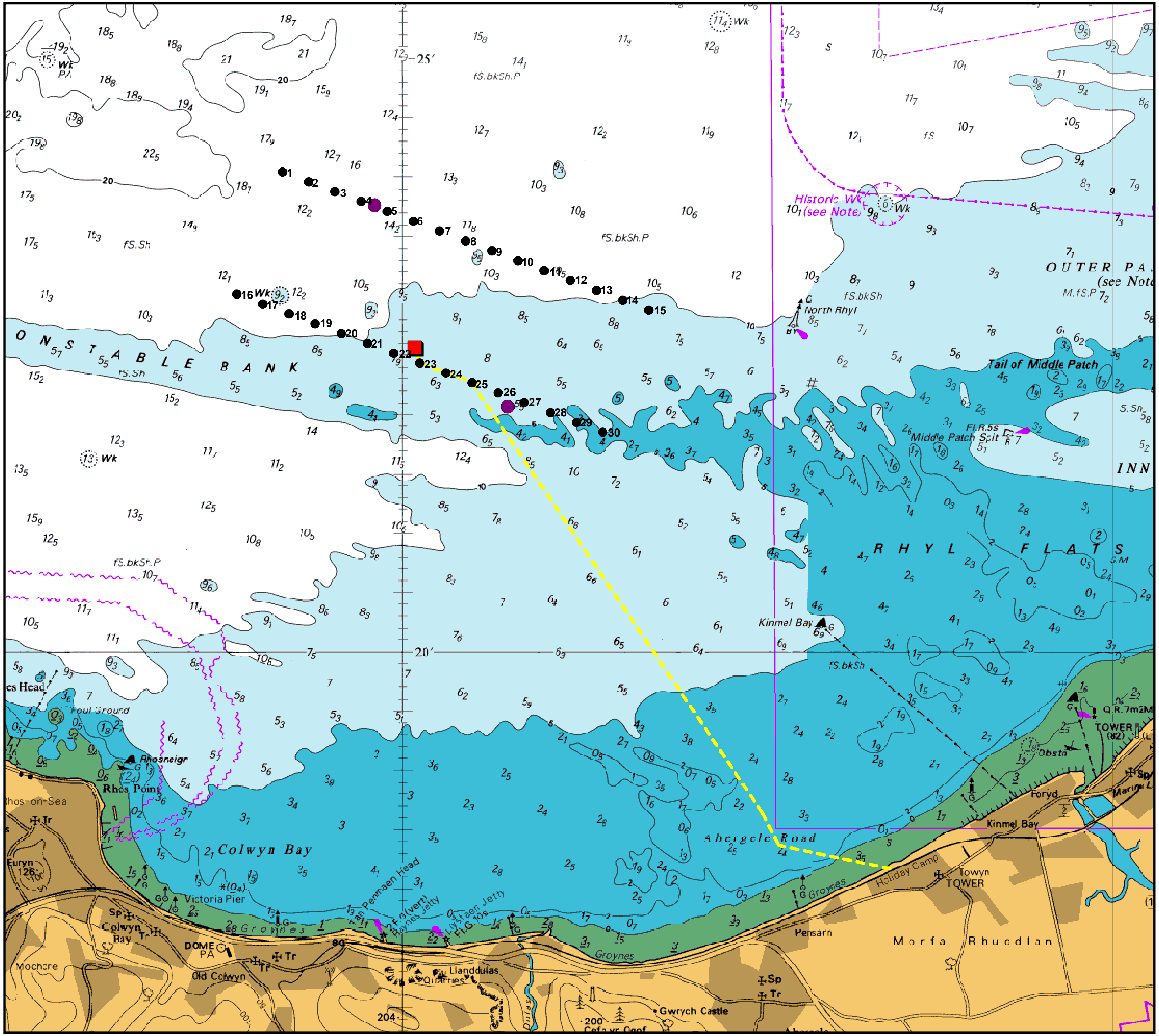
The remainder of this section describes the offshore components of the proposed project and the methods by which those elements would be installed, operated and decommissioned. It must be noted that, due to the fact that the contractors have not yet been selected, some assumptions have been made where stated. Where appropriate, alternative options are discussed.

3.2 *THE OFFSHORE PROJECT COMPONENTS*

3.2.1 *Wind Farm Layout*

The proposed wind farm layout is presented in *Figure 3.1*. The 30 wind turbines will be installed in two parallel rows oriented along a west-north-west / east-south-east bearing. The spacing between the turbines within each row will be 437m and the spacing between the two rows will be 2,040m. This configuration has been selected to maximise energy capture by minimising losses due to wake interactions within the wind farm, whilst still complying with the site boundary constraints stipulated by Crown Estate and with other environmental constraints, as described in relevant sections of this ES.

Figure 3.1
Proposed Wind Farm Layout and Substation Location



Also shown on *Figure 3.1* are the locations of the two meteorological masts. The first mast (Mast 1) is to be installed during the first half of 2002 to enable COWL to measure the wind speed and other conditions of the site. This information will be used to optimise the turbine design for the site. The second mast (Mast 2) is to be installed at the same time as the wind farm. Once the wind farm enters operation, the masts will be used to record climatic and possibly sea state data as part of the operational monitoring of the wind farm.

Figure 3.1 shows the proposed location for an offshore substation for transformation between 132kV and medium voltage (MV), typically 33kV, and the proposed route for the submarine cable from the wind farm to the shoreline. The offshore substation is an alternative option to having such a station onshore. This ES therefore includes an assessment of the potential environmental impacts of both of these options, although in practice only one option will be progressed.

At the landfall, there will be a section of underground cable leading into the onshore grid connection.

