ANNEX B – THE LIFE OF AN OFFSHORE WIND FARM

Introduction

During its life, an offshore wind farm project will require the expertise and knowledge of a large number of people with a wide range of skills. The relatively simple concept of harnessing the offshore breeze to generate electricity contrasts with the large range of issues which need to be tackled through an offshore wind farm's development, construction and operation.

The development of an offshore wind farm project brings together a diverse team, including specialists such as meteorologists, planners, ornithologists, marine biologists and ultimately bankers, as well as the more obvious marine and electrical engineers. The construction and operation of offshore wind turbines around the coasts of the UK presents design engineers with a considerable challenge, as most of the sites designated for development are located in severe marine environments.

This section aims to describe the work required during each phase in the life of a typical offshore wind farm project, including the range of skills required and the length of time each phase can be expected to take. These phases are as follows:

- pre-consent phase
  - Environmental Impact Assessment
  - technical studies
  - consent determination
- procurement phase
- grid connection
- financial close
- construction phase
- operation and maintenance phase
- re-powering
- decommissioning phase.

The following skills are required at each stage during the project evolution:

- project management
- public relations
- legal
- health and safety
- environmental management
- offshore technical expertise.

Pre-consent phase

The activities in this phase are focused on progressing the project in a diligent and timely manner, through to the issue of the statutory consents (the equivalent of planning permission for onshore developments). This involves consultation with a wide range of government and public consultees, and the commissioning of an Environmental Impact Assessment and supporting technical studies, such as ornithological monitoring and seabed scour assessments.

Prior to obtaining its consents, a wind farm project is highly vulnerable to criticism from public and media lobbying. There must therefore be careful attention to public relations, including a proactive stance to providing the local population and media with correct information about the proposal.

Environmental Impact Assessment

Under government legislation, all offshore wind farm projects are required to submit to an Environmental Impact Assessment (EIA). The results from this process are summarised in an Environmental Statement (ES), which is a public document submitted together with the applications for statutory consents. The EIA is a detailed process involving many different disciplines, and can take from one to two-and-a-half years to complete. The main tasks involved in a representative EIA include the following.

EIA management
The EIA process is often managed by consultants experienced in this field. They are usually responsible for the compilation and production of the ES.

Ornithological assessment
In the assessment of the effects of the proposed wind farm on birds, both aerial and boat-based survey methods are employed to assess the number and distribution of bird species in and around the site. Boat-based surveys are usually undertaken once per month for a minimum of a year, using three to four people for one or two days per survey. Aerial surveys are usually undertaken during a selection of winter and summer months – one day of survey effort using three or four people in the aeroplane is usually sufficient for most wind farm projects. The results of these surveys, together with an assessment of the likely environmental impacts, are documented by an experienced ornithological consultant and form part of the ES.

Land and Seascape Visual Assessment
The effect of the wind farm on the visual environment is determined in a Land and Seascape Visual Assessment. This assessment, usually performed by landscape architects, involves the characterisation of the seascape in the vicinity of the development, the representation of the wind farm using such techniques as photomontages, the analysis of Zones of Visual Influence and an assessment of the effects of the development.

Noise
The likely effects of noise from the wind farm, during both construction and operation, are often assessed against the prevailing background noise levels at the coast. In such cases, background noise monitoring is undertaken by professional

acousticians at several locations for two to four weeks, and predictions on the likely environmental effects are include in the ES.

Safety of navigation
The safety of navigation is paramount, and much work is undertaken to ensure that the wind farm is properly located, designed, lit and marked, following discussions with a wide range of consultees. Such consultees include the Maritime and Coastguard Agency, Trinity House, the Royal Yachting Association, the Royal National Lifeboat Institution, local harbour authorities, commercial shipping operators, fisheries organisations, angling associations, and sailing and cruising clubs. A detailed Navigational Risk Assessment is performed, using on-site traffic surveys and input from the navigation community.

Commercial fisheries
The possible effects of offshore wind farms on commercial fisheries are investigated using analysis of catch records and consultations with local and national fishing organisations and individual fishermen. Sample trawls may be performed at selected times of the year to confirm information gathered from the fishing industry.

