CHAPTER 2: PROJECT DESCRIPTION

2.1 Objectives of the Development

Burbo Offshore Wind Farm is designed to produce up to 90MW of clean, sustainable energy. By displacing power generation from fossil fuels, Burbo Offshore will assist in reducing carbon dioxide, sulphur dioxide and nitrous oxide emissions that would otherwise contribute to environmental degradation and global warming.

The electricity generated by Burbo Offshore will help the Government meet their target of 10% of electricity generation from renewable sources by 2010. The recent Energy Review 2002 highlighted the Government's desire to further raise renewable energy production to 20% by 2020.

2.2 Site Location and Physical Characteristics

2.2.1 Site Location

Burbo Offshore is located approximately 6.4 km (4.0 miles) from the Wirral and Liverpool coastlines. The site will consist of thirty turbines situated on the Burbo Flats sand bank close to the entrance of the Mersey River. The turbines are situated within the Port Authority controlled area, operated by Mersey Docks and Harbour Company Ltd (MDHC).

A plan of the wind farm is shown in Figure 2.1.

The co-ordinates in Table 2.1 define the boundary of the area within which the turbines will be situated.

Table 2.1: Burbo Offshore Wind Farm area

Easting (OSGB)	Northing (OSGB)	Latitude (WGS84)	Longitude (WGS84)
318855	401444	53° 30‘ 11“ N	03° 13‘ 24“ W
321201	401444	53° 30‘ 12“ N	03° 11‘ 17“ W
323791	398988	53° 28‘ 55“ N	03° 08‘ 55“ W
321736	397767	53° 28‘ 14“ N	03° 10‘ 45“ W
318855	400404	53° 29’ 38” N	03° 13’ 24” W

The monitoring mast for the wind farm will be sited at the following location (Table 2.2).

Table 2.2: Location of monitoring mast

Easting (OSGB)	Northing (OSGB)	Latitude (WGS84)	Longitude (WGS84)
322170	398210	53° 28' 29" N	03° 10' 22" W

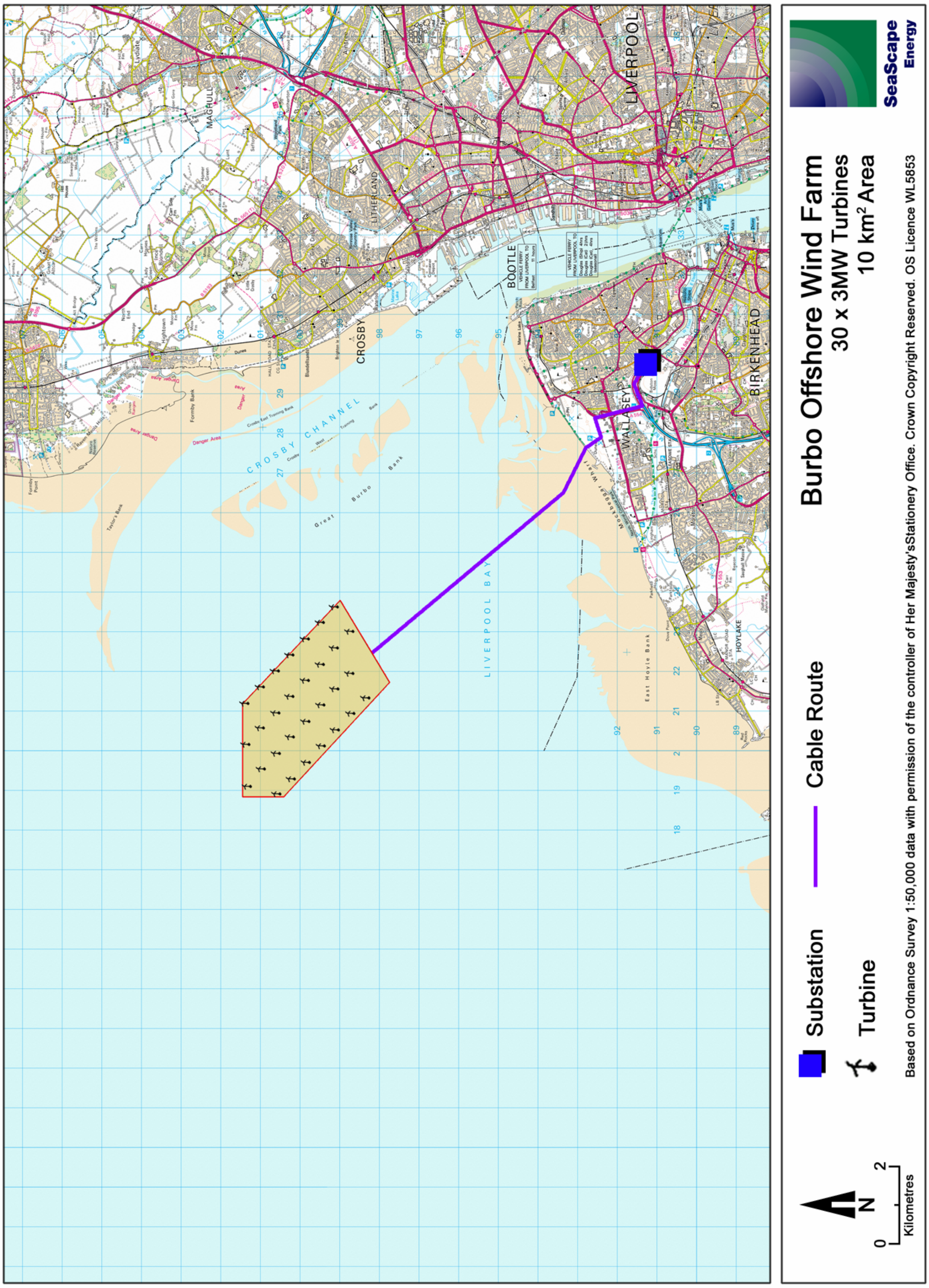

Figure 2.1: Burbo Offshore Wind Farm

2.2.2 Physical Characteristics

The wind farm site has the following physical characteristics (Table 2.3).