3.2.2 Wind Turbines and Towers

General

The wind turbines will be of the conventional design, namely, a three-bladed upwind horizontal axis rotor design. The rotor will drive a mainshaft, gearbox and generator (all located within the nacelle assembly). Power generated will be transformed from a low voltage (typically 690 V) to medium voltage by a transformer located on each wind turbine unit. This transformer will be located either in the nacelle, within the tower base or in a module mounted outside the tower on the same foundation.

Although the exact model of wind turbine or its supplier has not at this stage been determined, there are several features which can be confirmed:

- A three-bladed rotor will be used, with the rotor upwind of the tower in normal operation. The hub height will be in the range 60 m to 100 m above mean sea level. At this stage it is necessary to define a range for this as it will be dictated by the characteristics of the wind resource and on the selected turbine model.

- The rotor diameter will be in the range 80 m to 105 m (allowing for developments in turbine technology in the near future).

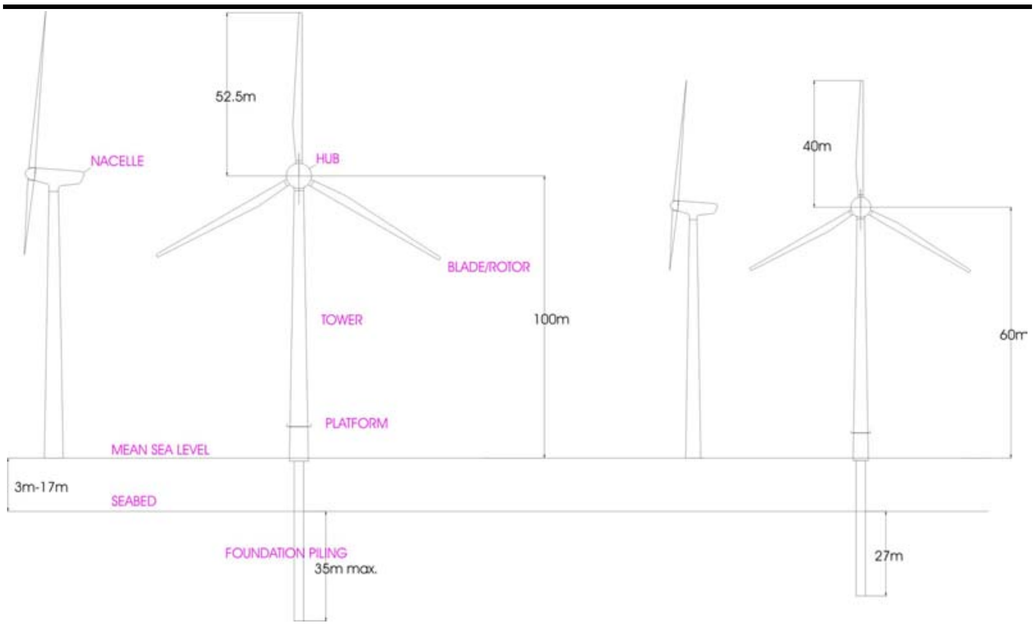
- Typical rotor speeds would be 8 to 22 rpm.

- A tubular "monopile" tower of steel construction will be used.

- The colour finish of the turbines will be such as to minimise visibility and reflections (*eg* a dull light grey), except to the extent that specific navigational marking or colouring is required (see below).

For the largest turbine size under consideration, the maximum expected height of the tip above mean sea level is 152.5 m. The lowest point of the blade arc is expected to be at least 20 m above mean sea level. The outline dimensions of the largest and smallest turbines under consideration are shown in *Figure 3.2*.

Figure 3.2 Dimensions of Largest and Smallest Turbine Models Under Consideration



Wind Turbine Control and Safety System

The operation of each wind turbine will be by an internal controller to allow continuous unmanned normal operation. The controller will be designed so as to ensure the safe operation of the turbine with continuous monitoring of parameters which may indicate either an internal fault or an environmental condition which is outside the specification of the turbine in operation. In the event that such a fault or condition is detected the turbine will be shut down in a controlled fashion. It may then auto-restart after the fault or condition has ceased to exist. In the event that this is not possible, a remote restart may be possible (using the wind farm control system) or, failing that, a maintenance visit will be made.

Earthing and Lightning Protection

The wind turbines will be earthed so as to ensure both the safety of the operational personnel and general public who may be in the vicinity as well as to protect the wind turbine and ancillary equipment in the event of a lightning strike.

Basis for Design of Wind Turbines and Towers

To ensure the safe operation of the wind turbines and a basic level of performance and reliability, the design will be based on appropriate design standards from the offshore industry and from the wind energy industry (most notably IEC 61400) [1]

In addition, specific requirements will be placed on the contractors in terms of proving the track record of the wind turbines through operation of identical or similar models and through testing of key components. The wind turbines and towers will be procured so as to be fit for purpose for specific site conditions.

Marinisation

The wind turbines will be designed so that they can operate safely and reliably in the environment in which they are to be deployed. All necessary marinisation measures will be made to minimise the risk of environmental damage. Measures will also be taken to facilitate:

- installation;
- reliable operation, *eg* through the use of high reliability components, condition monitoring and climatic protection both enhanced with respect to normal onshore procedures; and
- maintenance, *eg* through the use of internal cranes and methods for landing and accommodating personnel.

Corrosion Inhibition and Antifouling

Corrosion of the foundation structures will be controlled by a combination of cathodic protection and high integrity coating systems.

Cathodic protection will be provided by the welded attachment to the outside of the foundation structure of sacrificial anodes manufactured from aluminium alloy.

The coating system would comprise two coats of epoxy-based paint which may be overcoated with a polyurethane topcoat or colour retentive markings as required.