Marine ecology
A range of marine ecological surveys is undertaken within the EIA process, from fish trawls and marine mammal surveys to benthic sampling (ie sampling of life on and within the seabed). Benthic sampling requires the collection and analysis of small (0.1–0.2m3) samples from the surface of the seabed. Such surveys require a medium-sized vessel with three or four personnel aboard. The analysis of each benthic sample can take a person from half a day to one-and-a-half days to complete, and some projects may involve in excess of 150 samples. Determining the likely effects of the proposed wind farm on the marine ecology of the area forms a major part of the EIA process, and is undertaken by companies experienced in this field.

Coastal processes
Determining the likely effects of the wind farm (especially the turbine foundations) on the wind, waves and currents in the area, and thus its potential to influence the patterns of any nearby coastal erosion, may require specialist numerical modelling techniques. To increase the accuracy of these numerical models, wave and current data is collected at the site for a period of up to a year.

Cumulative effects
The effects of the proposed project have to be determined, not just in isolation, but when acting in combination with other projects and activities that have been or may be carried out. Projects or activities to be taken into account include existing completed projects, approved but uncompleted projects, projects for which an application has been made and which are under consideration by the consenting authorities, and projects which are reasonably foreseeable. They may include, for example, other offshore wind farms, harbour developments, dredging activities or offshore gas pipelines.

The range of skilled personnel contributing to this phase includes:

- landscape architects
- vessel operators
- engineers (marine, coastal, acoustic, civil, electrical)
- fisheries consultants
- ornithologists
- archaeologists
- marine biologists
- numerical modellers.

Technical studies

A range of technical surveys and studies is required to progress the project, and these can also support the EIA.

Geotechnical survey
In order to design the foundations for the wind turbines, sub-surface ground investigations must be performed. These involve a jack-up barge, with a crew of 10–20, drilling cores of material from the seabed. This material is then taken to accredited laboratories for analysis, the results of which are used in the detailed design phase of the project.

Anemometry mast
A monitoring mast is installed at the site to measure wind speed and direction. The structure, which can be up to 100m tall, comprises a lattice mast supported on a steel piled foundation fixed to the seabed. Installation of the mast is usually performed within one week of mobilisation, by a jack-up barge similar to that described above. The mast is instrumented with anemometers and wind vanes, and fitted with warning lights (to make it visible to both boats and aircraft) and sometimes a foghorn.

Geophysical survey
A non-intrusive geophysical survey is undertaken for the wind farm area and cable route(s) to shore to ascertain (among other things) the seabed topography and sub-bottom profiles. The survey is performed from small vessels towing measurement equipment below the water surface. Information from this survey is used to inform the marine ecology, archaeology and coastal processes assessments, as well as giving valuable baseline information for the wind farm site layout.

Oceanographic data acquisition
The gathering of oceanographic data provides the basis for understanding the existing physical environment within the site and its surroundings. Such information is used to inform the coastal processes assessment, with subsequent implications for the ecological studies and assessments of weather risk for the construction phase. The following data is usually taken:

- wind measurements
- wave measurements
- current velocity
- tidal elevations
- seabed sediment
- water quality.

The range of skilled personnel contributing to this phase includes:

- equipment suppliers (anemometry mast, offshore foundations, wave and current sensors, warning lights, etc)
- vessel operators

- marine construction contractors
- geotechnical consultants
- oceanographers.

Consent determination

Once the consent applications are submitted, a large number of bodies are invited to give their opinions on the project. These include statutory consultees (eg English Nature, Countryside Council for Wales, local authorities), local interest groups, non-governmental organisations, trade associations (eg fisheries bodies), commercial bodies (eg shipping companies) and members of the public. At this time, the developer usually organises public exhibitions to provide the local community with the opportunity to comment on the application.

The results of the consultation process, together with any supplementary information which may be submitted, provide the basis on which the regulatory bodies (notably the Department of Trade and Industry, the Department for Environment, Food and Rural Affairs, the Department for Transport, the National Assembly for Wales and the Environment Agency) then pass judgement on the project.

To date, the typical timescale for gaining the necessary statutory consents has been from six to twelve months, assuming that a Public Inquiry is not called.

The range of skilled personnel contributing to this phase includes:

- regulators
- statutory consultees and their environmental and technical agencies
- non-statutory consultees.

