AN ASSESSMENT OF THE ENVIRONMENTAL EFFECTS OF OFFSHORE WIND FARMS

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Contractor
Metoc Plc

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EXECUTIVE SUMMARY

1) The Aim and Objectives of the Work

This Project, conducted by Metoc plc on behalf of the DTI, was commissioned to help develop an agreed approach to the formal environmental assessment (EA) of large-scale offshore wind farms around the UK coast, and to highlight key research requirements to address identified key environmental issues. The objectives of the Project therefore were as follows:

(i) To identify the obligations on offshore wind farm developers to provide EAs under the consents process to be adopted for their development.

(ii) To identify those issues that will or may need to be addressed in the EA.

(iii) To determine whether there are sufficient baseline data, scientific analysis and expertise on these issues to allow full assessment of the likely effects.

(iv) To identify research needs and other requirements for further work on understanding the potential environmental effects of offshore wind farms.

(v) To achieve as high a degree of consensus as possible on the environmental requirements and issues to the benefit of industry, regulators and the public.

2) Background to the Work

In 1992, the UK signed the United Nations Framework Convention on Climate Change that commits signatories to take measures aimed at reducing emissions of carbon dioxide (CO_2) and other greenhouse gases to their 1990 levels. Specifically, the UK has an agreed target reduction of 12.5% of greenhouse gases by 2008-2012 and a goal of reducing emissions of CO_2 by 20% by 2010. The Government also has a stated goal of generating 10% of UK electricity supplies from renewable sources by 2010. With one of the largest wind resources in Europe (40% of Europe's total potential), the development of offshore wind power in the UK is recognised as being one of the key means of meeting the Government's commitments.

EA of offshore wind farms at the scale currently envisaged is likely to be a formal requirement, and it is therefore important to understand the EA requirements associated with the chosen consent processes. The development of large-scale offshore wind power will be an entirely new industry in the UK, although the processes of construction, operation and decommissioning in the marine environment share many characteristics with existing offshore industries such as the oil and gas, telecommunications (submarine cables) and marine aggregate extraction industries.

Whilst aspects of the industry are environmentally benign and wind power represents one of few essentially sustainable energy sources, there are environmental issues which need to be identified, examined and (where possible) agreed before individual projects are assessed under the new consenting procedures. The current state of data availability and scientific knowledge on these issues (nationally and internationally) needs to be understood, gaps identified, and research priorities agreed. This required a process of consultation in order to gain consensus amongst all stakeholders where feasible.

3) Approach Adopted

This study has been undertaken in parallel with a comprehensive legislative review by Bond Pearce Solicitors. One possible route for the development of offshore wind farms in England and Wales, may include an Order under the Transport and Works Act 1992 (the TWA), in conjunction with a licence under the Food and Environment Protection Act 1985 (FEPA). A lease must also be obtained from the Crown Estate Commissioners. It should be noted that the consent process differs in Scotland.

The methodology adopted generically identified all potential physical, biological and human issues associated with an offshore wind farm and considered their likely importance. It must be noted that this is not a site-specific assessment, which would require an evaluation of the baseline conditions and potential changes to them. For a given wind farm, the degree of each effect will be entirely dependent upon the site-specific details of its location and design. Effects can be positive, neutral or negative and can result directly or indirectly from particular activities or events associated with offshore wind farms.

A list of all likely phases of constructing, operating/maintaining and decommissioning an offshore wind farm was drawn up. The potential importance of each effect was then considered. This was conducted through literature review, data searches and discussions with selected practitioners in order to establish:

- the key physical, biological and human environmental issues and potential effects;
- the availability of data and the current state of scientific knowledge on each key issue and effect (in the UK, EU and overseas); and
- current research programmes under way to improve the level of understanding.

Normal and abnormal operations, as well as accident and emergency situations, have been considered. In addition to highlighting areas that will require detailed assessment on a case by case basis during the EA process, associated with any offshore wind farm, additional research requirements were identified and listed.

A working draft of the present report was issued to a broad range of consultees and their views and comments were incorporated into this Final Report.

4) Conclusions and Recommendations

The Project has identified a number of generic issues that are likely to be of key importance/concern during wind farm development although the degree of effect will be highly dependent upon the site-specific characteristics. Some of these issues are well understood as a result of experience gained through other, existing offshore industries. Other issues are unique to this industry, in particular the visual effect of turbines, noise and vibration effects and the potential for birds to collide with rotating blades.

Existing information and expertise means that those issues that are already well understood can be readily assessed on a site by site basis and mitigated with available techniques without the need for further industry-wide research. However, additional work is required in the following areas:

1. ***Checklist on marine environmental issues associated with offshore wind farms:*** Annex 4 of the TWA Guide to Procedures provides a generic checklist of aspects that require assessment in an EA to support an application for an order. However, an official list tailored specifically for offshore wind farms by the regulators (the Department of Trade and Industry (DTI); the Department of Environment, Transport and the Regions (DETR); the Ministry of Agriculture, Fisheries and Food (MAFF)), and drawing on the findings of the present Project, would be useful to both developers and regulators.

2. ***Full characterisation of the noise and vibration generated by offshore wind farms:*** A study is required to enable a better understanding of noise and vibration emitted by offshore wind turbines, and the potential for effects upon sensitive receivers (humans and biological).

   The study should firstly characterise the nature of the noise and vibration at source, with aspects of under water sound and its propagation receiving the same emphasis as sound in air. Measurements should also be taken to determine the level of background noise (above and below the surface) generated by wind and waves in the vicinity of offshore turbines to enable an assessment of the contribution of wind farms to the background noise conditions. The attenuation of noise from wind turbines over and under water then needs assessment, in a variety of conditions, to enable prediction of the potential noise levels reaching the coast and any human receivers present.

   The present Project has identified that relevant work on this topic involving measurements at sites offshore is currently being undertaken in Holland. The findings of this study will help determine what additional work is required. The methodology should be developed in conjunction with noise, benthic, fish and marine mammal specialists to ensure that the characteristics of noise and vibration that are most likely to cause an effect on these sensitive receivers are being measured.

3. ***Further study of the effect of noise and vibration on the biological environment:*** In addition to direct measurements, study is required of the

effect these emissions have on the surrounding environment. Research to investigate the reaction of benthic, fish and marine mammal species to operational offshore turbines is required, paying particular attention to temporal aspects, such as important breeding, nursery or feeding periods.

During the development of future offshore wind farms, the benthic and fish communities should be sampled prior to and after construction, to determine any changes in species abundance and composition. During operation, benthic and fish communities should then be monitored and compared with the baseline data, and where possible at a control site, using standard protocols approved by MAFF. Agreement should also be sought from specialists in benthic and fish species behaviour to ensure optimum monitoring programmes.

4. ***Strategic review of potential effects upon fisheries – positive and negative:*** It is considered that the wind farm industry could benefit from a strategic fisheries study aimed at identifying the specific effect of offshore wind farms on various types of fishing techniques and fisheries activities. This study should review the potential effect of a variety of wind farm layouts and foundation designs on all major fishing techniques and equipment used in UK waters. It would provide valuable information to enable developers to interpret the results of the site-specific fishing intensity studies and identify which fishing methods are likely to cause potential conflicts or concern.

5. ***Study to assess visual aspects of offshore wind farms for use in future EAs and public information exercises:*** A generic study that investigates and develops a selection of appropriate options for wind farm layouts, arrays and designs would be beneficial. This could assist developers by highlighting the most visually acceptable 'footprints' and designs, although these would need to be modified on a site-specific basis. It is understood that the British Wind Energy Association (BWEA) Offshore Core Group is currently considering visual effects. Any study should therefore ensure that findings presented by the BWEA are fully reviewed and incorporated.

6. ***Further assessment of the effect of operational wind farms on birds:*** In order to expand knowledge of the effects of offshore wind farms on as wide a variety of bird species as possible, monitoring should be undertaken for new developments (both before and after) and continue for existing ones. Internationally recognised methods agreed with the Royal Society for the Protection of Birds (RSPB) should be used. In particular, future studies should focus on:

- continued assessment of the effect of operational wind farms on all species;
- information on which seabirds use which particular areas for feeding or during parts of their seasonal movement cycles to expand information held by the Joint Nature Conservancy Council (JNCC) Seabirds at Sea team. This could be complemented by developing a coastal sensitivity atlas, similar to that developed by JNCC for the offshore oil industry;

- analysis of information about known migratory routes of birds across Europe in relation to the height at which each species migrates;
- the reaction of birds to wind farms and risk of collision under varying weather conditions including fog and rain. Monitoring is required to determine the level of risk from collision with wind turbines and whether there are ways that any risks can be mitigated;
- the effect of disturbance from maintenance ships; and
- the effect of large scale wind parks.