Table 2.3: Characteristics of Burbo Offshore

Description	Measurements
Water Depth (Admiralty Chart 1978)	0 m to 6 m at chart datum
Tidal Range (Admiralty Chart 1978)	Mean Spring 8.0 m Mean Neap 4.4 m
Currents (Admiralty Chart 1978)	Approx 2 kts max
Mean Surface Temperature (JNCC 1996)	5^{o}-7.5^{o} (Feb/Mar) 13^{o}-16^{o} (Aug/Sept)
Salinity (JNCC 1996)	31-32 g/Kg, winter 31-33 g/Kg, summer

2.3 Burbo Offshore Layout

The position and layout of the Burbo Offshore Wind Farm has been influenced by a number of factors:

- Proximity to the Mersey Estuary channel
- Proximity to the Port Authority Mersey Estuary training wall
- Distance from the shoreline (Wirral and Liverpool)
- Sewage outflow pipe to the SW from Wirral
- Mean Low Water (MLW)
- Energy capture efficiency

The turbines are orientated in a NW to SE direction, consisting of five rows regularly spaced. Separation of turbines is 560m in the NW/SE direction and 760m in the NE/SW direction.

The positions of the turbines are listed in Table 2.4 and shown in Figure 2.1. Due to localised variations in seabed conditions, these positions could vary by as much as 50m. Final positioning of each turbine will be determined once detailed geotechnical investigation of the individual turbine locations has been completed. This work will ascertain the geotechnical characteristics of the seabed at each turbine location in order that the foundation designs can be optimised to ensure minimum material use and precise control of the installation processes.

2.4 Construction Schedule

Work is scheduled to take place on Burbo Offshore in the Summer of 2004 or later, depending on the date of receipt of consent. The detailed construction methodology and the installation contractor have yet to be decided, but an outline plan of how construction will progress is provided below. A similar project is currently being constructed at Horns Rev in Denmark. It is expected that the example of Horns Rev will be closely followed in the installation of Burbo Offshore.

Table 2.4: Burbo Offshore Wind Farm turbine positions

Turbine Number	Easting (OSGB)	Northing (OSGB)	Latitude (WGS84)	Longitude (WGS84)
1	321254	401298	53° 30' 08" N	03° 11' 14" W
2	320207	401298	53° 30' 07" N	03° 12' 11" W
3	319160	401298	53° 30' 07" N	03° 13' 08" W
4	321660	400915	53° 29' 56" N	03° 10' 52" W
5	320613	400915	53° 29' 55" N	03° 11' 49" W
6	319566	400915	53° 29' 55" N	03° 12' 46" W
7	322066	400532	53° 29' 44" N	03° 10' 30" W
8	321019	400532	53° 29' 43" N	03° 11' 26" W
9	319972	400532	53° 29' 43" N	03° 12' 23" W
10	318925	400532	53° 29' 42" N	03° 13' 20" W
11	322472	400149	53° 29' 31" N	03° 10' 07" W
12	321425	400149	53° 29' 31" N	03° 11' 04" W
13	320378	400149	53° 29' 30" N	03° 12' 01" W
14	319331	400149	53° 29' 30" N	03° 12' 58" W
15	322878	399766	53° 29' 19" N	03° 09' 45" W
16	321831	399766	53° 29' 19" N	03° 10' 42" W
17	320784	399766	53° 29' 18" N	03° 11' 39" W
18	319737	399766	53° 29' 18" N	03° 12' 35" W
19	323284	399383	53° 29' 07" N	03° 09' 22" W
20	322237	399383	53° 29' 07" N	03° 10' 19" W
21	321190	399383	53° 29' 06" N	03° 11' 16" W
22	320143	399383	53° 29' 05" N	03° 12' 13" W
23	323690	399000	53° 28' 55" N	03° 09' 00" W
24	322643	399000	53° 28' 54" N	03° 09' 57" W
25	321596	399000	53° 28' 54" N	03° 10' 54" W
26	320549	399000	53° 28' 53" N	03° 11' 51" W
27	323049	398617	53° 28' 42" N	03° 09' 35" W
28	322002	398617	53° 28' 42" N	03° 10' 31" W
29	320955	398617	53° 28' 41" N	03° 11' 28" W
30	321361	398234	53° 28' 29" N	03° 11' 06" W

The work will take place in the summer months, commencing early in the year so that all thirty turbines can be installed within twelve months. It will be necessary to order materials and book construction vessels at least twelve months in advance of the installation date.

Where possible, much of the work will be run in parallel. Installation of the turbines can progress whilst the sea-to-shore cabling takes place. Construction of the onshore substation, interconnection facility and cabling can also progress at this time.

The target is to have the wind farm generating electricity by the end of the year in which construction commences.

2.5 Detailed Components of the Development

Construction of Burbo Offshore Wind Farm will require a variety of components to be installed. These include:

- Wind turbines
- Turbine foundations
- Foundation platforms
- Scour protection material
- Cabling (offshore and onshore)
- Electrical substation (onshore)
- Interconnection facility (onshore)

2.5.1 Wind Turbines

Burbo Offshore will consist of thirty wind turbines, purpose-built for the offshore environment. A typical example is the V90 design by Vestas A/S, as shown in Figure 2.2. Each turbine will produce a maximum 3MW of electricity and consist of a structure 130m high to blade tip. The wind turbines will consist of the following components:

- Foundation
- Access platform
- Tower section (80m high)
- Nacelle (transformer and gearbox)
- Blades (45m long)

The turbines will be operational in wind speeds of between 5 and 25 m/s. They will cut out when wind speeds consistently exceed 25 m/s to prevent damage to the turbines. The operation of the turbines is fully automatic, turning into the wind and shutting down when necessary. The operation of the wind farm will be monitored, and can be controlled, remotely from an operations room.

The colour of the turbines has not yet been finalised, although it is expected to be a dull grey colour to help blend into the background. Consultation with relevant authorities will help decide on the most appropriate colour.

The turbines will require regular servicing. Two service visits a year are required to maintain the turbines in operational condition.

Vestas A/S have a new wind turbine fabrication plant located close to Campbeltown on the Kintyre peninsula on the west coast of Scotland. Turbines manufactured here can be loaded directly on to ships for transport. The same ship can be used for transport and installation onto the prepared foundations. An example of the type of ship likely to be used is the Mayflower TIV-1 wind turbine installation vessel (Figure 2.3). When the TIV-1 reaches the wind farm site, it positions itself beside a foundation and lowers supporting legs onto the seabed. The ship then lifts itself on these legs so as to provide a steady platform from which the wind turbines can be lifted onto the foundations using the cranes fitted to the ship. Once the turbine is in place, the ship raises its legs and moves on to the next foundation.