3.2.3 Wind Turbine Foundations

There are three technical options for the wind turbine foundations: gravity base, monopile or multi-legged foundation. It is expected that a tubular steel

(1) International Electrotechnical Commission (IEC), 1999: IEC 61400 Wind Turbine Generation Systems: Part 1: Safety Requirements.

monopile foundation will be used and it is this option that has been assessed during the EIA.

The monopiles would be 3.5 m to 4.5 m in diameter and with a maximum penetration into the sea bed of 35 m.

This tubular steel monopile arrangement is derived from inshore civil construction projects and from the offshore oil and gas industry, and lends itself well to wind turbines as the pile is in practice an extension of the turbine tower. This technology has recently been successfully used for offshore wind farms at Blyth (UK), Bockstigen (Sweden), Utgrunden (Sweden) and Lely (Netherlands), and is also in use for the Horns Rev project currently under construction in Denmark.

The installation method for the monopile is highly dependent on the exact geotechnical conditions. It can be by one of the following methods:

- driven piling (above-surface hammering);
- drilling of a hole to accept the monopile, insertion and grouting in place; or
- combined drilling and pile driving.

3.2.4 Scour Protection

Local erosion (scour) of the seabed is a possibility and the foundations may need to be protected against this tidal stream effect.

In the first instance, any arisings generated by drilling monopile foundations will be placed at the predicted location of the scour hole, where the relative shelter from the tidal currents will reduce the dispersion, and the material could also help prevent scour.

A pre and post-construction monitoring programme will identify the rate at which scour takes place. Scour protection measures will be recommended at such a time that suitable information to inform design becomes available. Potential options for mitigation measures will include:

- installation of rock armouring around the base of the turbines;
- use of mattresses (concrete, or grout filled);
- use of sandbags (grout filled bags); and
- use of fronds to promote sedimentation (these can be used in conjunction with mattresses).

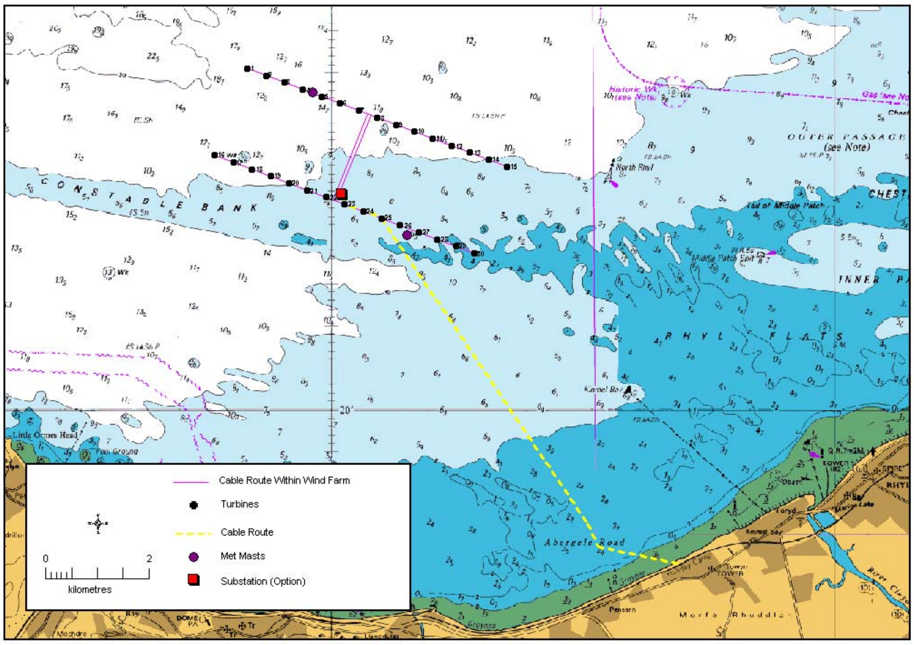
The main factor to consider when installing scour protection is the level of protection to be afforded under the design wave and current conditions. The rock armouring, mattresses and bag options can be designed to withstand various storm conditions. Whichever method is used the protection layer will extend between 2.5 to 5 m from the turbine to provide adequate protection against scour. For rock armouring, mattresses and bags, a suitable filter layer (usually quarry run stone and/or geotextile layer) will be placed between the protection layer and the seabed material to prevent settlement. The thickness of the scour protection material will not be excessive as it would otherwise provide additional blockage to the flow and shift the scour development to the edge of the protection layer.

3.2.5 Internal Electrical Infrastructure

The wind turbines will be connected by armoured submarine cables which will carry the MV power phases and also an optic fibre cable for communications. The cables will be installed in subsea trenches at a depth below the seabed which affords a good level of protection against damage from marine activities and scour.

The cables will be laid as four radial feeders linking all turbines to a gathering point (see *Figure 3.3*). This gathering point will be the offshore substation, if that option is pursued.

Figure 3.3 Schematic of Site Cable Routes - Radial Layout



Reproduced from Admiralty chart 1978 by permission of the Controller of Her Majesty's Stationary Office and the UK Hydrographic Office

Cables will be connected into each wind turbine and collectively to the substation through a J-tube which routes from the cable trench into the turbine tower base or onto the substation deck.

3.2.6 Navigation and Warning Systems

The wind farm will be fitted with such navigational aids as are required for the safe conduct of marine and air traffic, as agreed with the Trinity House

Lighthouse Service, the Civil Aviation Authority and other relevant authorities. The current marine recommendations for marking of offshore wind farms (I*nternational Association of Marine Aids to Navigation and Lighthouse Authorities May 2000*) include the measures listed below, which the project will comply with.

- Yellow flashing marking lights with a nominal range of 5 miles to be positioned at the end of each turbine string and at intermediate points along the two rows, so that there is a maximum separation of 2 miles between lights. The lights will be positioned at a height which is above the Highest Astronomical Tide but below the lowest point of arc of the rotor blade.