1. ***Assessment of the effects of wind farms on sediment transport and wave climate:*** To determine the significance of diffraction and focusing effects on waves and currents, and associated processes, resulting from turbines it is considered that a generic study should be undertaken. This would involve wave refraction modelling (frequently used, for example, to identify metocean design criteria for offshore oil and gas installations and assess beach erosion).

2. ***Review of the degree of interference of wind turbines with radar:*** The scale of interference with radar caused by wind farms is unclear. The Ministry of Defence (MOD) has undertaken a number of trials to determine the precise extent of the interference. It is considered that this information should be made available to developers to enable them to fully understand the implications of radar interference, so allowing them to locate their proposed developments in areas that avoid these issues. Depending upon the extent of these trials, additional study may also be required to expand upon the existing data and to further quantify the effects on radar. MOD is best placed to advise upon and potentially undertake this work.

3. ***Chemical notification scheme:*** Within the oil and gas industry, operators have agreed a voluntary code of practice for chemical usage, which contributes to minimising the environmental effects of their operations. It is recommended that this scheme, which is likely to become compulsory, be adopted by offshore wind developers, to demonstrate a commitment to minimising the effects (particularly during construction) upon the marine environment.

   A study is recommended to determine the most appropriate way of implementing this. Consultation with the UK Offshore Operators Association (UKOOA) and the DTI is recommended to examine their operating methods, identify the costs and benefits to the wind industry, and define a strategy to implement the scheme.

4. ***Cumulative environmental assessment of offshore wind farms:*** Developers must ensure that their EAs consider the cumulative effects of offshore wind farms, taking account of any other such developments or plans in the vicinity of their site.

There are various options for funding the studies outlined above, those being by bodies such as DTI and through the Marine Foresight Programme, or members of the offshore wind industry themselves. An example worth noting is the way in which research is often funded in the oil and gas industry. The trade body of UKOOA acts as a forum for information exchange, pooling resources of the oil and gas developers and commissioning work that is of benefit to the industry as a whole. In addition to avoiding duplication of effort for researching environmental issues, UKOOA has served to promote the oil and gas companies as a proactive industry in terms of addressing environmental concerns. It is recommended that discussion be held between UKOOA and the BWEA to investigate the working practices of the former that could be beneficial to the offshore wind energy industry.

CONTENTS

TABLES

APPENDICES

INTRODUCTION

BACKGROUND TO THE PROJECT

In 1992, the UK signed the United Nations Framework Convention on Climate Change that commits signatories to take measures aimed at reducing emissions of carbon dioxide and other greenhouse gases to their 1990 levels. Specifically, the UK has an agreed target reduction of 12.5% of greenhouse gases by 2008-2012 and a goal of reducing emissions of carbon dioxide (CO_2) by 20% by 2010. Some renewable sources of energy such as wind and tides produce no emissions, and it is recognised that the use of these sources at the expense of fossil fuels helps to reduce emissions of environmentally harmful gases such as CO_2, sulphur dioxide (SO_2) and oxides of nitrogen (NOx). The UK Government also has a stated goal of generating 10% of UK electricity supplies from renewable sources by 2010, reaffirmed in the Government's recent document 'New and Renewable Energy Prospects for the 21st Century'[i].

The UK has one of the largest wind resources in Europe (40% of Europe's total potential) and the development of offshore wind power in the UK is recognised as being one of the key means of meeting its commitments.

Environmental assessment (EA) of offshore wind farms at the scale currently envisaged is likely to be a formal requirement, and such assessments will be required to comply with EU Directives 85/337[ii] and 97/11 on environmental assessment and Directive 92/43 on the conservation of natural habitats. They must also be compliant with the various Regulations that implement these Directives in the UK, and with the requirements of whatever consenting regime is adopted.

Environmental assessment obligations will, therefore, be partly dependent upon the consenting process that is adopted for offshore wind farms. For this reason, it has proved beneficial to run this Project, investigating the environmental assessment requirements of offshore wind farms, in parallel with a review of the legal consents required.

The development of large scale offshore wind power will be an entirely new industry in the UK, although the processes of construction, operation and decommissioning in the marine environment share many characteristics with existing offshore industries such as the oil and gas, telecommunications (submarine cables) and marine aggregate extraction industries. Whilst aspects of the industry are environmentally benign and wind power represents one of few essentially sustainable energy sources, there are environmental issues associated with the development of offshore wind farms that need to be identified, examined and (where possible) agreed before individual projects are assessed under the consenting procedures. The current state of data availability and scientific knowledge on these issues (nationally and internationally) needs to be understood, gaps identified, and research priorities agreed. Failure to do so could lead to major uncertainties in the assessment of effects, controversy and disagreement during public consultation on individual projects, and possibly significant delays in the approval of projects and their implementation.

AIMS AND OBJECTIVES OF THE PROJECT

The principal aim of this Project, conducted by Metoc plc on behalf of DTI, was to develop an agreed approach to the formal environmental assessment (EA) of large-scale offshore wind farms around the UK coastline, and to identify the range of environmental issues associated with such developments which will be supported by all 'stakeholders'.

The objectives of the Project were therefore as follows:

(i) To identify the obligations on offshore wind farm developers to provide EAs under the consents process to be adopted for their development.

(ii) To identify those issues that will or may need to be addressed in the EA.

(iii) To determine whether there are sufficient baseline data, scientific analysis and expertise on these issues to allow full assessment of the likely effects.

(iv) To identify research needs and other requirements for further work on understanding the potential environmental effects of offshore wind farms.

(v) To achieve as high a degree of consensus as possible on the environmental requirements and issues, to the benefit of industry, regulators and the public.

BENEFITS OF THE PROJECT

To help achieve a high degree of consensus among stakeholders, a consultative approach was adopted, with contributions invited from a range of key interests. The benefits of achieving consensus on the generic scope of EAs will become most apparent when individual EAs reach the public consultation stage: though there will undoubtedly be conflicts of interest on individual issues, an agreed scope of work will be of considerable benefit to all parties involved in the process.

Any consenting process will clearly influence the approach to environmental work and, similarly, the consenting process must be designed to allow for the analysis of environmental issues in a manner which is comprehensive but not burdensome to industry.

This Project seeks to assist future programme planning by clearly identifying research needs. Environmental issues that are poorly understood may become significant barriers to the development of the industry. Research needs have therefore been prioritised by their relevance to the decision-making process on applications for development consent.

It is anticipated that key interest groups will benefit from this Project as follows:

- **Wind farm developers, consortium members, suppliers:** Clear understanding of EA procedures and agreed scope of work for environmental studies, with consequential cost savings; streamlined data collection and analysis; co-ordinated research programme driven in part by industry needs. Early understanding of key issues that could delay projects or reduce flexibility of choices.

- **Regulators:** Ability to influence scope of EAs and focus on key issues; consistency of approach in EAs and consent applications; ability to recommend "best practice" for assessment of key effects.

- **Public Interest:** Opportunity to highlight issues of greatest public concern; ability to gauge adequacy of EA work against the key issues identified.

LEGISLATION AND POLICY FRAMEWORK

This study has been undertaken in parallel with a comprehensive legislative review by Bond Pearce Solicitors. One possible route for the development of offshore wind farms in England and Wales, may include an Order under the Transport and Works Act 1992 (the TWA), in conjunction with a licence under the Food and Environment Protection Act 1985 (FEPA). Furthermore, a lease must be obtained from the Crown Estate Commissioners to place structures on or pass cables over Crown seabed or foreshore or to erect structures for economic purposes on the Continental Shelf.

While it is considered that the above represents a possible route, there is currently no compulsion on developers to adopt it. Developers could alternatively seek consents under a combination of the Coast Protection Act (CPA), FEPA and the Electricity Act 1989 and possibly the Town and Country Planning Act 1990. This section outlines the obligations of offshore wind farm developers to provide environmental assessment (EA) under the possible consent process outlined above i.e. a TWA Order and a FEPA Licence.

It should be noted that the TWA does not apply in Scotland, and presently most offshore wind farms would be licensed through the Crown Estate Commissioners lease, FEPA, and the Electricity Act 1989. Additionally, offshore wind farms in Orkney and Shetland will fall under Local Authority's control, since special Acts of Parliament extend their jurisdiction beyond the Low Water Mark in these locations. There is some uncertainty over the legislative approach that will be appropriate in Scotland because of potential changes that may result from devolution. The extent to which new Scottish legislation has been introduced should be identified prior to any site-specific EA process.