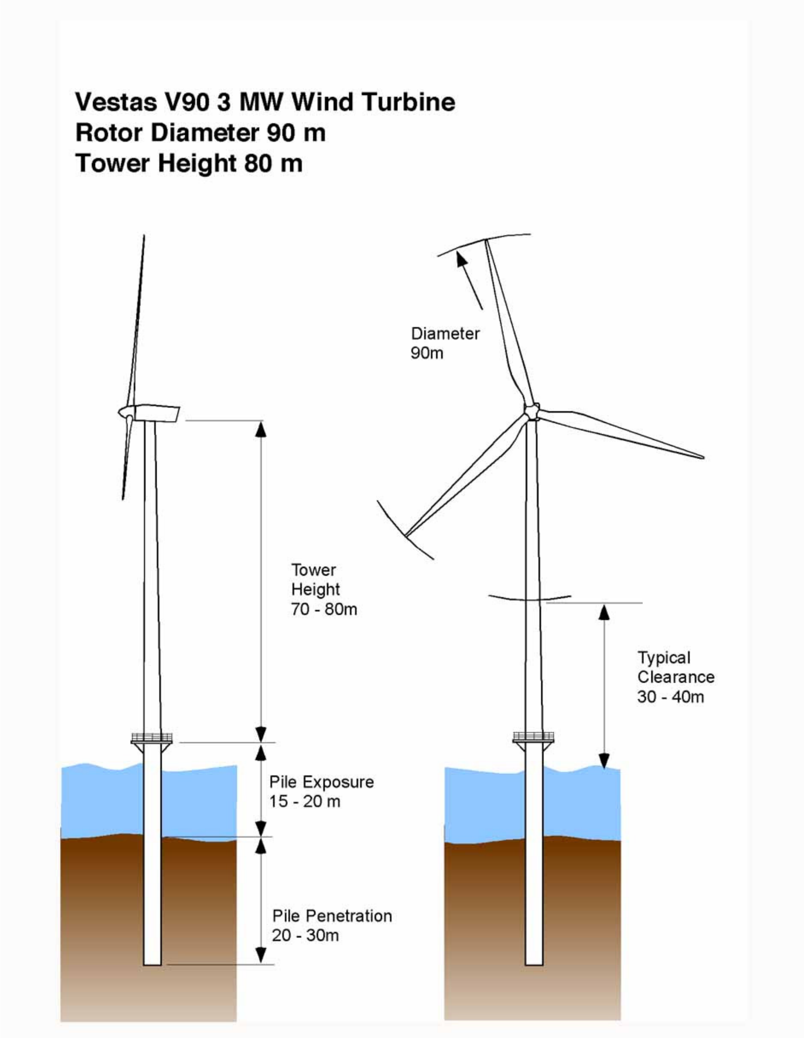

Figure 2.2: Vestas V90 turbine schematic

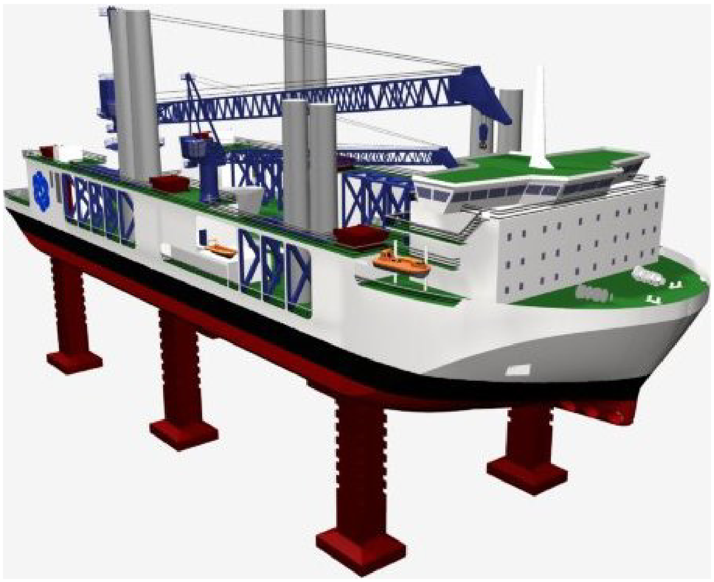

Figure 2.3: Mayflower TIV-1 installation vessel
(Courtesy of Mayflower Energy)

If the Mayflower vessel is not available at the time of construction, an alternative is available from the A2Sea company (Figure 2.4). The A2Sea approach involves modifying existing vessels by fitting legs and installation equipment. The principles of installing the turbines remains the same as with the Mayflower ship.

Figure 2.4: A2Sea installation vessel
(Courtesy of A2Sea)

2.5.2 Turbine Foundations

In order to site the wind turbines within the sea, it is necessary to first install a foundation on which they can be erected. Installation of the foundations will be a component of the construction contract.

The purpose of the foundations (Figure 2.5 and 2.6) is to provide support for the turbine structure that exists above sea level. The foundation will have to withstand the forces of the sea, the weight of the turbine above it and the stresses created by the wind and the operation of the turbine.

Between the foundation and the turbine will be a steel platform (Figure 2.6). This will provide access ladders to the turbine and a secure working environment for maintenance and installation personnel. The foundation will also provide an access point for the connecting cables. The monopile foundation will consist of a single steel tube (pile) 4m in diameter which is either driven or drilled into the seabed (depending on the sediment at that location). This process is carried out from a jack-up barge. After installation of the pile, a 'transition piece' will be connected to the exposed pile and fixed by grouting. The transition piece will be fully fitted out with the boat fending arrangements, access platform and equipment, cable ducting and attachment flange for the turbine tower.