- Met masts and turbine towers to be painted yellow from the level of Highest Astronomical Tide (HAT) to the height of the marking lights. The lights are likely to be positioned on or near the platform.

- Consideration of the use of retro-reflective markings.

- Appropriate use of radar markers.

- Appropriate use of sound signals.

- Met mast to exhibit a white flashing light with a nominal range of 10 miles.

- Fog signal with a nominal range of two miles to be installed.

The north-west extremity of the wind farm will be marked by a North Cardinal Lighted Buoy positioned 500m north of Turbine 1, exhibiting a white light with a five mile nominal range. An intermediate green conical lighted buoy will be established to mark the edge of the channel between this buoy and the existing North Rhyl Buoy.

3.2.7 Offshore Substation Option

In order to connect the wind farm to the onshore electrical grid system, a substation is required to give a voltage step up from medium voltage (MV), typically 33kV, to 132 kV. If selected, the offshore substation will be located within the wind farm site area. An indicative location is shown on *Figure 3.1*.

The offshore substation is likely to be mounted on a foundation of similar design to those used for the wind turbines although a multi-legged option may be used. This is described in *Section 5.2.8*. The foundation will project approximately 15 m above mean sea level (MSL) and, if a monopile, would have diameter between 3.5 and 4.5 m.

The footprint of the substation enclosure is likely to be 16 m by 16 m, with a height of approximately 17 m. The substation is likely to consist of the main elements listed below.

- Monopile structure between 3.5m and 4.5m diameter.
- 132 kV/MV (oil-filled) power transformer.
- Decking and enclosure to accommodate the transformer.
- Sump to catch any oil leakages from the transformer with capacity to hold the total oil volume.
- Enclosed room to accommodate MV switch gear and with emergency shelter.
- Decking and boat landing access.

Figure 3.4 illustrates such a substation, without a heli-deck.

Figure 3.4 Typical Offshore Substation (Courtesy of Siemens Netherlands)

3.2.8 Connection to Shore

The Subsea Cable

If an offshore substation is selected, a single armoured submarine cable will be installed running from the substation to the landfall point along the path defined in *Figure 3.1*. This cable will be used to carry the 132 kV power phases and the optical fibre cable for communications.

The cable will have a diameter of approximately 200 mm and be installed in subsea trenches at up to 3 m below the seabed, depending on local conditions, to afford a good level of protection against damage from marine activities and scour.

If an onshore substation is selected then there will be a maximum of four submarine cables running from the gathering point on the wind farm site to the shore landing point, along the path defined in *Figure 3.1*. These cables will be used to carry the MV power phases and the optical fibre cable for communications and have a diameter of about 130mm. They will be installed and protected as described above for the 132kV cable. Typical cable separation distances are twice the water depth or 30 m, whichever is greater.

The subsea cable is likely to comprise the following components:

- copper conductors (3) plus optic fibre;
- Ethylene Propylene Rubber (EPR) or cross-linked (XLPE) insulation;
- metallic electromagnetic screen (aluminium, copper or lead);
- double armouring (steel braid); and
- polypropylene outer coating.

The Landfall

The landfall location is shown on *Figure 3.1* and is at NGR: 296580, 379600. The beach and sea defences will be crossed by open cut trench. This technique is described in *Section 3.3.*

When the subsea cables come ashore, they will be anchored to the ground on small concrete plinths approximately 1 m by 1 m. The marine cables will then be routed to a junction chamber immediately to the landward side of the sea defences.

If the offshore substation option is chosen, there will be one subsea cable, which will connect to three single-core land cables in the junction chamber, which will be approximately 12 m by 5 m. The land cables will run to a metering and switchgear building, which will have a smaller footprint than the proposed onshore substation and will be located at the same position as that identified for the onshore substation. The cables to the metering and switchgear building will be laid in a trench approximately 1.5 m deep and 1 m wide.

If there is no offshore substation, there will be a maximum of four subsea cables running to the junction chamber, which will be approximately 9 m by 5 m. There will be a maximum of 12 single-core cables from the landfall junction chamber to the substation, with three connected to each of the four marine cables, at the junction chamber. The land cables can be clustered in groups of three and spaced not less than 0.45 m apart with a total trench width of approximately 1.9 m. An alternative arrangement would be to have a deeper, but narrower trench with the cables still in groups of three, stacked above each other.

For both options, additional joint bays will be needed every 500 m. These will be 6 m by 2 m for the onshore substation option and 6 m by 3 m for the offshore substation option. All joints will be embedded in sand, protected with concrete covers and backfilled with excavated material ('solid filled').

3.2.9 Control and Monitoring System (including Meteorological Masts)

Under normal operating conditions, the wind farm will operate autonomously with remote monitoring and intervention, as necessary, using the control and monitoring system. The system will serve to monitor output and performance as well as for remote control of the wind turbines. The control and monitoring system will consist of the elements listed below.

- two meteorological masts used to measure climatic conditions, for location see *Figure 3.1*;
- monitoring equipment and communications terminals, located within each wind turbine;
- optical fibre communications networks (within the power cables defined above); and
- shore-based computer and optic-fibre modem.

Figure 3.5 Typical Offshore Meteorological Mast (Courtesy of Thales Geosolutions)

The meteorological masts will use a foundation base of similar design to, but smaller dimension than, the wind turbines and will have a lattice tower mast, see *Figure 3.5*. Sensors will be installed at various locations on the mast to measure wind and other climatic conditions. Metocean conditions may be measured using subsea sensors. An enclosure will be mounted on the structure containing data recording equipment and the communications terminal for the control and monitoring system.

The masts will either be powered autonomously (*eg* solar panels) or through a low voltage submarine connection to the nearest wind turbine.