THE SCOPE OF THE TRANSPORT AND WORKS ACT 1992

With respect to offshore wind farms, the TWA introduces a Ministerial order-making system in England and Wales for authorising the construction or operation of structures interfering with rights of navigation. Construction projects outside harbour areas, formerly the subject of Private Acts of parliament, will therefore normally have to be approved by an Order under the TWA.

Specifically, the Secretary of State may make an order relating to, or to matters ancillary to, the carrying out of works which interfere with rights of navigation in waters within or adjacent to England and Wales, up to the seaward limits of the territorial sea. Works for the purpose of this Project are described as:

barrage, bridge, cable, land reclamation, navigational aid, offshore installation, pier, pipeline, tunnel, utilities structure.

THE SCOPE OF FOOD AND ENVIRONMENT PROTECTION ACT 1985

FEPA provides for licensing of the deposit of articles on the seabed. A licence would be required for the placing of any structures (other than cables which are exempt) below mean high water springs. Its purpose is to protect the marine environment and living resources that it supports. An application for a licence for works around the coast of England and Wales is made in writing to the Minister of Agriculture Fisheries and Food, or to the Scottish Office of Agriculture, Environment and Fisheries Department (SOAEFD) for works around the coast of Scotland. Each will take particular care in assessing applications that may have implications for the nature conservation interests of European Sites (as defined by the Habitats Regulations 1994).

REQUIREMENTS FOR ENVIRONMENTAL ASSESSMENT

Environmental Assessment Requirements under the TWA

The Applications Rules[iii] for the TWA require applicants to provide an Environmental Statement (ES) with every application unless they have sought, and obtained, an absolute waiver from the Secretary of State.

The Secretary of State cannot grant such a waiver if:

- the project falls within one of the classes listed in Annex I to the European Community Directive 85/337/EEC (on the Assessment of the Effects of Certain Public and Private Projects on the Environment) as amended by the Environmental Impact Assessment Directive 97/11/EC; or

- the project falls within one of the classes listed in Annex II and is likely to have significant environmental effects.

Offshore wind farms are now included in Annex II of the amended Environmental Impact Assessment Directive 97/11/EC. This means that from 14 March 1999, the date that the new Directive was implemented through Statutory Instrument 1999 - No. 293 (S.I. 1999 No. 293) Town and Country Planning (EIA)(England & Wales) Regulations 1999, any proposal for an offshore wind farm that is likely to have *significant* environmental effects has to be subject to environmental assessment and full consultation before consent can be given. In the normal course of events (and unless the developer wishes to prepare an environmental impact statement in any event as a matter of good practice) it will be the competent authority which will decide on 'significance'[(iv)]. In the case of offshore wind farms the competent authority will be the DTI.

The Department of the Environment (now Department of Environment, Transport and the Regions) Circular 15/88 entitled 'Environmental Assessment' suggests three main criteria for classifying a project as 'significant':

- whether the project is of more than local importance, mainly in terms of physical scale;
- whether the project is intended for a particularly sensitive location, for example a national park or a site of special scientific interest, and for that reason may have significant effects on the area's environment even though the project is not on a major scale; and
- whether the project is thought likely to give rise to particularly complex or adverse effects, for example in terms of discharge of pollutants.

To ensure that the relevant authorities apply consistent criteria to defining significance, 'indicative thresholds' have been introduced for Annex II developments of different types[v]. For wind-powered generators these state that EA is likely to be required if the development is located within or is likely to have significant environmental effects on a National Park, the Broads or New Forest, an Area of Outstanding Natural Beauty, Site of Special Scientific Interest or heritage coast, or if the development consists of more than ten wind generators or the total installed capacity of the development exceeds 5 megawatts.

Based upon these criteria, especially the last, it is likely to be necessary for developers to subject almost all offshore wind farm proposals to environmental assessment. Amendments to the Environmental Assessment Regulations to reflect Council Directive 97/11/EC also require the developer to include in the ES the main alternatives studied for the development.

Applicants may ask the Secretary of State for a conditional waiver of the rule requiring the provision, at the time of application, of all of the environmental information required for a proper assessment to be carried out. This can be granted if they could not reasonably be expected to have all the relevant information at that stage. But they must provide the balance of the ES by the end of the 42-day objection period. Further detail about the preparation of an ES is provided below.

Environmental Assessment Requirements of FEPA

In determining whether to issue a licence under FEPA, the Ministry of Agriculture, Fisheries and Food (MAFF) for England and Wales, or SOAEFD for Scotland, must under Section 8.(1) of the Act have regard to the need:

- to protect the marine environment, the living resources which it supports and human health;
- to prevent interference with legitimate uses of the sea; and
- to other such matters as the authority consider relevant.

The Act further states that the licensing authority (MAFF/SOAEFD) may require an applicant to 'supply such information and permit such examinations and tests as in the opinion of the authority may be necessary or expedient to enable the authority to decide whether a licence should be issued to the applicant and the provisions which any licence that is issued ought to contain'.

The licensing authority has a duty to ensure that any proposed works will not have significant adverse environmental impact, particularly upon designated conservation areas such as SSSIs, SPA/Ramsar sites and other areas listed under the Conservation (Habitats etc.) Regulations 1994. Discussion with MAFF/SOAEFD by the developers will therefore be required prior to applying for a FEPA licence to determine the extent of any environmental information that the authority would expect. Based upon discussions with MAFF, it is considered 'such information' is likely to comprise a full ES, similar to that submitted for a TWA order. The scope, however, would be more restricted as certain works and cables are excluded from the provisions of the Act. It is likely that any ES prepared to accompany an application for an order under the TWA would also be suitable (though possibly more comprehensive than required) to accompany a FEPA licence application.

Other Environmental Assessment Requirements

In addition to meeting the requirements of the TWA and FEPA, developers will have to fulfil the requirements of relevant European legislation that may apply as a result of the legal status of a particular site.

The Habitats Directive[vi] requires member states to designate sites on land and at sea to form part of the EC Natura 2000 network. This comprises Special Areas of Conservation (SACs) under the Habitats Directive and Special Protection Areas (SPAs) under the Birds Directive[vii]. Member states are required to protect any designated sites from activities that may affect their integrity. Integrity is not defined but can be regarded as ecological and functional coherence. The Conservation (Natural Habitats, etc) Regulations 1994 implement the requirements of the Habitats Directive in the UK. The regulations define the duties of the regulator in relation to plans and projects likely to significantly affect these 'European sites'.

Before deciding to give consent to a project that is likely to have a significant effect on a European site in Great Britain (either alone or in combination with other plans or projects), the competent authority (as defined in the Habitats Regulations) must make an assessment of the implications of the project in view of the site's conservation objectives. A developer applying for a consent to develop an offshore wind farm within or in the vicinity of such a site should anticipate the need to provide information to the competent authority relating specifically to the assessment of effects on that site. An appropriate environmental assessment will therefore be required for the project alone, but also taking into account other plans and projects in the area i.e. cumulative assessment must be undertaken. It is understood that both the Countryside Council for Wales (CCW) and ETSU are currently developing methods for assessing cumulative effects of wind farms. It is recommended therefore that developers consult the CCW and ETSU to determine the most appropriate methodology prior to initiating such an assessment.

THE PROCESS OF ENVIRONMENTAL ASSESSMENT AND CONSULTATION

The formal requirements relating to the contents of a TWA application, pre-application notification and consultation are set out in the TWA Applications Rules. Although the statutory requirements relating to consultation prior to making an application have been kept to a minimum, consultation is seen as possibly the most important stage in the environmental assessment and authorisation process. Informal notification, pre-consultation discussions with the regulator and consultation with a draft ES are also extremely important stages to ensure that there are 'no surprises' for the regulator or the developer at the formal consultation stage.

Except where the Applicant has sought and obtained an absolute waiver from the requirement to provide an ES, a 'notice' must be served on:

- the local authority, in all cases where the proposed works are within the boundaries of such an authority, or on the relevant coastal authority (as defined in rule 2);
- the Nature Conservancy Council for England (English Nature) and the Countryside Commission in the case of works affecting land or tidal waters in or adjacent to England; and
- the Countryside Council for Wales (CCW) in the case of works affecting land or tidal waters in or adjacent to Wales.

The notices ensure that statutory bodies are alerted, ahead of the application, to proposed works and ancillary effects which are likely to be of interest to them.

They also place an obligation on the person notified to provide information to the applicant (except confidential material) which is relevant to the preparation of the ES if asked to do so. The obligation on statutory consultees relates only to information already in their possession – they are not required to undertake research on behalf of the applicant.