The piles for the foundations will comprise a number of rolled steel 'cans' fabricated by a specialist facility and welded together to make the required length of pile. The individual cans or completed piles will be moved from the fabrication facility to a temporary shore-based store area for final finishing and preparation for installation. For the purposes of this EIA it is assumed that the piles will be fabricated by a company such as Cambrian Engineering based in Bangor, North Wales. They will be transported (probably by road) to shore base facilities on the Mersey. The Mersey Docks and Harbour Company have indicated that they will be able to provide the necessary space and infrastructure, but other options such as the Cammel Laird shipyard are possible.

Figure 2.5: A2Sea vessel installing platform onto foundation (Courtesy of A2Sea)

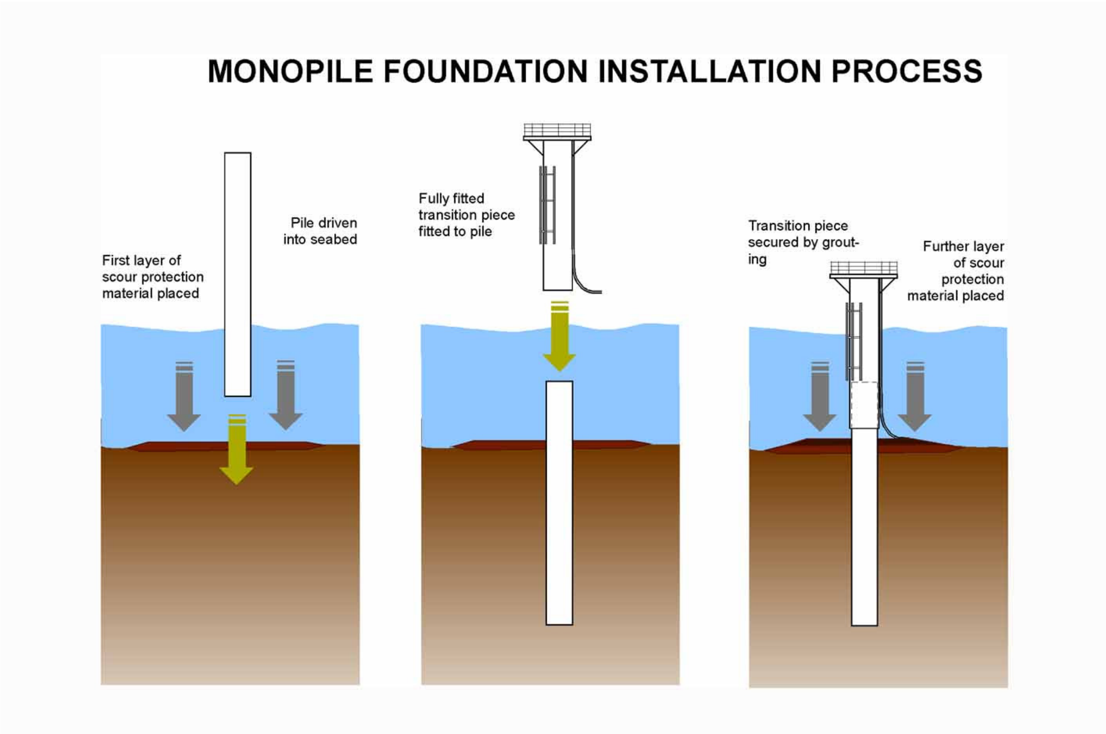

Figure 2.6: Monopile installation

The monopile foundation will typically have the specifications as outlined in Table 2.5.

Table 2.5: Monopile specification

Description	Measurements
Pile Diameter	4m
Pile Steel Thickness	8cm
Pile Length	50m
Weight (Approx.)	390 tonnes
Total Weight 30 units (Approx)	11,700 tonnes
Transition Piece	50 tonnes
Transition Piece Grout	3m^3

2.5.2.1 Driven Monopile Installation

This option involves the monopile being 'hammered' (Figure 2.7) into the seabed sediments using a pile-driving technique. The foundation is then held in position in the seabed by the pressure of sediments around the underground section of the pile. The depth that the monopile is driven into the seabed is dependent on the types and density of sediment identified beforehand, using geotechnical investigation.

The installation of the monopile is carried out from an offshore platform (jack-up barge) or other similar vessel. The vessel is equipped with a crane, piling and ancillary equipment. Other vessels required during installation will include a support barge, tug, and safety/transfer vessel.

Figure 2.7: Drill (left) and pile-driven (right) monopile installation equipment (Courtesy of www.windpowerphotos.com)

The first step in the process is to lay a mattress of anti scour material, which will comprise graded rock placed by a grab working from a hopper barge. The support barge then carries the monopile foundation, including transition piece, to the waiting jack-up rig. The monopile is lifted into place above the installation point and lowered to the correct position on the seabed. Piling of the foundation commences until the monopile is driven to the required depth in the seabed. The transition piece is then installed on top of the pile. A final layer of anti scour material is then placed around the base of the monopile.

The jack-up barge and all associated equipment will then move on to the next location. This installation process is repeated for all thirty turbines.

2.5.2.2 Drilled Monopile Installation

The drilled monopile installation follows the same procedure as 2.5.2.1 apart from the following. If bedrock or compact sediment prevents installation of the monopile by driving, then a drill (Figure 2.7) is used to core out the foundation socket. The crane is used to position the drill bit over the installation point and remove material from the seabed to allow the installation of the monopile section.

The depth of drilling can be shallower than with the driven monopile, as the solidity of the stronger seabed sediments or rock provides greater support to the foundation.

A steel sleeve is first driven into the surface sediment layer to provide a guide to the drill bit and to contain the drilled material. This sleeve extends above the surface of the seabed by approximately 1m. This prevents excess sediment and buried contaminants from entering the surrounding waters prior to removal for safe disposal. The water containing the sediment is pumped out to a waiting barge which filters the water, removing the sediment for separate disposal. It may be possible that the rock obtained from the later stages of the drilling can be reused as scour protection. This process will result in a total of approximately 350 m^3 to 400 m^3 of excavated material being brought up to the seabed.

Once the cored hole has reached the required depth, drilling ceases and the foundation is lowered into place. Grout is used to seal the join between the monopile and the cored hole. This is extruded through the monopile using special pipes to ensure the correct amount of grout is delivered along the length of the installed pile.

There is a small possibility that some grout will escape from the cored hole onto the surrounding seabed surface, forming a protective collar which will contribute to the scour protection.