Communications will be achieved either through an optic fibre cable within that submarine cable or by a low-powered radio link to the nearest wind turbine. The first mast (Mast 1 in *Figure 3.1*), to be erected in advance of the wind farm construction, will be completely autonomous and it is anticipated that data collection will be by a mobile phone (GSM) modem.

The meteorological masts will be of lattice type construction and their height will vary as follows:

- Met Mast 1: top height of 56 m above MSL; and
- Met Mast 2: top height at turbine hub height.

3.3 CONSTRUCTION WORKS AND PROGRAMME FOR OFFSHORE COMPONENTS

3.3.1 General

The main steps in the construction procedure are described below. The description is based on current best practice as used recently on sites of a similar nature to that at Rhyl Flats.

The inshore nature and water depth of Rhyl Flats lends itself to the utilisation of a jack-up type barge which provides facilities for stable drilling / hammering and lifting operations. Jack-up barges have the following advantages:

- minimum draft to facilitate operation in shallow waters;
- less weather dependency during installation operations;
- general availability of vessels in the marketplace; and
- cost advantages compared to offshore crane type vessels.

Figure 3.6 shows a typical jack-up barge such as would be used for this project.

The scale of this project is expected to require the use of three jack-up barges which will be dedicated to installing the foundations, erection of the wind turbines, installing the electrical infrastructure and the offshore substation if utilised.

Figure 3.6 ***Photographs of Typical Jack-up Barges (Courtesy of Hydrosoil Services (left hand picture) and Enron Wind (right hand picture))***

It is expedient that the majority of assembly operations are completed onshore at a designated staging area thus reducing operational difficulties at sea. It is envisaged that onshore assembly will take place at a local port. The assembled modules will then be lifted onto the vessels using a mobile crane. A suitable dock area will be used throughout construction to temporarily store turbine parts and components brought to the site by sea, *eg* large items such as monopiles. For the purposes of the EIA it has been assumed that the staging area will be at Mostyn Docks in Flintshire, although other options will be available.

At sea, the jack-up barges, supplemented by a transport barge and tugs, will transport all components and assembly equipment to site as and when required in accordance with the construction programme.

3.3.2 *Schedule*

Construction of the wind farm is scheduled to begin in April 2004 and to be completed by September 2004. The expected programme of key activities is set out in *Table 3.1* below.

Table 3.1 ***Project Plan (Site Works)***

	2004						
	Mar	Apr	May	Jun	Jul	Aug	Sep
Mobilise vessels to staging point	■						
Modifications to vessels, as necessary		■					
Delivery of foundations to staging point		■	■				
Delivery of turbines to staging point				■			
Delivery of towers to staging point				■			
Delivery of balance of plant				■			
Transport to site and install foundations			■	■	■		
Transport and install submarine cables				■	■	■	
Transport to site and install towers					■	■	
Transport to site and install substation						■	
Transport to site and install mast						■	
Transport to site and install turbines						■	■
Onshore grid connection works, inc. landfall		■	■	■	■	■	■
Commissioning							■

3.3.3 *Sequence of Operations*

Assuming monopile foundations are selected, the offshore construction procedure is likely to be subdivided into the stages listed below:

1. The pile foundation will be placed by the vessel and drilled/driven into the seabed for the wind turbine bases, the substation base (option) and the meteorological mast by a jack up vessel.

2. The wind turbines and substation (option) will be installed by a jack-up.

3. The submersible power cable within the wind farm will be laid and terminated.

4. Either a single submarine cable will be laid between the shore and the offshore substation or four cables will be laid between the shore and the gathering point.

5. Connection will be made at the landfall point.

The work on the grid connection on the land side of the coastal defences will be undertaken in parallel with, or in advance of, the offshore cabling works.

By utilising a number of installation vessels, several construction operations will be carried out simultaneously thus increasing working efficiency by decreasing set-up times.

If drilling is the preferred option for monopile installation it is anticipated that only one monopile will be installed at a time, each taking up to two days (plus weather downtime) to complete.

The stages of construction are described in more detail in the following sections. *Section 3.3.15* summarises the equipment likely to be on site through the construction process.

3.3.4 *Mobilisation and Delivery to Site*

Offshore wind energy production by its very nature lends itself to transportation of components and construction equipment to site by sea. Further, the physical scale of the proposed wind turbines and their associated facilities raise difficulties to road haulage. The contractor will be responsible for organising manufacturing facilities which have the local infrastructure to transport towers and blades to a sea port location, for delivery to a local port in proximity to the present site.

The components and installation equipment will be shipped to a suitable staging port awaiting removal to site.

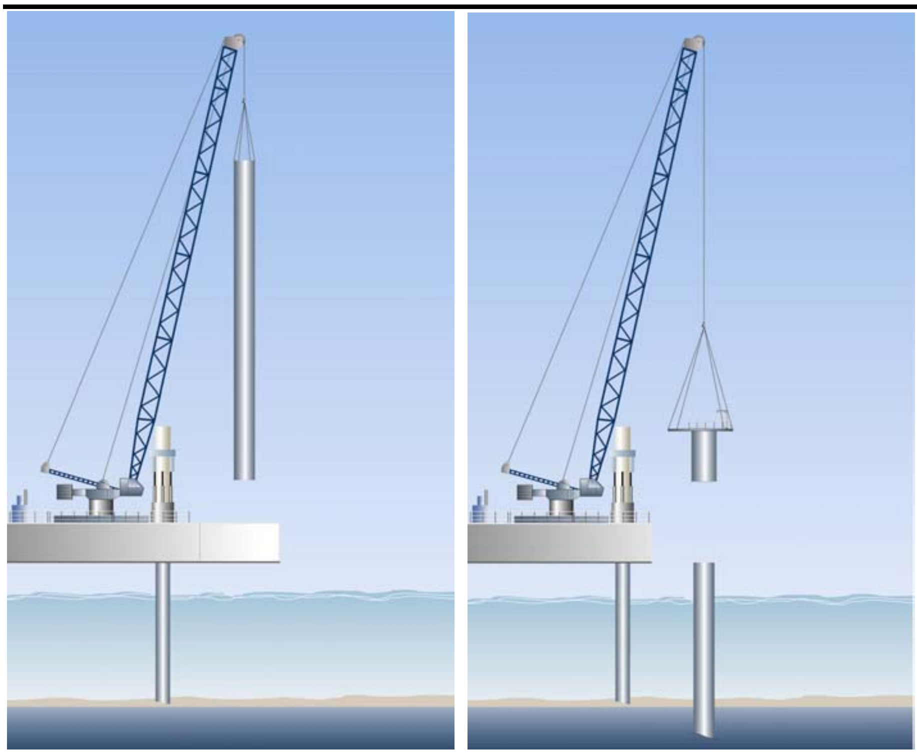
In any operation, the vessels involved in the installation will first be anchored and stabilised at the required work location. Crews will be transported to the installation vessels using small service boats.