Thought should be given to the Environmental Assessment at a very early stage, ideally when the site is being selected so that the environmental merits of practical alternatives can be considered. If not considered from the outset, environmental issues may well emerge as major problems when a project's design is well advanced, causing possible delay and reworking.

THE ENVIRONMENTAL STATEMENT

The Environmental Statement is the final product of an EA. The Department of the Environment, Transport and the Regions (DETR) states that the preparation of the ES should be a collaborative exercise involving at the very least discussions with the local planning authority and other statutory bodies who are to be notified as detailed above. Other persons with a specialist interest in the environment (such as the Royal Society for the Protection of Birds) and organisations representing those exercising rights of navigation should be consulted as appropriate. The applicant can ask for these discussions to be treated in confidence by the consultees.

Although there is no prescribed form for the ES, it must be compliant with the Directive 85/337/EEC and the regulations implementing the Directive. The applicant should also be prepared to face close cross-examination at a public inquiry, if one is called for, on the document's contents. At this stage, consultees and other national and local environmental organisations will have the opportunity to challenge the adequacy and contents of the ES.

The ES should provide a systematic and objective account of the significant environmental effects to which the project will give rise. Sufficient information should be provided to enable those who wish to do so to verify those conclusions and to identify the source of the information provided. The formal requirements of an ES for a TWA application are detailed in Rule 2(1) and

Schedule 1 of the TWA Applications Rules. For the use of applicants, the regulator has summarised these formal requirements as a checklist of issues requiring consideration when preparing the ES. This list, taken from the Annex 4 of the TWA Guide to Procedures[viii] published by the Department of Transport, is provided in Appendix A.

IDENTIFICATION OF KEY ISSUES

INTRODUCTION

The second and third objectives of this Project are to identify the issues that will or may need to be addressed in an EA, and to determine whether there are sufficient baseline data, scientific analysis and expertise on them to allow an assessment of the likely environmental effects to be made.

To enable this, data searches and discussions with selected practitioners have been conducted in order to establish:

- the key physical, biological and human environmental issues and potential effects;
- the availability of data and the current state of scientific knowledge on each key issue and effect (in the UK, EU and overseas); and
- current research programmes under way to improve the level of understanding of these issues and effects.

The methodology employed is detailed below.

METHODOLOGY

The methodology adopted generically identified all potential physical, biological and human issues associated with an offshore wind farm and considered the likely importance.

It must be noted that this is not a site-specific assessment, which would require an evaluation of the baseline conditions and potential changes to them. For a given wind farm, the degree of each effect will be entirely dependent upon the site-specifics of the wind farm's location and design.

Throughout this section, the term environmental 'issue' is used to describe particular activities or events that could lead to environmental effects. Effects can be regarded as any change in the environment (or its use) that might occur as a result of those issues. Effects can be positive as well as neutral or negative and can result directly or indirectly from particular activities or events associated with offshore wind farms.

A list of all likely phases of constructing, operating and decommissioning an offshore wind farm was firstly drawn up, listing all project elements other than preliminary site investigation stages, such as installation of anemometry masts and borehole sampling. The extent of site investigation will be highly dependent on location, varying considerably from site to site. The project elements considered were:

- Manufacture of the foundations, towers, nacelles, blades and turbines
- Transportation to the 'holding' port and subsequent transport to the site of installation
- Installation of the turbines
- Construction of associated facilities (ancillary buildings, overhead poles)
- Installation of the cables to shore and between the turbines
- Operation of the turbines and associated facilities
- Decommissioning of the turbines (dismounting and removal from site).

Any potential environmental effects were ascribed to each element of the offshore wind farm, with the following main areas being considered:

- *Emissions/Discharges* - This was further categorised into Air, Sea and Seabed.

- *Waste* - Cost to operators and regulatory compliance was reviewed.

- *Amenity and Visual* - Possible visual effects and the extent to which wind turbines may affect 'wild land' (i.e. land remote from human influence) and seascape character, noise, odour, or air quality effects were reviewed.

- *Socioeconomics* - Possible socio-economic effects (graded as either positive, negative or zero effect), such as increased local employment.

- *Other users* - Fishing, marine traffic, archaeology, recreational users, etc.

- *Ecology* - Effect on individual species, communities or habitats.

Having identified any potential effects, the potential 'importance' of each effect was considered, as summarised in Table 1, to provide guidance as to the required focus of this report. The 'significance' of any potential effect can only be determined in a site specific context. The full matrix of potential effects is presented in Table 1. Normal and abnormal operations, as well as accident and emergency situations, have been considered.

The desk study into available information and research has investigated all potential effects (other than temporary, short-term disturbance effects which are common to many industries and easily mitigated), as listed below:

- The creation of jobs in the UK, particularly in manufacture and assembly;

- Zero emissions during operation contributing to reductions in emissions of environmentally harmful gases such as CO_2, SO_2 and NOx;

- The physical presence of the turbines creating an obstacle and potential hazard for other sea users (for example, fishermen, shipping, and the Ministry of Defence, microwaves);

- The potential for accidental collision of vessels during construction and with the turbines during operation, and the associated release of pollutants such as oil;

- The physical presence of the turbines creating an obstacle for aircraft (civil and military), particularly during abnormal weather conditions such as fog;

- Potential hazards to birds from the operational turbines (both day and night) and onshore transmission lines and pylons, particularly during migration periods;

- The visual effects of the operational turbines and the ancillary structures, including overhead transmission lines, poles and substations;

- Interference with radar installations;

- Detrimental effects of underwater noise from drilling or piling equipment on marine mammals, fish and benthic organisms, particularly during spawning, nursery or migratory periods;

- Disturbance to archaeological artefacts and wrecks during foundation installation;

- Potential contamination of sediments and marine organisms when cementing/grouting the foundations;

- Changes in morphology of the immediate area and reduction of local water depths, if spoil is deposited on the seabed, which could affect navigation and wave climate;

- Long term changes in benthic species composition as a result of modification of the substrate around the wind towers, if excavated material is deposited on the seabed;

- Disturbance to a considerable area of sea bed, and associated ecological effects, if a large number of turbines and inter-linking cables are installed;

- Alterations to local wave climate, local geology, local scouring and sediment deposition resulting from the turbines; and

- Interference with telecommunication and televisions.

- Electric, magnetic interference and heat effects resulting from the operational electricity transmission lines; and

- The effects on humans of noise generated by the operational turbines.

review of available information

INTRODUCTION

Having listed the potential effects of an offshore wind farm development and the importance of those potential effects, this Project has investigated:

- whether there are sufficient baseline data and expertise to allow an assessment to be made of the important effects (whether these are likely to be positive or negative, direct or indirect, primary or secondary, short or long term); and

- the research needs and other requirements for further work to understand more fully the potential environmental effects of offshore wind farms.

The following sections focus largely on those aspects of the work that could potentially have an important effect i.e. other than temporary effects leaving no detectable changes. The sections have been divided into the various main aspects of a wind farm development:

- Manufacture and Transportation

- Installation of Cables and Turbines

- Operation

- Decommissioning

MANUFACTURE AND TRANSPORTATION

Background

The main stages of manufacturing and transporting the various wind farm components to site are as follows:

- Manufacture of components;
- Transport components to port;
- Storage of components on the docks;
- Marine transportation of components to site of installation; and
- Moving drilling barge/jackup pontoon to installation site.

Potential Effects

As identified in Table 1, the manufacture and transportation of wind farm components (foundations, towers, nacelles, blades, gearbox, generator etc) may result in:

- temporary, localised disturbance effects such as noise, waste (sewage and construction debris), atmospheric emissions;
- an increased demand for construction materials and energy leading to a decline in natural resources;
- creation of jobs in manufacturing and assembly; and
- increased revenue at ports with appropriate storage facilities and locations.

Importance of Effects

Purpose built manufacturing facilities for the large-scale manufacture of multi-megawatt wind turbines are currently being established in Germany and Denmark[ix]. Leading UK offshore wind developers consider that there is still an opportunity for the UK to invest in manufacturing plant to serve both the domestic market and overseas prospects. Even if the components continue to be manufactured abroad, it is envisaged that they will largely be assembled in the UK. This emerging market therefore has the potential to lead to the creation of jobs within the UK, which is an important beneficial effect as highlighted in the Government's recent review of renewables[1]. The number of jobs that may be created has been investigated in further detail elsewhere[9]. The potential physical, biological and human effects of any facilities developed to manufacture or assemble wind turbines would be managed through the environmental assessment of those facilities during the associated planning applications, and subsequent environmental management systems.

The mode of transport used to move the components would depend upon the infrastructure in the area. The development of a wind farm is unlikely to significantly affect transport infrastructure in an area, except to temporarily increase traffic movement.