Procurement phase

The objective of this phase is to enter into a single contract or an ensemble of complementary contracts for the construction of the wind farm at minimum cost whilst managing the associated risks. There are many contracting options that are applicable to the construction of an offshore wind farm, and it is likely that more of these options will be employed as the industry matures. For example, contracts may span several summer seasons, or developers may split the scope of work into many discrete packages with the intention of managing overall cost and risk.

The award of the contract to construct an offshore wind farm comprises the following high-level steps:

- The developer advertises the contract(s) in the Official Journal of the European Commission, and invites expressions of interest. From the responses received, the developer scores the submissions using a consistent approach and draws up a list of potential tenderers (usually a minimum of three).
- The developer drafts the specification, selected for the form and specific conditions of the contract, and sends this to the tenderers.
- The tenderers submit their tenders within the time specified, a representative tender period being three months.
- The developer and tenderers enter negotiations concerning (among other things) technical and financial issues, contract conditions, timetable and price.
- The developer and successful tenderer(s) enter into the construction contract immediately following financial close (see below).

This entire process can be expected to take eight months or longer.

The range of skilled personnel contributing to this phase includes:

- procurement professionals
- wind turbine manufacturers
- construction contractors
- construction consultants
- offshore design engineers
- offshore consultants
- electrical consultants
- financiers
- insurers and underwriters.

Grid connection

Every offshore wind farm requires a connection to either the electricity distribution or the transmission system. The developer will agree with the operator of the relevant electricity network the extent, cost, timing, and contractual conditions of any works required for connection, and in some cases for the reinforcement of the network if the present network is unable to accept the whole projected output of the wind farm.

Technical studies are undertaken to determine the extent of work required to connect the development, based on the specifications of the type of wind turbine chosen. Once the above issues are agreed, the developer and the electricity network operator can enter into contract together for the connection of the wind farm.

The range of skilled personnel contributing to this phase includes:

- systems design engineers
- electrical engineers
- electrical systems modellers
- civil engineers.

Financial close

Financial close is the process whereby the developer, who has undertaken the necessary work to progress the project to this stage, decides whether to proceed with construction or not. The issues which are considered at this stage of the project include:

a) the completeness of the statutory consents obtained, and the implications of any conditions attached
b) any non-statutory consents or wayleaves required for the project to proceed
c) the terms of a construction contract, which will be in an advanced state and ready for signature
d) the terms of a grid connection contract, which may or may not already have been signed
e) the terms of any debt required to finance the project
f) project economic viability – the factors affecting the finances of a project include:

- capital cost
- operating cost
- predicted energy yield, this having been derived from data taken from the anemometry mast described above
- terms of any power purchase contract
- any government support, eg DTI capital grants.

The range of skilled personnel contributing to this phase includes:

- the developer's technical and commercial staff
- financiers
- insurers and underwriters.

Construction phase

The wind farm construction is the most intensive phase of the project, with input from many sources including equipment suppliers, onshore and offshore contractors, ports, consultants and electricity supply companies.

For large projects, the construction phase may span several years, with construction contracts potentially spanning two to three years. The main contributors to the construction phase, and their contributions (subject to the contracting route adopted) include:

- **wind turbine supplier** – the wind turbine supplier supplies the wind turbine blades, the nacelle and the tower, and may also be responsible for turbine erection
- **foundation supplier** – the foundation supplier generally supplies the foundations, transition pieces and other steelwork, for which the typical lead time is six months
- **subsea cable supplier** – the typical lead time for cable manufacture is five months
- **installation contractor(s)** – there is generally more than one contractor, as different skills and vessels are needed for installation of the foundations, turbines and cables
- **construction port** – the port rents quayside space and a storage area to the contractor(s).

In addition, given the large number of offshore crew and engineers, the project provides opportunities for local service companies, hotels, and restaurants throughout the construction phase.

Throughout the construction phase, the contractor(s) must make sure that working procedures safeguard the health and safety of the workforce, while at the same time ensuring that the environmental impact of the works is as low as possible.

The length of time from letting the construction contract(s) to the commissioning of the wind farm depends on the project size: for a development of 30–50 wind turbines a period of 18 months to two years (including manufacturing time) is reasonable.