2.5.3 Turbine Foundation Ancillary Equipment

2.5.3.1 Access Platform

The foundation will be fitted with a platform that will enable safe access to the turbine itself. The platform will consist of a boat landing and safety ladders to provide access to the platform during reasonable weather conditions. The platform will be ringed with a safety rail containing life-rings. The platform will be installed as part of the transition piece.

2.5.3.2 Attachment for Interconnecting Cables

The turbines will be inter-connected on site by a series of electrical cables. The cables will run down the side of the foundations contained in a steel "J" tube to protect them from damage. The "J" tube will be attached to the transition piece before fitting to the monopile. The tube is a shaped hollow section of pipe with a wide mouth to allow the cables to be passed through and connect to the turbine.

2.5.3.3 Corrosion Protection Measures

The harsh conditions imposed on the turbine foundation and platform by the coastal environment makes it necessary to install anti-corrosion measures. This will be achieved using a process called 'sacrificial anodes', used on other similar offshore structures such as oil rigs. The plates of sacrificial anodes will be attached to the foundation once the monopile is in place, to prevent dislodging during installation.

2.5.4 Scour Protection Material

Scour protection is necessary to prevent the erosion of sediment on the seabed around the base of the foundation. This occurs when water movement due to either currents or wave action, creates vortices around a structure, causing surface material to become mixed into the water column and carried away.

The detailed design of the scour protection material at the base of the foundations will be determined once detailed coastal process modelling of the site has been completed.

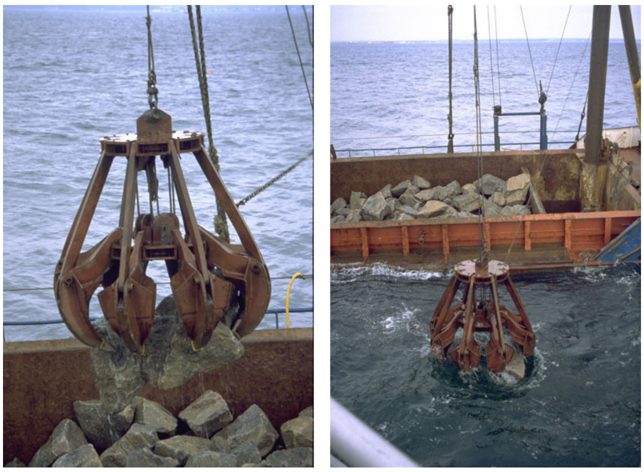

Figure 2.8: Dumping of scour protection material
(Courtesy of Middelgrunden Wind Farm)

Typically, the scour protection material will consist of rock, usually sandstone, of varying grades deposited around the base of the foundation.

The rock will be sourced from the local area where at all possible. The rock is transported to site via barge (Figure 2.8) and deposited on the seabed using a grab crane and bucket (depending on size).

Placement of the scour protection material is monitored remotely using either surface sonar equipment, divers or a camera-mounted ROV (remotely operated vehicle). Type of equipment used will be dependent on water visibility and necessary safety precautions.

2.5.5 Offshore Cabling

Subsea cables (Figure 2.9) are necessary to inter-connect the turbines and to connect the wind farm to the onshore substation, to enable the transmission of electricity into the grid. The cables will consist of copper conductors, insulation (heat and electro-magnetic interference) and steel armouring (to prevent damage from external sources, such as anchors).

Figure 2.9: Laying cable between turbines and to shore
(Courtesy of www.windpowerphotos.com)

2.5.5.1 Interconnecting Cables

These cables will connect the turbines together within the wind farm site. The cables will be laid along the rows that run NW/SE, so each section will be approximately 600m in length. The cables will be 125mm in diameter and will be buried up to 3m below the seabed to protect them.

Total cable length will be approximately 17,500m.

2.5.5.2 Cables to Shore

The electricity from the wind farm will be transmitted to shore using three cables running parallel to each other, spaced 2m apart. Distance to shore is approximately 7.5 km where the cables will join with the onshore cabling at the interconnection facility. This will be located behind the sea wall on Wirral at Mockbeggar Wharf.

Total cable length will be 21,500m.

2.5.5.3 Offshore Cable Installation

Both the interconnection and wind farm to shore cabling will be installed using the same type of equipment. This will consist of a barge holding the cable and towing a jet trenching machine (Figure 2.10) used to lay the cable in the seabed. As the barge tows the cable trenching equipment across the seabed, the cable is deployed from the barge into the trench. The process is designed to ensure quick installation with minimum disturbance.

Figure 2.10: Jetting machine for subsea cable burial
(Courtesy of CTC Marine)

Burial of the cable is designed to ensure no harm can come to the cables from external sources, such as fishing activity or anchors dragged across them.

The cable trencher can excavate to depths of 1-3m. Coastal process modelling will be used to determine the optimum depth for cable burial to ensure the chance of exposure on the seabed is kept to a minimum. Burial is carried out simultaneously with trenching, with the equipment back-filling over the cable once it has been deposited on the seabed.

The installation process is the same for the interconnecting cables as for the cables to shore. The only possible variation is the use of a land-based trenching machine in the intertidal zone during low tide. The methodology for installation is the same as when below water.

2.5.6 Monitoring Mast

A monitoring mast will be installed on the Burbo Offshore site by the end of 2002 or early 2003. Permission has been granted for its installation. The mast is designed to collect wind speed, wave, temperature and pressure data on the site.

The monitoring mast will consist of a 2m diameter steel monopile foundation surmounted by a steel lattice tower approximately 55m tall. The mast will be fitted with three levels of instrumentation equally spaced on the tower. Wave and current measurements will be taken using sub-sea equipment.

Data will transmitted to shore using remote dial-up technology.

The lifespan of the mast is expected to be five years from installation. The duration is long enough to collect relevant data on the site prior to the construction of the complete wind farm.

Drilling the profile

A small diameter pilot hole is drilled under directional control to a predetermined path using a mud-motor or jet bit on the end of the pilot string. The pilot string is drilled up to 80 metres in length, then the washover pipe is advanced in rotary mode until it is approximately 30 metres behind the drill bit. Alternate pilot string and drilling operations take place until the exit point is reached. Then the smaller pilot string is removed.