All potential effects associated with this phase of development are well understood and can be assessed using existing techniques, such as traffic surveys. No additional research or information gathering is thought to be necessary.

TURBINE AND CABLE INSTALLATION

Background

There are basically four options for the foundation design of offshore wind farms[x], especially for shallow water depths (up to 15 metres). The most common designs are summarised below:

- Concrete gravity based caisson foundations: These rely on gravity to keep the turbine in an upright position – most existing offshore wind farms use gravity foundations[xi].

- Steel gravity foundations: These are generally considerably lighter than concrete and thus easier to transport. Once on site they are weighted with a dense fill material such as olivine. The diameter of this foundation design to date is approximately 15 m for water depths from 4 to 10 m, although designs will vary significantly in size and depth with varying seabed conditions. Seabed preparation is required to 'smooth' the area by removing silt and laying a horizontal bed of shingle.

- Monopile foundations: These presently comprise a single steel pile with a diameter of between 2.5 m and 4.5 m. No seabed preparation is required prior to installation, although this foundation type is not suitable for locations with an uneven seabed. For example, the presence of large boulders may prohibit their use.

- Small diameter tubular framed structure foundations: Comprising three or four-legged steel jackets, this design is suited for deeper water depths. The main advantage of this type of structure over caissons and gravity base types is that the loading from wave action is significantly lower due to the much lower inertial forces.

Currently, monopiles appear to be favoured by UK operators[xii]. This report has therefore tended to focus on this foundation type, while highlighting the potential effects of other designs where necessary.

The key stages associated with installing an offshore wind farm are as follows:

- marine construction vessel activities on site;
- foundation installation and associated site preparation;
- disposal of any spoil excavated during installation;
- installation of tower, nacelle, generator, hub, blades;
- cable installation (using techniques such as trenching or jetting methods or by laying cables on the seabed) between turbines and to shore; and
- construction of ancillary buildings and infrastructure such as terrestrial cables to link the development to the National Grid, and associated traffic.

The potentially important effects of each stage are considered below. As discussed in Section 3, it should be remembered that this report aims to highlight all potential issues that could result from an offshore wind farm. Not all wind farms will lead to all the effects investigated. The degree of each potential effect will be entirely dependent upon the site-specific details of the wind farms location.

Vessels Associated with the Works

In addition to the temporary, localised disturbance effects discussed in Table 1, the review has identified a number of potentially important effects that could result from vessel movement and activity:

- The physical presence of the vessels (transport barges, drilling barges, jackup pontoons, cable installation equipment) may cause an obstruction to navigation. Other sea users such as the Ministry of Defence (MOD), fishermen, shipping, yachts, water sports, recreational fishermen, marine dumping and aggregate extraction may be prevented from using the area around the construction vessels.

- Accidental collision of vessels involved with the works and resulting release of pollutants such as oil.

Consultation during the scoping stage of any offshore wind farm development will be particularly important to identify potential conflicts and determine the most appropriate location to minimise interference with other sea users. Fishing intensity studies can be used to identify fishing 'hot spots', while Admiralty charts, vessel surveys and liaison with key personnel, such as harbour masters and coastguards, can be used to identify shipping routes and other users.

The MOD should be consulted at the earliest opportunity during site selection to ascertain whether there are any danger areas, mined areas or submarine exercise areas in the vicinity of the study areas.

Where interference is unavoidable, potential effects may be minimised through timing activities to avoid sensitive periods, for example for fishing activities and commercial fish stocks. Interference with other users, both marine and onshore, will be temporary. Appropriate liaison should be employed to notify other uses of the construction activities.

In summary, vessels associated with the works may lead to temporary disturbance effects. The degree of these effects can be minimised through planning and liaison with appropriate regulators and other sea users. It is considered that existing techniques are sufficient to allow appropriate assessment of these issues. This information will vary for each site and will be collated during the site-specific EA process. No further generic research is considered necessary.

Foundation Installation

Where monopiles are installed, the potentially important effects of the construction activities have been identified as follows:

- direct loss of marine life and habitat;

- disturbance effects of underwater noise from drilling or piling equipment on marine mammals, fish and benthic organisms particularly during spawning, nursery or migratory periods;

- disturbance to archaeological artefacts and wrecks; and
- potential contamination of sediments and marine organisms from the accidental release of cementing/grouting materials into the marine environment.

Many of these effects will be common, to varying degrees, whatever the foundation type used.

Direct loss of marine life and habitat may result from installation of the turbine foundations, as well as indirect effects such as smothering and clogging of benthic organisms by disturbed sediments. The extent of these effects will depend upon the seabed type, and site-specific sensitivities such as the seasonal sensitivity of young/larvae and adult organisms, the recoverability of any species lost, and the importance of the species for the ecosystem. This will require assessment on a site by site basis, which can be undertaken using existing ecological assessment techniques.

In addition to localised disturbance effects from associated vessels, more important effects may result from underwater noise caused by drilling or piling equipment during construction. Both fish and marine mammals are sensitive to noise in the marine environment, with sensitivity depending upon the noise frequency, sound power level and duration. The severity of potential noise effects will depend upon whether there are sensitive receivers (fish and marine mammals) in the area. Where a potential conflict is identified during the EA process, such effects should be minimised. This can either be achieved by avoiding important feeding, spawning and nursery areas/times of year, or by mitigating the noise effects through the use of devices such as underwater bubble curtains, which prevent the propagation of underwater noise through the water column through interference.

There are a number of wrecks classed as important under the Protection of Wrecks Act 1973 around the UK, which are protected by an exclusion zone. Details are available from the Royal Commission on the Historical Monuments of England. Additional wrecks, fishermen's fastenings and casualties are identified on Admiralty charts and logged by the Wrecks Officer of the Hydrographic Office, the National Monuments Record and the Department of Culture, Media and Sport. Although such wrecks are not formally protected, it is good practice to follow the "Code of Practice for Seabed Developers" produced by the Joint Nautical Archaeology Policy Committee. If any previously unknown wrecks are found during surveys or installation these should be reported under the Merchant Shipping Act 1894[xiii] and avoided. Historical records investigation and site surveys should be completed before deciding upon the exact site layout.

The extent of water quality and associated ecological effects will be dependent upon the physical and chemical nature of the released materials and the receiving biotopes. The release of organic polymers or heavy metals associated with grouting/cementing material could be toxic to marine organisms whilst the grout is wet, while potentially contaminating seabed sediments and inhibiting recolonisation of the area after construction. This could detrimentally affect benthic communities and those organisms which rely upon them as a food source. As a result, it is considered that contractors installing offshore wind farms should be responsible, firstly, for using chemicals approved by the Environment Agency for use in the marine environment and, secondly, for employing methods that minimise the release of polluting materials into the water column.

Within the oil and gas industry, operators have agreed a voluntary code of practice for chemical usage, which contributes to minimising the environmental effects of their operations. It is recommended that this scheme, which may soon become compulsory, is adopted by offshore wind contractors, to demonstrate a commitment to minimising the effects of construction upon the marine environment. Specifically, the UK Offshore Chemical Notification Scheme (OCNS) provides offshore operators and subcontractors with information on the chemicals and components that the Government does not wish to be used offshore or which have been prescribed by international agreement. As a first step, the list of chemicals (and their toxicity) that may be placed in the marine environment could be refined to include those acceptable chemicals associated with offshore wind farm development. This would enable operators to take account of environmental factors when selecting chemicals for use offshore. The scheme could also be used to ensure that operators inform the Government of the substances that are likely to be used and on their potential scale of use, enabling consultation where necessary. CEFAS, MAFF's fisheries laboratory, already provides detailed advice to the DTI under the current OCNS and as such would be the appropriate body to update the list to encompass offshore wind farms. The chemicals notified under the existing OCNS, which are expected to become statutory in due course, may be closely related to those used for wind farm construction/operation. It is understood that where possible, operators will use sea-water as drilling fluid and that chemicals such as potentially toxic anti-fouling paints will not be used. However, it is considered that an OCNS would provide valuable guidance where chemicals are required.

Exploration and production chemicals are classified into 'groups' depending upon their biodegradation and bioavailability characteristics together with toxicity to a range of taxonomic groups. Chemicals are categorised by the manufacturers, who are responsible for conducting the required tests outlined above if they wish their chemicals to be used offshore. In this way, the operators are not burdened with the cost of testing chemicals.

In summary, foundation installation could potentially result in temporary disturbance effects, loss of benthic organisms, disturbance of artefacts, and noise from drilling or piling. It is considered these can be assessed using existing information and techniques, and appropriate mitigation. It is recommended however that the viability and potential benefits of an offshore chemical notification scheme for wind farm developers should be investigated further, as summarised in Section 5.