3.3.5 *Wind Turbine Foundation*

The monopiles will be either drilled and grouted into the seabed substrata or be driven in using a pile hammer, or inserted by a combined drill-drive process. Drilling is currently considered to be the most likely option, however this will be finalised following the completion of geotechnical investigations.

The monopiles will be transported to site using a jack-up vessel and positioned in place. If the pile is to be driven, it is then lifted into the vertical plane using cranes on board the jack-up. The hammer is then located on top of the pile and hammering commences until the pile is driven to the requisite depth into the seabed. One pile will be driven at a time.

Figure 3.7 Illustration of the Foundation and Transition Piece Installation (Courtesy of Enron Wind)



In the event that the monopile must be drilled and grouted into the seabed the procedure would be as follows:

- Drilling of the hole to accept the foundation, with excavated material being discharged to the area immediately surrounding it (predicted scour hole). Approximately 500m^3 of excavated material is anticipated for each foundation. Excavated material will consist of the following:
  - fractured and abraded sandstone (size typically <50 mm);
  - gravels (>2 mm);

- sands (60 microns – 2 mm);
- silts (2 microns – 60 microns); and
- clays (<2 microns).

- The foundation is placed *in situ* in the drilled hole.

- Grouting concrete is pumped into the annulus around the foundation. The concrete would be of a cement based product and seawater and a volume of approximately 10 m^3 per foundation may be required. An excess of approximately 50% will result and will be deposited in the area immediately around each foundation, effectively forming a 'collar' around each monopile.

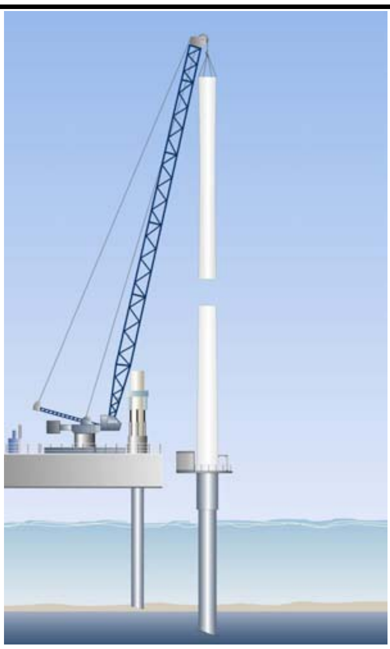
A transition piece (complete with pre-installed features such as boat landing arrangement, cathodic protection, cable ducts for sub-marine cables, turbine tower flange, *etc*) is mated with the monopile and secured. It is anticipated that this connection will be made using a high strength grout.

3.3.6 Wind Turbine Tower

The wind turbine towers are transported to site in a similar fashion to the monopiles. However, the erection of the upper tower sections require a high reach crane which is usually a mobile crane operated from the vessel deck.

The lower tower section is lifted into the vertical plane and positioned over the previously installed transition piece on top of the pile. The tower is then secured to the transition piece by a bolted connection. The upper tower sections are positioned in a similar manner with the bolted flange secured by technicians working within the tower.

Figure 3.8 Illustration of the Tower Installation (Courtesy of Enron Wind)



3.3.7 *Nacelle and Rotor*

The nacelle assembly is transported to the site on a jack-up barge as one or, possibly, two modules. The nacelle assembly is lifted into position on top of the tower and a bolted connection is made by technicians from inside the tower.

The rotor blades are assembled to the rotor hub onshore and lifted as a complete unit onto a jack-up deck and shipped to site. Alternatively, the rotor hub may be pre-assembled to the nacelle assembly, in which case the blades are transported as a set of three to the site.

A high reach crane is used to lift the blades or rotor assembly and a smaller crane used to assist the assembly. Finally, bolted connection is made to the nacelle assembly.

Figure 3.9 *Nacelle and Rotor Installation (Courtesy of Enron Wind)*

3.3.8 *Offshore Substation (Option)*

At a convenient stage in the overall installation procedure, the offshore substation (option) will be installed by a jack-up vessel. The monopile installation is according to a similar method to that for the wind turbines.

The substation (if offshore) will be delivered in modular form to the local staging quay, where it will be assembled into either a complete assembly or two to three sub-assemblies. It would then be transported to the site and assembled on the foundation.

3.3.9 *Submarine Cables*

The submarine cables are to be laid at a depth below the seabed so as to provide protection from third party activities such as fishing and avoid hydrodynamic forces in the tidal stream which could de-stabilise the cables in time resulting in failure.

The depth of burial will be dictated by the conditions discovered by the geophysical and geotechnical investigation. It is likely that cables will be installed up to 3m below the local sea bed. Cables will be installed either by jetting or ploughing. Although burial is the expected method of installation, where soil conditions prevent burial the cables will be appropriately restrained and protected.