Enlarging the hole

Pre-reaming operations are carried out to enlarge the drilled hole to a size suitable for accepting the product pipe. Pull-back pipe is added behind the reamer. Depending upon the pipe diameter to be installed several pre-reaming operations may be necessary, each progressively enlarging the hole.

Installing the pipe

The pull-back pipe is connected to a 'cleaning' reamer which in turn connects to a swivel joint, (to prevent pipe rotation) that is attached to the pipeline towhead. The drill rig is then used to pull the product pipe into the preformed hole. The drilling fluid consisting of water and clay minerals will remain in the annulus and protect the pipe.

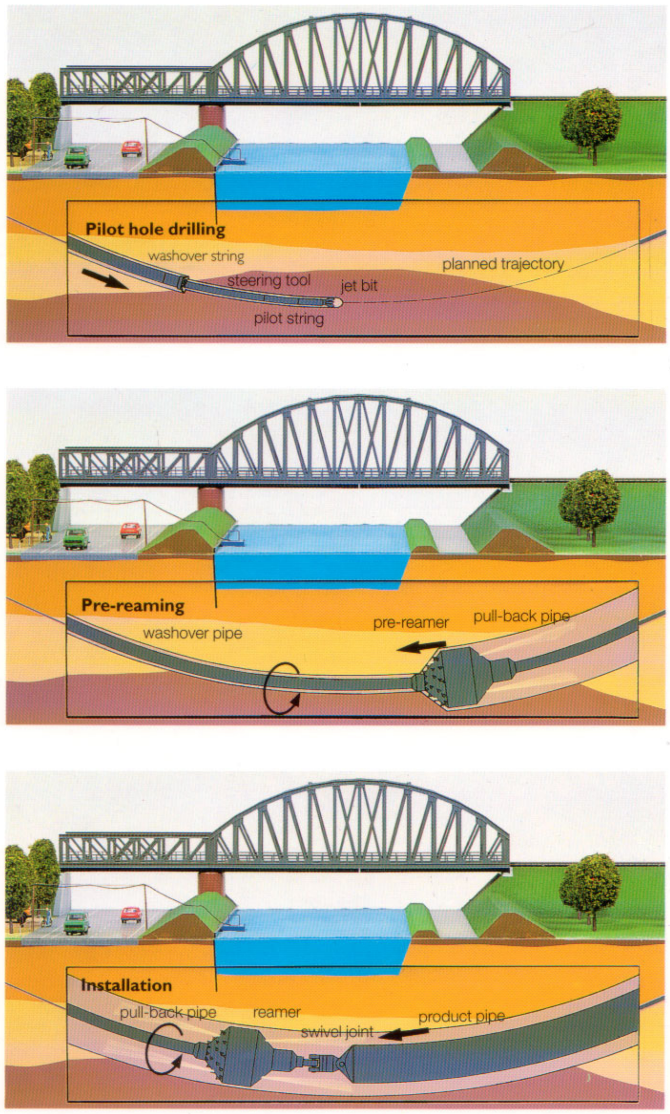

Figure 2.11: Example of how directional drilling is carried out
(Courtesy of LMR Drilling UK Ltd)

2.5.7 Onshore Cables

Onshore cabling is necessary to link the offshore cables to the proposed substation on Wirral, to facilitate the transfer of electricity. Onshore and offshore cables will be connected together at the interconnection facility. This will be located behind the sea wall on Wirral at Mockbeggar Wharf. Directional drilling (Figure 2.11) under the sea wall will ensure no breach in the coastal defences occurs.

The onshore cables will be similar to the offshore cables, being 125mm in diameter. Cables will be buried 1m apart creating a trench which is 3-4m wide. Depth of burial will be 1-3m depending on the local conditions being traversed.

Cable installation from the interconnection facility will take place along highways and across brownfield land to minimise environmental disturbance. The route is shown in Figure 2.12, indicating the main roads followed to reach the substation.

The length of onshore cabling will be approximately 3.5km.

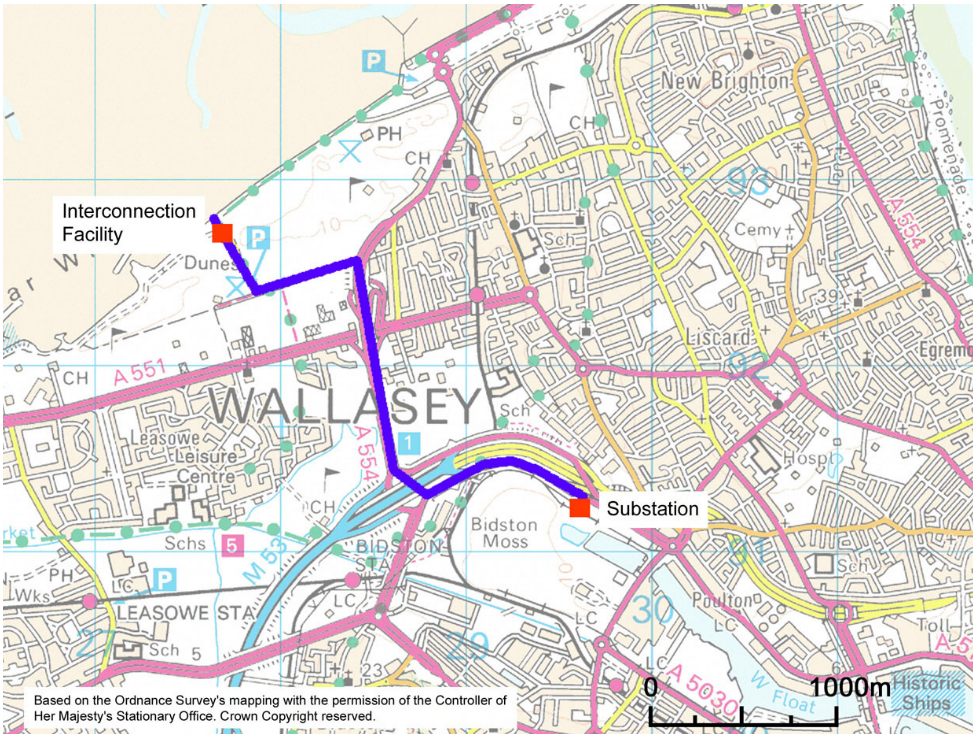

Figure 2.12: Route of onshore cabling and location of substation

2.5.7.1 Installation of Onshore Cables

Cables will be buried throughout their entire length to the substation from the interconnection facility. Where the cables traverse roads, a trench will be dug 1m deep and 1.5m wide (Figure 2.13). Consultation with the Wirral

MBC Highways Department will ensure traffic disruption is kept to a minimum.