Disposal of Excavated Spoil

If excavated material is deposited on the seabed the following important effects could result:

- Changes in morphology of the area and reduction of local water depths, which could affect navigation and wave climate.

- Changes to the substrate available to marine organisms surrounding the wind towers may result in long term changes to the species composition of the benthic community.

The degree of effect resulting from changes in water depth will depend upon a variety of factors including the existing depth of water and seabed characteristics. There are a number of simple modelling tools available that could be employed to rapidly assess the potential effects of drilling activities on the seabed. These water quality and cuttings dispersion models, developed to assess offshore oil and gas activities and the effects of marine discharges, simulate the likely pattern of sediment/material deposition in the marine environment. As such, it is considered that there are sufficient tools currently available to assess the effects of spoil deposition on a case by case basis without further model development or research. Where detrimental effects would result from changes to local water depths, spoil removal should be considered.

In addition to these physical effects, discharging any excavated spoil onto the seabed could result in local smothering of seabed communities. The recolonisation rate of any deposited material will be influenced considerably by factors such as the hydrological nature of the site (i.e. how rapidly any material settles or is transported from the site), the nature of local communities, the seabed type and whether contamination has occurred from drilling lubricants.

Studies have been undertaken at various locations around the UK coast to assess recolonisation rates of various seabed types after marine aggregate extraction and drilling associated with oil and gas activities. Typically aggregate extraction removes substrate rather than disturbing or burying it so direct comparisons are not possible. However, these provide a preliminary indication of possible seabed recolonisation rates. These indicate that, provided seabed substrate is not contaminated and that it does not differ substantially before and after disturbance, the bottom fauna communities will recover from the effects[xiv,xv] of disturbance. This has been noted to start immediately, although full recolonisation may take at least 3-5 years, with species recruiting from the surrounding undisturbed area. It will be important to ensure that ecologically sensitive areas/times of year are avoided to prevent effects upon juveniles and possible long term effects upon marine populations.

If removed from site, the reuse/disposal of excavated material is not predicted to lead to important effects provided the material is reused in a way that has been approved or is disposed of at an approved site. As detailed in Section 2, the Food and Environment Protection Act 1985 requires that a licence is obtained for the deposit of material in the sea whether for the purpose of waste disposal or during marine construction.

While potential effects may result from the disposal of excavated spoil, there appears to be sufficient information and tools available to assess those issues identified above within the EA process. No further research requirements are envisaged.

Installation of Remaining Wind Farm Components

The installation of the remaining wind farm components onto the foundation will principally cause temporary disturbance effects. These are not predicted to be important, are well understood and can be minimised through appropriate site management. However, the visual effects during this stage may be important as people often respond very strongly to the first visible structures of wind farms, on land and this is likely to be the case offshore. These create the 'first impression' of the development and are often the first indication of the real scale of the turbines. Appropriate visual impact assessment will be required during the assessment process to ensure that this potential effect is fully taken into account and mitigated as far as possible. To support offshore wind farms, it is considered that the industry could benefit from a strategic visual impact assessment, to identify a variety of preferred wind farm designs and footprints. This recommendation is highlighted in Section 5.

No further research into these aspects of the development, apart from assessment on a site by site basis, is deemed necessary as these effects are well understood.

Cable Installation and Ancillary Buildings

Cables will be installed both between the turbines and to the shore. There are a variety of installation methods available, which are dependent upon the nature of the seabed substrate, the ecological sensitivity of the area and whether other cables or pipelines are present in the area which need to be crossed. It is considered likely that in most marine locations the cables will be buried:

- for cable protection; and
- to prevent cables presenting a physical obstacle to anchors and fishing equipment. This is important as vessels have the right to anchor as part of their public right of navigation. Most recreational vessels do not by choice anchor in the open sea, but there are many instances when anchoring is by necessity rather than by choice, for safety or similar reasons[xvi].

It is considered that the offshore wind industry should consider whether burial of all cables for all offshore wind farm projects (subject to ground conditions) is the responsible way forward for creating a long-term industry.

Techniques for laying cables on the seabed include jetting/ploughing the cables into position or trenching prior to cable laying. Careful consideration will need to be given to crossing any existing pipelines or cables, and protection measures for any cables and pipelines need to be detailed and agreed with third party owners.

Potential environmental effects will comprise disturbance to the seabed and associated ecological communities. Where a large number of turbines are being installed, a considerable area of the seabed could be disturbed by cable laying and burial resulting in potentially important effects especially in ecologically sensitive areas. It will be important to ensure that construction methods are chosen that minimise disturbance to the seabed and the water column, and that ecologically sensitive areas/times of year are avoided where possible. Where rock scour cable protection is required, the effects upon sediment transport in the local area should also be considered to ensure that the rock does not adversely affect the local rate of coastal erosion/accretion.

Additional effects may arise as cables are installed across the shoreline. These may include disturbance to marine organisms, coastal habitats and processes from trenching across the beach and coastal zone, disturbance to sea defences, and possible interference with the recreational use of beaches, especially in the peak summer months. Consultation with the relevant coastal defence authority, the local council and the Environment Agency will be necessary to ensure that any potential effects are considered and mitigated as far as possible. Ecological issues such potential effects on rare species or sites of conservation importance should be identified and assessed against their own conservation objectives.

Once on shore, electricity is normally transferred over land via overhead transmission lines and poles or buried cables. Cables and ancillary structures (including overhead poles and substations) have been installed on land for a considerable period of time, and the effects of these activities are well documented and well understood. As this report aims to focus on nearshore and coastal issues, further coverage to terrestrial aspects of offshore wind farms is not provided within this report.

In summary, installation of cables in the marine environment has the potential to cause both temporary and permanent effects. These will require assessment on a case by case basis. However, it is considered that sufficient information is available to enable assessment of these effects, and further generic research is not required.

OPERATION OF AN OFFSHORE WIND FARM

Background

The operation of an offshore wind farm could lead to environment issues as a result of the following:

- energy generation - generating energy from renewable sources results in substantial CO_2 savings when compared with alternative methods of electricity generation;
- the physical presence of the towers;
- rotation of the wind turbine blades;

- presence and operations of routine maintenance vessels;

- the physical presence and operation of ancillary structures including the cables and poles; and

- emergency repair of the turbines.

The potentially important effects of each stage, which may be positive, neutral or negative, are considered below.

Generating Energy from Renewable Sources

As outlined in Section 1, the use of renewable sources of energy such as wind and tides produces no emissions and are essentially environmentally sustainable. It is recognised that the use of these sources at the expense of fossil fuels helps to reduce emissions of environmentally harmful gases such as CO_2, SO_2 and NOx. CO_2 savings made through the production of wind energy represent an important benefit that should be noted during the EA process. There will also be savings in other serious pollutants such as particulates (PM_{10}s) and volatile organic compounds (VOCs).

The conversion factors used to calculate CO_2, SO_2 and NOx emissions during the production of electricity from coal fired, oil fired or gas fired power stations are readily available[xvii]. The 'energy balance' of electricity generation by wind farms can also be calculated, by comparing the energy used to manufacture the turbine components with the energy generated by the farm.

For example, the analysis of data from the Danish Central Bureau of Statistics, Danish Energy Agency and the Riso National Laboratory has shown that a modern Danish 600kW wind turbine will recover all the energy spent on its manufacture, maintenance and decommissioning within approximately three months of its commissioning. Over its twenty year lifetime, a wind turbine will supply at least 80 times the energy spent in its manufacture, installation, operation, maintenance and decommissioning[xviii].

The tools required to calculate potential benefits of offshore wind farms within the EA process are therefore readily available, and should be employed to determine the beneficial effects of proposed developments.

Physical Presence of the Turbines

The assessment of issues summarised in Table 1 highlighted a number of potentially important effects resulting from the physical presence of the operational wind farm, those being:

- the physical obstacle that the turbines represent to other sea users, including fishermen employing certain fishing methods, shipping and recreational vessels, navigation, Ministry of Defence (MOD) practice exercises and anchorage areas;

- the obstacle that the turbines represent to aircraft (civil and military);
- visual effects from their physical presence and the eye-catching nature of the blade movement;
- alterations to wave climate and local geology resulting from the turbines; and
- interference that the turbines may cause to microwave signals if the turbines are located in the line of the path to path links.