Jetting involves the use of a jet sled which is pulled over the cable route by a barge. The sled carries a vertical 'claw' which consists of two tubes equipped with jets, one on each side of the cable route. Water is pumped from the barge down hoses to the jets which are aimed at the cable route on the seabed. The pressure of the water erodes the seabed and forms a slurry of water and sediment. A jet eductor system ejects the slurry to one side. The cable is then laid in the trench, following which backfilling occurs.

If ploughing is used the plough is supported on the seabed by skids or wheels, with shares on either side of the cable. It is pulled over the cable route by an anchored barge. When the plough is pulled forward by a cable fixed to the front end of the beam, the shares rotate and close under the cable and a V-shaped trench is formed in which the cable falls. The lifted sediment falls back in place immediately after the cable has passed through the shares, thus minimising disturbance to sediment.

The cable is terminated at the turbine by being pulled through the existing J-tube arrangement attached to the foundation transition piece and connected to the turbine power cabinet. At the opposite end of each cable, termination is performed in identical manner at the adjacent turbine or substation.

3.3.10 Landfall

The landfall is suited to open cut and cables can be laid through an existing gap in the flood defences currently closed with stop boards. The gap will then be reinstated in a more secure manner which will improve the defences.

The following sequence of events is typical:

- Cabling will be floated ashore from a cable-laying barge lying as close to shore as possible on a high tide. If four MV cables were used, the cables will be floated ashore in pairs. Winches can be used to assist the pull ashore and when the cable is above the proposed route, buoyancy is released to allow the cables to sink into the seabed.

- At low tide, a back hoe excavator will work up the beach from the low tide mark excavating a trench into which the cabling will immediately be placed and the trench backfilled using the excavated material. The trench will be of a sufficient depth (minimum 2 m) to ensure that it is not subsequently exposed by seasonal or storm induced movement of the foreshore. Excavation, burial and reinstatement will take place within one or two tidal cycles. If four MV cables are used, two separate trenches will be required.

- The timber stop boards at the gap in the sea defences will be removed and jack-hammers used to lower the existing sea defences to a depth of 0.5-1 m below the surface. All the cabling will be laid through this gap in the defences and then routed to the junction chamber.

- The sea wall will be reinstated using reinforced concrete keyed into the existing sea defences either side of the crossing point to provide a standard of flood defence which is more secure than that which currently exists.

3.3.11 Control and Monitoring System

With the exception of the meteorological masts, the components of the control and monitoring system are assembled into the wind turbines and submarine cables in manufacture. Therefore, offshore installation procedures consist only of connection and testing of these components.

The meteorological mast foundations will be installed in similar fashion to the wind turbine foundations. The lattice towers will be installed in a small number of sections by a suitable crane on a jack-up. Instrumentation will be installed on the mast and tested *in situ* by technicians.

3.3.12 Commissioning and Testing

On completion of installation, the electrical and earthing system will be subject to a rigorous safety test procedure. Thereafter, the system will be energized and commissioning of the substation, wind turbines and control and monitoring system will be completed. The commissioning will follow a well-defined procedure to demonstrate the contracted level of performance and, once completed, the wind farm will enter commercial operation.

3.3.13 Polluting and Hazardous Materials

Where materials are excavated, they will either be replaced *in situ* (as in the case of cable trenches) or, where excess material accrues, deposited in the area immediately surrounding its source. In the event that monopile foundations are drilled, the generation of up to $500m^3$ arisings are anticipated for each hole drilled.

The following project components comprise chemical constituents which have the potential to cause polluting impacts to the marine environment;

- marine cement (used for grouting); and
- epoxy based paints (used as corrosion protection for the monopiles).

Although the chemical constituents will only be determined when the installation technique has been finalised, the contractor will ensure that the chemical constituents are environmentally acceptable under The UK Offshore Chemicals Regulations (2001) which implement the Harmonised Mandatory Control System [(1)].

This scheme provides a code of practice regarding offshore chemical use in hydrocarbon exploration and production initiatives. Under this system, chemicals are classified into groups depending on their biodegradation and bio-availability characteristics together with their toxicity to a range of taxonomic groups. On this basis, operators will be able to select the least harmful chemicals. Although this control system is not directly applicable to offshore wind farms, this method will be used to ensure that best practice is followed.

Other than the manufactured components of the wind farm and the installation plant, it is anticipated that the following materials will be on the site during construction:

- fuel and lubricants for installation plant (including vessels);
- fresh water and food for crews;
- concrete grouting (cement based product mixed with seawater), for grouted monopiles, and for pile caps, with a total volume of approximately 330m^3; and
- bottles of nitrogen.

The wind farm will include the following fluids:

- gearbox oil for wind turbines;
- lubricating grease for all major bearings in wind turbines;
- hydraulic fluid for wind turbine control and safety systems; and
- cooling oil for optional 132/MV transformer substation.

To avoid risk of spillage to the environment of any of these fluids, the following steps will be taken:

- sealed systems will be used for containment of all oils;

- containment vessels within the structures to catch any spillages; and

- specific procedures for changing of oils which make the avoidance of any spillage a priority.

3.3.14 *Safety*

Construction at the site will be managed according to applicable health and safety legislation and relevant best practice guidance. Health & Safety Plans will be prepared for the project as required by the CDM Regulations [(2)].

(1) for the Use and Reduction of Discharge of Offshore Chemicals (in accordance with PARCOM Decision 96/3).
(2) Construction (Design and Management) Regulations 1994.