Figure 2.13: Installation of cables in a trench
(Courtesy of Bohlen & Doyen)

Cables will be transported to site on reels for direct installation into the prepared trench. The trench will then be back filled with the same excavated material and the road surface restored.

Where cables have to traverse ground other than roads, then the surface will be restored to its former condition. Where necessary, suitable landscaping will take place to ensure local plant species are able to re-colonise the disturbed ground.

The Highways Department will provide details of any and all utilities which cross or parallel the proposed cable trench. All necessary measures will be carried out to ensure the trenching does not interfere with these services.

Work will continue until the cables have reached the substation location, ready for connecting to the transformer equipment.

2.5.8 Cable Interconnection Facility

This facility is the junction point between the offshore and onshore cabling. It comprises an underground chamber where the equipment to connect the cabling can be housed. The only visible surface feature will be a fully lockable, water-tight manhole access cover.

The interconnection facility will be located behind the coastal defences on Wirral, several metres behind the sea wall. The chamber will be approximately 4m square in size. It will consist of a concrete lined chamber to house the equipment.

2.5.9 Connection to the National Grid

Burbo Offshore will connect into the National Grid through its substation. Cables will run underground to a nearby overhead line, removing any need for additional overhead cabling to be installed.

2.6 Wind Farm Operation

The thirty turbines for Burbo Offshore will be installed within a specific area, agreed with the Crown Estate and the Mersey Docks and Harbour Company. This area will not be designated an exclusion zone, but it will be clearly marked on charts and by buoys and appropriate navigational markers. All vessels entering the area will do so at their own risk.

The wind farm will be fitted with the required navigation aids as laid down by Trinity House Lighthouse Service:

- Corners of the wind farm to be marked with flashing lights, fog horns and radar reflectors
- All turbines will be fitted with flashing yellow lights
- All turbines will have aerial navigation lights, to be switched on in case of an emergency. Only the perimeter turbines will be lit continually
- Turbine foundations will be painted yellow, to improve visibility from the sea surface

The wind farm and subsea cables will be marked on the relevant Admiralty Charts for the region. Appropriate Notice to Mariners will be issued and adverts announcing the wind farm placed in all relevant newspapers and journals.

The ability to shut down the turbines, individually or as a group, will rest with the operator. In event of an emergency, the Coast Guard and MDHC will also be able to shut down the wind farm.

2.6.1 Control, Inspection and Maintenance

Burbo Offshore is designed to remain operational with minimal maintenance and supervision for twenty to twenty five years. Each of the turbines has a self-regulating system installed within it which can fully control all of its operations. In the event of a fault occurring, the system diagnoses the problem and determines the correct course of action, shutting down the turbine if necessary.

All information from the turbines can be accessed on a 24hr basis by the operators. This includes standard operating information (wind speed, power output, etc) as well as fault diagnostics. Upon notification of a problem, SeaScape Energy can respond with the correct maintenance required.

Servicing and maintenance of Burbo Offshore will take place from a nearby port facility, most likely Liverpool. After construction, servicing will occur twice yearly (every 6 months). All cabling, the interconnection facility and substation will be inspected on a regular basis to ensure operational standards are maintained. Any concerns discovered on inspection visits will be dealt with as quickly as possible.

2.7 Decommissioning

One of the requirements of the Agreement for Lease from the Crown Estate for Burbo Offshore is that provision is made to remove the wind farm and all associated structures at the end of the agreement. This agreement runs for twenty-five years.

Decommissioning is the requirement to return the wind farm site back to the condition it was in before construction took place. Due to the potential environmental impacts of removing the offshore structures, consultation will take place with environmental groups to ensure minimal disturbance is caused.

Removal of the monitoring mast and wind turbines will use equipment similar to that deployed during construction. The above-sea components will be dismantled and taken to shore for recycling. The foundation would be removed by one of two methods. The first involves vibrating the foundation out of the ground, whilst the second involves cutting the turbine foundation away several metres below seabed. The appropriate method employed will depend on the condition of the foundations and the environmental consequences, which can only be judged nearer the time. For example, if marine colonies have formed around the foundations over the years, it may be preferable to leave some parts *in situ*.

All cabling, onshore and offshore, can be removed and recycled. The offshore cabling can be removed using a variety of methods, such as a de-trenching grapnel or a cable ‘under-roller’. The onshore cabling can be removed from its trenching along the roads to the substation, or left *in situ* if the disruption is judged to be unwarranted.

2.8 Alternative Locations

2.8.1 Wind Farm Location

The evolution of Burbo Offshore to its present location and form can be traced back through a series of stages. This section outlines how that evolution took place and the various options which were considered.

In 1998/9, Wind Prospect Ltd undertook an initial site selection process. A number of general locations were identified around the cost of the UK and initial environmental screening carried out in associations with Casella Stanger Ltd.

The initial site selection criteria included those are listed below:

Physical Environment
- Mean wind speed
- Water depth
- Seabed sedimentology
- Sub-surface geology
- Coastal processes
- Seascape and landscape assessment

Biological Environment
- Protected areas (SPA's, SSSI, etc)
- Benthic species
- Bird species
- Mammal species

Human Environment
- Electrical infrastructure and connection
- Economic development opportunities
- Tourism
- Leisure
- Archaeology
- Navigation
- Fisheries
- Port facilities
- Oil and gas industry

Consideration was given to onshore aspects as well as offshore.

Seventeen sites around the UK were identified at this stage, to be investigated in more detail.

In 1999, Gifford and Partners were commissioned to manage a more detailed site selection process. They assembled a multi-disciplinary team, including the Department of Oceanography at Southampton University, EMU Environmental and Fugro Ltd.

Their report contained a site by site assessment and an overall multi-factor scoring process was used to rank the sites. A shortlist of six locations was produced as a result of this study. These locations were then investigated further by Wind Prospect in consultation with turbine manufactures, electrical consultants, bird and ecology experts as well as being the subject of detailed wind modelling.