4.4.3.1 Obstruction to other sea users

The scale of any development (i.e. the 'footprint' of a group of turbines, the number of such groups in a sea area, and the siting of individual groups or 'groups of groups' in relation to shipping and boat movement patterns), particularly in coastal areas, will all affect the extent to which wind farms represent obstructions to sea users. Detailed consultation during the scoping phase of an offshore wind farm development should rule out locating wind parks in particularly busy marine areas so reducing the risk of obstructing other sea users. As indicated in Section 4.3.2, fishing intensity studies may be required to identify and avoid fishing 'hot spots', while Admiralty charts, traffic surveys and liaison with key personnel such as harbour masters, coastguards and the MOD will identify shipping routes and other sensitive users. The MOD has requested that they are fully consulted about proposed developments prior to the formal approval procedure, to ensure that proposals do not infringe upon any military exercise, danger or operating areas.

However, even when key sensitive areas are avoided, the majority of the UK coastal waters are used by vessels to some extent which have the right to anchor as part of their public rights of navigation. Unless situated on rocky outcrops, there will be the potential for interference to some degree, as well as the potential for collision between vessels and the operational turbines. In addition to threatening human life, such an incident could lead to the accidental release of pollutants such as diesel, and associated detrimental ecological effects.

Full details of the turbines' location should be given to mariners and included on Admiralty and fishing charts, to minimise the risk of collision as far as possible. Windfarm developments in navigable areas will have to be marked and/or lit in accordance with the requirements of the General Lighthouse Authority as well as being equipped with radar reflectors/intensifiers and fog signalling devices, as specified by the DETR.

In addition to the above, potential obstruction to other sea users will always require detailed assessment in an EA of an offshore wind farm. It is considered that the wind industry could benefit from a strategic fisheries study aimed at identifying the specific affect of offshore wind farms on various types of fishing techniques and fisheries activities. This would provide valuable information to enable developers to interpret the results of the site-specific fishing intensity studies. This recommendation is highlighted in Section 5. Other than this, existing techniques and information are considered sufficient to assess the degree of obstruction. This information will vary for each site and will be collated during the site-specific EA process.

4.4.3.2 Obstacle for aircraft

In the offshore environment there are principally two classes of aerial activity at low level, namely military low flying and flights by civil helicopters in support of the offshore oil and gas industry. Closer to shore airport approach paths and approaches to MOD Coastal Air Weapon Ranges should be avoided.

The Directorate of Airspace Policy (the Directorate) is a joint service resourced by the Civil Aviation Authority (CAA) and the MOD. It is responsible for airspace policy and planning in the UK for the benefit of all airspace users, both military and civil. Its principal interest in offshore wind farms is their effect on aviation activities as a result of their physical obstruction to air navigation.

When transiting to and from offshore installations, helicopters endeavour to fly along predetermined tracks known as Helicopter Main Routes (HMR). In this way, the Directorate is able to establish procedures to provide separation between helicopters and low flying military aircraft. Whenever possible, the helicopters travel at a level well above the upper turbine tip height. There are occasions, however, when helicopters are forced to fly very much lower as a result of factors such as rotor icing. During poor weather conditions helicopters may also be forced to operate without visual reference to the surface. In both events, the presence of an offshore wind farm could create an obstacle.

The Directorate has indicated that in many instances problems caused by conflicting requirements affecting use of airspace can be overcome by negotiation and compromise. It will therefore be imperative that the Directorate is consulted by developers at an early stage in any proposals to establish offshore wind farms. Once approved, notices to aviators would be required for sites that go ahead. Other than discussion on a site by site basis, no additional research into the effect of the physical presence of the turbines on aircraft is considered necessary.

4.4.3.3 Alterations to wave climate and local geology

The physical presence of a wind tower could lead to diffraction or funnelling of waves and currents between the turbines, reductions in the wave energy reaching the coast and changes in local wave patterns. Wave diffraction around gravity base structures is a local effect that also influences the local scour effects. Local erosion or deposition around the base of the structure may result, depending upon the current strength and the resistance of the seabed surface. These effects may increase with the number of turbines installed, depending upon spacing and alignment.

The effect of the towers will be determined by:

- the influence that the piles have on their immediate location (the 'wake effect'); and
- whether there are any combined effects such as diffraction or funnelling between the piles resulting from their proximity to each other.

The 'wake effect', which identifies the area over which a detectable wake occurs around a structure, is usually approximately ten times the diameter of the structure. The degree of the effect will depend upon the size of the foundations, the distance between them, and the wavelength and direction of the incident waves. Although erosion in the lee of the structure may occur locally, the requirement to space turbines sufficiently far apart to prevent wind shadow makes it unlikely that the turbines would lead to changes in sediment movement or coastal processes, unless situated on unstable sandbanks. Based upon existing monopile designs, a gap of >300m between each pile should be sufficient in UK waters to ensure that wake effects generated by each pile do not interact with each other. However, it is considered that a generic study to determine the significance of interference effects would be beneficial to the wind farm industry, as highlighted in Section 5.

Further study in the form of wave refraction modelling (frequently used, for example, to identify design criteria for offshore oil and gas installations and assess beach erosion) may be required on a case by case basis depending upon the conclusions of the generic study. Site specific study would investigate potential interference with local water movement, and is recommended particularly if a wind farm is proposed on sandbanks as their stability will require assessment. Appropriate tools are already available to conduct wave refraction modelling, where deemed necessary.

4.4.3.4 Visual and Socio-economic effects

The visual effect of wind farms results both from their physical presence and from the eye catching nature of blade movement. This makes visual effects potentially important, as discussed further in Section 4.4.4.2. Socio-economic effects will require assessment on a site by site basis. It is considered that sufficient techniques are available to undertake this assessment.

4.4.3.5 Interference with Microwaves

An operational turbine has the potential to cause interference with microwave links, used for communication systems such as mobile phone networks. This interference results from the physical presence of an obstacle situated in the line of a microwave path to path link. Discussion will be required with operators using microwaves (including mobile phone operators) to ensure that developers avoid interference with these communications networks, through siting turbines to avoid these links.

Rotation of the Wind Turbine Blades

The assessment of effects summarised in Table 1 highlighted a number of potentially important issues resulting from the movement of wind turbine blades:

- interference with radar installations;
- visual effects on adjacent sensitive receivers;
- bird strikes and associated effect on bird populations and migration paths;
- noise and vibration effects on ecological sensitive receivers (benthic communities, fish, marine mammals);
- noise and vibration effects on humans;
- potential hazards to small craft with tall masts or large commercial vessels with a substantial height of superstructure; and
- interference that the rotating turbines may cause to telecommunications and televisions through reflecting signals that pulse with the rotation of the blades, although from experience from on-land wind farms, these effects have been minor and can be easily rectified.

4.4.4.1 Radar interference

The rotation of turbine blades can cause interference with radar installations. Following discussion with the CAA and MOD, it appears that both authorities are concerned with the potential effects on radar facilities, and that these effects would require assessment on a case by case basis.

Specifically, the MOD considers that if a wind farm is in the direct line of sight of a radar it can have an extremely detrimental effect upon radar performance as the rotating blades create a source of interference. Where wind turbines are in the line of sight of a radar, the turbines can appear as genuine aircraft targets that could either mask aircraft responses or desensitise the radar within the sector containing the wind farm. Shadowing of aircraft at similar radar-to-target elevation angles as the wind farm may degrade radar performance even further which could be potentially hazardous.

It is further understood that the MOD has undertaken a number of trials to determine the precise extent of interference with radars from wind turbines. Unfortunately these data were not available during this study. It is considered that this information should be made available to developers to enable them to fully understand the implications and limitations of radar interference, so allowing them to locate their proposed developments in areas that avoid these issues. Depending upon the extent of this research, additional study may also be required to expand upon the existing data and to further quantify the effects on radar. Detailed consultation with the MOD and CAA with regard to radar installation will be required at the earliest opportunity in a project's development to ensure that conflicts do not arise.

4.4.4.2 Visual effects

Visual effects may result from a combination of the physical presence and colour, and the blade movement of an offshore wind farm. The latter is considered to have a greater visual effect as a result of its eye-catching nature.

When determining the potential visual effects of a wind farm development it is firstly important to identify the nature of the existing landscape and seascape. This should include how the landscape/seascape is experienced and why it is valued. Many parts of the coastal zone and the close inshore area are valued both for the views seen by those on the land looking out to sea and those on the sea looking towards the coast.

Secondly, it is important to evaluate the potential visual effect of the proposed development upon the existing landscape/seascape, assessing how the wind farm will affect the intrinsic characteristics of the area. The potential visual effect upon 'sensitive receivers' will require assessment within the EA. It is considered that developers should adopt a consistent approach to the assessment of effects upon the landscape and seascape. The significance of any visual effects will be dependent upon factors such as:

- the scale of the wind farm;
- complete turbine design (including the size, relative proportions of the components and the blade configuration);
- the overall 'footprint' of the site;
- whether there are other foci present in the sea;
- whether there is public access along the shore;
- distance from sensitive receivers;
- the nature of the adjacent coast line (topography, land use and visual quality); and
- prevailing weather conditions.