The range of skilled personnel contributing to this phase includes:

- comprehensive project management teams within the developer and contractor organisations
- wind turbine manufacturers
- steelwork (foundations etc) fabricators
- offshore construction contractors
- subsea cable suppliers
- installation contractors
- port operating staff
- vessel operators
- back-up services staff (administrative, technical, health and safety, environmental)
- financiers
- insurers and underwriters.

Operation and maintenance phase

Once the commissioned wind farm has been 'handed over' to the developer by the contractor, the operation and maintenance phase commences. In general, the construction contract provides for the wind turbine manufacturer to operate and maintain the wind farm for a certain period – anywhere from two to five years. At the end of this time, the developer has to decide whether to contract out the operation of the wind farm or to take over this task.

During the operation and maintenance phase, regular inspection of turbines, foundations, cables etc will be undertaken and any necessary remedial work performed. The work falls into three categories:

- periodic overhauls
- scheduled maintenance
- unscheduled maintenance.

Periodic overhauls
Periodic overhauls will be carried out in accordance with the turbine manufacturer's warranty. They will be planned for execution in the periods of the year with the best access conditions, preferably in summer.

Scheduled maintenance
Scheduled maintenance refers primarily to inspections and work on wear, parts susceptible to fail or deterioration in between the periodic overhauls. A scheduled inspection of each turbine is likely to take place every six or twelve months.

Unscheduled maintenance
Unscheduled maintenance takes place in the case of any sudden

defects. The scope of such maintenance ranges from small defects to complete failure or breakdown of main components. It may require the intervention of construction vessels similar to those used for wind farm construction.

The range of skilled personnel contributing to this phase includes:

- port staff
- vessel operators
- operation and maintenance staff (plus administrative and technical support)
- offshore construction contractors, for major refits.

Re-powering

In the latter part of the operational life of the wind farm, the client may decide to re-power the wind farm using new turbines. This decision will be based on the performance of the wind farm to date, and the likely returns of re-powering versus full decommissioning and removal of the project components.

It may be possible to reuse some infrastructure from the first phase to reduce the capital cost for the second (re-powered) phase. For example, much of the original subsea cabling may be utilised, along with the existing grid connection. The probable increases in turbine size between the present day and 15–25 years hence mean that it is unlikely that the foundations will be reused.

In order to re-power, a distinct financial close procedure will have to be undertaken, leading to a second construction phase and operation and maintenance phase, with all that these phases entail.

The range of skilled personnel contributing to this phase will be similar to those required in the financial close, construction and operation and maintenance phases above.

Decommissioning phase

The decommissioning of the wind farm is the final phase of the project. Although industry practice relating to the extent of decommissioning has not yet been determined, the aim of this phase should be to return the seabed to its original state as far as practicable.

Prior to construction of the first phase of the wind farm, the developer must submit to the relevant regulatory authority a decommissioning method statement, including the scope and method of decommissioning and consideration of health and safety and environmental protection issues. This statement will be updated nearer to the time of actual decommissioning.

It is likely that decommissioning will mean the removal (and potential reuse, recycling or scrapping) of the wind turbines and also (to a suitable depth with respect to the seabed) of foundations and ancillary structures. It may also potentially mean the removal of subsea cables, though it may be judged more environmentally sound to leave the buried cables undisturbed.

The range of skilled personnel required for decommissioning will be similar to that for the construction phase.

The environmental obligations of the wind farm operator may potentially continue after decommissioning if any latent issues should come to light after this time.

This annex was written by Dr David Bean. Dr Bean is a director of the independent consultancy Project Management Support Services (PMSS). Prior to joining PMSS in May 2003, he was Offshore Development Manager at National Wind Power, and was responsible for all its offshore wind developments. He was the Project Manager of North Hoyle offshore wind farm, the first commercial-scale UK project, from its inception in 1998 to the start of construction in autumn 2002.

PMSS is involved in the permitting and Environmental Impact Assessment of several offshore wind farms, and was the health and safety advisor during the construction of the Blyth Harbour, North Hoyle and Arklow Bank projects. PMSS also provided environmental management to Vestas Celtic Wind Technology and Mayflower Energy during the construction of North Hoyle, and is the appointed health, safety and environmental advisor to NEG-Micon on the Kentish Flats project.

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