These further studies resulted in a short list of three locations:

- Shell Flats (near Blackpool)
- Burbo Bank
- Skegness

Burbo was finally selected from these three because it was judged to give the most favourable balance of factors needed for a low risk option that was both environmentally and economically attractive. The dominant factors that influenced the final choice included:

- Good mean average wind speed
- Shallow water depth
- Seabed surface and sub-surface geology suitable
- Suitable electrical infrastructure close by
- Suitable port for all phases of operations
- Within Port Authority jurisdiction for safety reasons
- MoD/CAA approval of site
- Industrialised setting
- Local familiarity with wind power (Seaforth Docks Wind Farm)
- Potential for minimal ecological and environmental disturbance, particularly with respect to birds.

2.8.2 Design of the Wind Turbine Layout

In accordance with the Agreement for Lease from the Crown Estate, all offshore wind farms submitted for the first round must be a maximum of $10km^2$ and thirty turbines. These constraints dictated the size and shape of the wind farm as much as the place where it was to be sited. Great Burbo Flats, on which the wind farm is situated, is constrained to the north and east by the Mersey Channel and training walls. To the west, the water depth exceeds suitability and to the south the site encroaches on the shoreline. An initial design and position of turbines was determined based on these criteria.

Variations on the layout were investigated with the aim of maximising the energy output within these constraints. The correct spacing of the turbines relative to each other and the prevailing wind direction is important to minimise loss of energy as the wind passes through each turbine. Typically 7-10 rotor diameters separation is necessary, depending upon the orientation to the wind. Burbo Offshore is designed with 560m separation between turbines in the NW/SE direction and 760m in the NE/SW direction.

The layout was also constrained by navigation concerns. Located close to the entrance of the Mersey River and Liverpool Port, Burbo Offshore had to be situated a safe distance from the navigation channel. The wind farm is located on a prominent sand bank, a navigational hazard, which automatically prevents large vessels approaching the site. Small boats, fishing trawlers and pleasure craft are able to navigate within the area at suitable states of the tide. A regular layout to the turbines is both aesthetically pleasing and also much safer for navigation purposes by all vessels.

The turbine layout is also designed to minimise the length of cabling required to connect turbines together. Closer spacing and greater regularity of the design reduces the quantity of cables which will need to be placed on the seabed. It also ensures cables do not cross each other to maintain connectivity.

Lastly, the visual impact of the wind farm layout is a driving factor in public acceptance of a project such as Burbo Offshore. Public attitude towards the proposal were carefully monitored during the design process. Initially, the layout was an elongated trapezoidal shape considerably longer in the NW/SE direction than NE/SW. A major modification to the layout has made as a result of the public consultation exercises and responses from other consultees. This resulted in Layout 2 (Figure 2.14). After further feedback from the final round of public consultation, SeaScape Energy modified the layout to further reduce the spread of turbines when viewed to the Crosby. This resulted in the layout in Layout 3. The angle of view from Crosby is reduced by almost one third as compared to Layout 2 and the majority of turbines are also further away from the viewer. From Wirral, the angle of view is slightly increased, but the distance from the viewer of all the turbines has increased.

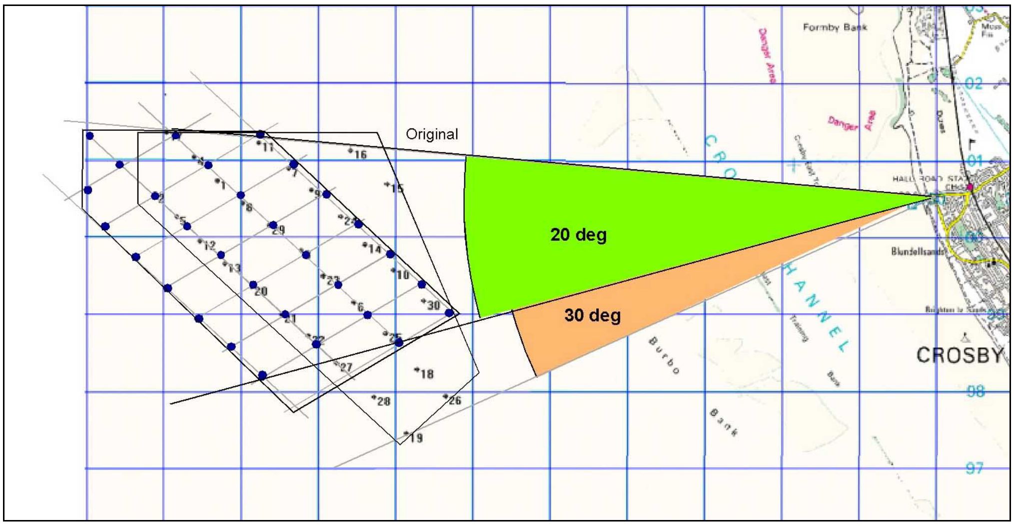

Figure 2.14: Alteration of Burbo Offshore Wind Farm, layouts 2 and 3

2.8.3 Onshore Electrical Connection

Besides determining the offshore components, it was necessary to examine where the cabling could be brought ashore and how best to connect it into the National Grid infrastructure. The decision to site the wind farm on Great Burbo Flats presented several options for connection onshore. They were:

- Wallasey
- Hoylake
- Formby
- Litherland

All four locations offered potential connection points of adequate capacity into the National Grid. Upon further investigation Formby and Litherland were discarded. The routes traversed the Mersey Channel and discussion with MDHC (in their capacity as the Port Authority) revealed concerns about the cable being a potential hazard to navigation. The process of laying the cable across the river was also technically difficult and this, coupled with the discovery that the wider electrical network would need to be reinforced, led to the rejection of this options.

Potential connections at Wallasey and Hoylake were examined in greater detail. Both appeared to be technically possible in that adequate capacity existed on the network and major reinforcement would not be necessary. The Hoylake option would require a longer underwater connection route but a shorter route on land. The availability of land for the siting of the substation was much greater in the Wallasey area, and this was the final determining factor in the rejection of the Hoylake option in favour of Wallasey.

The details of the onshore connection route and infrastructure are given in Chapter 8 of this volume.