Specific guidance for the health and safety systems framework for offshore wind projects is under development by the British Wind Energy Association, with input by the Health and Safety Executive (HSE). COWL is in ongoing discussions with the HSE regarding the application of this guidance. In order to provide a benchmark for the various parties involved in the construction project, COWL has adopted the UK Environmental Health and Safety Policy Commitments of Edison Mission Energy (one of the constituent partners comprising COWL).

It is expected that an exclusion area will be established around the wind farm site during construction, in compliance with the IALA Maritime Buoyage System. Aeronautical and marine warning lights on temporary buoys will mark this area. A typical exclusion zone would extend to 500 m from the nearest construction activity.

Notices to Mariners and Local Radio Navigational Warnings will be promulgated in accordance with relevant regulations.

3.3.15 Installation Plant

The following table lists the plant which is expected to be operational through the installation phase of the wind farm.

Table 3.2 Indicative Plant List

Plant	Capacity
Jack-up vessel (accommodation vessel)	100 Tonne
Jack-up vessel (transport vessel)	500 Tonne
Jack-up vessel (main vessel for lifting and drilling– foundations and turbines)	1000 Tonne
Utility / tug vessel	2000 HP
Mobile crane	500 Tonne
Transport barge	55 x 15m
Pile hammer (driven monopiles only)	S500 (500kNm; 25T ram; 60T total mass)
Large bore drilling equipment (drilled monopiles only)	Approx. 5m diam. x 35m
Personnel tender	10 persons
Dredging / scour protection vessel	
Concrete pump	

3.3.16 Workforce During Construction

The workforce during construction is likely to comprise the following approximate numbers:

- 60 workers will be employed on the installation of the wind farm;
- 10 local crew at the staging point and for the service boat;
- 20 workers for the cable route to shore; and
- 15 workers for the cable laid between the turbines.

3.4 OPERATION

3.4.1 *Introduction*

The operation methodology for the wind farm will be based on best current practice onshore with modification to reflect the different demands of an offshore environment.

3.4.2 *Remote Monitoring and Control*

A communications centre will be established at a suitable location onshore to enable operation and maintenance staff to monitor the wind farm using the control and monitoring system. Remote control will be exercised to the maximum extent possible.

3.4.3 *Maintenance*

The wind turbines will have a requirement for planned maintenance of a maximum of two times per turbine per year. This maintenance will involve one major service (typically programmed for summer periods of calm conditions) and a minor service. In each case, the work will be completed by two technicians per turbine, without a requirement for any external lifting equipment. Such scheduled maintenance will typically involve the lubrication of greased bearings, replacement of worn parts (*eg* brake pads) and occasional exchange of gearbox oil.

No major retrofit work will be planned for the operating lifetime of the wind farm.

Unscheduled maintenance is anticipated with a similar annual frequency to scheduled maintenance. In the unlikely event of major component failure, external lifting gear, possibly based on a jack-up vessel, will be required to remove and replace components.

Access will generally be carried by a suitable tender.

3.4.4 *Polluting and Hazardous Materials*

The Edison Mission Energy Health, Safety and Environment Policy will be in force throughout the construction and operational phase and will be adhered to by construction and operations contractors.

During operation and maintenance, polluting and hazardous liquids will be limited to gearbox oil and hydraulic oil, both of which will be changed at most a few times during the operational life of the plant, and bearing grease which will be added once or twice per year during scheduled service.

3.4.5 Safety

COWL is proposing to implement the following exclusion zone policy during the operating life of the project:

- a total exclusion zone of 50m around each turbine or structure;

- a total exclusion for mobile fishing gear[1] covering the full extent of the wind farm area, extended to 50m around the perimeter of the rectangle defined by the two turbine rows; and

- access for static gear[2] within the wind farm area, excluding the 50m from each turbine.

As part of the process of compliance with prevailing environmental, health and safety legislation, operations and maintenance activities at the Rhyl Flats site will be required to adopt the Edison Mission Energy UK Environmental, Health and Safety Policy commitments and adhere to the minimum requirements established under the relevant Edison Mission Energy Standards. In particular, comprehensive risk assessments will be developed consistent with the *Management of Health and Safety at Work Regulations 1999*.

In the worst case (a major component failure or ship collision), re-mobilisation of the construction plant will be required. Additionally, a major failure of rotor blades, for example as the result of lightning strike, may cause fragmentation of the composite structure. To strictly limit this risk, the wind turbines will be fitted with lightning conduction protection systems.

3.4.6 Workforce During Operation

For the operations and maintenance of the wind farm and its associated facilities a team of approximately five to ten workers would be involved (including boat crews).

3.5 DECOMMISSIONING

The Rhyl Flats wind farm will be designed for a lifetime of 20 years. A decommissioning plan will be agreed with Crown Estates as owners of the site seabed. It is expected that the following operations will be conducted.

- The wind turbines, wind turbine towers, substation and meteorological stations will be removed in the reverse sequence to which they were

(1) Mobile gear includes trawls, beam trawls and dredges. These methods would all have the capability to snag the cables between the turbines if they became exposed.

(2) Static gear, bottom gill nets or tangle nets.

installed using jack-up vessels and cranes. All components will be removed from the site and disposed of onshore.

- For the foundations an internal cut will be made beneath local seabed level. The depth of this cut will be such that scour action will not in the future cause any structure to project above the seabed. The foundation will be removed from site and disposed of onshore.

- Submarine cables may be removed and disposed of at appropriate onshore facilities. If the cables are left in place, to minimise disturbance to the seabed, they will be capped to prevent corrosion with ends ballasted onto the seafloor. This solution is expected to prove to be the best possible environmental option with minimal disturbance to the seabed. Fluid filled cables will not be used because of potential for adverse environmental impacts during decommissioning.

- Any installed scour protection will remain in place to minimise local disturbance and any excavations in the foundation locations will be allowed to fill by natural sedimentation processes.