Detrimental visual effects could also potentially have knock-on effects upon socio-economic issues such as tourism and recreation.

The most recent guidance available to developers are the 'Guidelines for Landscape and Visual Impact Assessment (GLVIA) produced by the Landscape Institute and the Institute of Environmental Assessment[xix]. In considering the visual impact of any proposed developments it will be important to address:

- the extent to which the project will result in short term or long term changes to the landscape and the nature of these alterations;

- whether the area holds any landscape designations of national, regional and local importance; and

- whether the relevant local authority has a landscape management plan for the area.

It is standard practice on land to define a Zone of Visual Influence (ZVI)[xx] for wind farms. It is considered that it would be appropriate to extend this practice to offshore assessment, although the ZVI may need to cover greater distances than those for wind farms on land, as the extent of visibility will be greater. Furthermore, the Countryside Council for Wales (CCW) is currently devising new methods for assessing seascapes and as such it is recommended that developers consult CCW to discuss these methods once finalised, prior to undertaking the EA process.

The scoping phase of an EA will be particularly important to ensure, wherever possible, that all interested parties are consulted and fully informed of the degree and nature of the visibility of any proposed development. This will enable consultees to make informed decisions, and enable developers to develop acceptable layouts for sites and avoid locations that are found to be particularly visually sensitive. The extent of any visual effect could also be reduced if turbines are painted a colour that is sympathetic to the existing seascape, although this may not be possible if the proposed development is in a navigable area. It will be necessary to consult the General Lighthouse Authority to determine the particular marking and/or lighting that a wind farm development would require.

Offshore wind farm development is a new industry, and it is considered that the industry could benefit from a generic study that investigates and develops a selection of appropriate alternatives and options for wind farm layouts, arrays and designs. This could assist developers through highlighting more visually acceptable footprints and those that should be avoided, although these would obviously then need to be adapted for the site-specific scenario.

Having identified a range of possible footprints and designs, there are a range of visualisation techniques that developers may use to inform consultees during the site-specific landscape and visual impact assessment phase. These include photomontages that are able to show the wider angle context of developments within a landscape, and computer generated videomontages to demonstrate the effects of blade movement. As highlighted in the Friends of the Earth (FoE) guidelines for wind power developers and local planners, public perception of a wind farm development may also be influenced by information on the level of contribution each project is seen to make to clean energy production[xxi]. It is recommended that this information is included within the site-specific environmental assessment.

It is understood that Novem BV, a Netherlands organisation for Energy and the Environment with a similar remit to ETSU, has carried out feasibility studies of near-shore and offshore wind farms in Holland. One concept involved approximately 100 turbines of 1MW some 9-16 km off the Dutch coast. Planning, environmental, technical and economic aspects were addressed. In particular, it is understood that they have studied visual effects including public perception. Although the results of these studies are not available for inclusion in the Final Report, it is recommended that developers undertaking EAs review this information when it becomes available.

4.4.4.3 Bird strikes and associated effect on bird populations and migration paths

The UK has some of the largest seabird concentrations in Europe and many sites and areas hold internationally important populations. It will therefore be necessary to ensure that offshore wind farm development does not affect the integrity of these populations.

The Royal Society for the Protection of Birds (RSPB) has indicated that offshore wind farm developments should avoid sites of national or international importance for birds, or migratory paths[xxii]. If this guidance is followed, no detrimental effects upon birds are anticipated. However, if operators seek to develop an offshore wind farm near a sensitive area, the potential effect would require full and detailed investigation. Potential operational effects may include:

- disturbance to bird feeding sites in the vicinity of the turbines;
- collision of birds with the turbines;
- effects upon bird flight patterns in the vicinity of the proposed structures;
- the potential risks of attracting birds to the turbines, particularly at night if the structures are lit for navigation/aircraft warning purposes; and
- indirect effects from changes to food sources, as a result of operational wind farms affecting prey species.

A number of studies have investigated the effect of upland, coastal and more recently offshore wind farms on birds. Ongoing monitoring exercises of operational wind farms at a variety of terrestrial sites have demonstrated only minimal effect upon individual birds[xxiii,xxiv,xxv] and no important effect upon bird populations. A number of important coastal[xxvi,xxvii] and offshore studies[xxviii] have also been undertaken which indicate that although operational turbines can affect individual birds, leading to effects such as avoidance and bird strike, the number of losses and degree of disturbance have not been shown to detrimentally affect bird populations.

It is possible from the general literature to identify some key species likely to be more sensitive to disturbance caused by wind farm construction and operation, including raptors, divers or loons, ducks and waders. The behavioural patterns of a species will dictate the degree of effect from a wind farm. For example, seabirds make use of the coast in large numbers for breeding, inshore waters for feeding, resting and as a route for flying. Large concentrations may be evident over narrow ‘corridors’, especially during migration, and low visibility may force seabirds inshore. Seabirds could therefore be vulnerable to wind farms within these ‘corridors’. This behaviour differs from waders and some seaducks, and these differences must be considered on a site by site and species basis.

However, there is still an overall deficit of information on the effect of large scale offshore wind farms particularly with regard to changes in normal average annual mortality, as there are too few established sites that have been monitored long-term from which to draw firm conclusions. Each individual wind farm proposal presents unique environmental features that combine with bird species to create a range of issues which must be addressed individually. It is therefore considered that a precautionary approach should be adopted, including monitoring both before (to establish baseline population numbers) and after development, until sufficient information is available. It is recommended that liaison with the RSPB is undertaken to determine the appropriate extent of this monitoring.

The review of available information, and input from the British Trust for Ornithology[xxix] has highlighted the following areas (as summarised in Section 5) where additional work would be beneficial:

- continued assessment of the effect of operational wind farms, both at day and night, to gather information on as wide a variety of bird species as possible as a result of the difference in sensitivity noted between species;

- information on which seabirds use which particular areas for feeding or during parts of their seasonal movement cycles. Much of this information is already available through the JNCC Seabirds at Sea team. However additional work may be needed in some areas and at certain times of year. This could be complemented by developing a coastal sensitivity atlas, similar to that developed by JNCC for the offshore oil industry;

- analysis of information about known migratory routes of birds to and from different parts of Europe in relation to the height at which each species migrates;

- the reaction of birds to wind farms and risk of collision under varying weather conditions and at night. Specifically, the precise way in which birds react to wind farms during foggy or rainy conditions requires assessment. Monitoring is required to determine the level of risk from collision with wind turbines and whether there are ways that any risks can be mitigated through lighting, noise or other means;

- the effect of disturbance from maintenance ships; and

- the effect of large scale wind parks.

4.4.4.4 Vibration effects on benthic communities

Unless vibration of the wind tower causes changes in the physical composition of the seabed (e.g. liquefaction) little or no effect on benthic communities is expected[xxx]. However, there has been very little research to firstly quantify the noise emitted underwater from turbines, and secondly to assess vibration effects on benthic communities with which to substantiate this conclusion. Any effects upon the benthic community could have a knock-on influence on species higher up the food chain, and as such could be important.

The Vindeby offshore wind farm provides some information on the affect on benthic communities. Constructed in 1991 off the Danish coast, this pilot wind farm comprises 11 x 450kW wind turbines, and was constructed to investigate the offshore wind resource and environmental considerations. It is understood that test fishing was conducted at Vindeby both before and after commissioning[xxxi,xxxii]. The results indicated that fishing yields increased, and this was attributed to the fact that the turbines' concrete gravity foundations appeared to act as an artificial reef. Mussels were found to be growing on the foundations and the flora and fauna had generally improved. However, it is understood that the data from this study were somewhat sparse and inconclusive. Furthermore, it is anticipated that the majority of the turbines in the UK will have monopile foundations. As a result of the difference in foundation design and the different ecological communities that will be present in UK waters, the Vindeby study provides insufficient data to reach a conclusion on the effect of vibration on benthic species in the UK. There are large differences between the vibrational behaviour of concrete and steel-monopile foundations. For this reason, as well as the fact that concrete provides a very different substrate to ecological communities and the measurements at Vindeby were inconclusive, this study can not be used to anticipate the vibrational effects of monopile foundations at other sites.

It is considered that further study is required to provide this information, as summarised in Section 5.

4.4.4.5 Noise and vibration effects on fish communities

Potential operational effects upon fish species may be of far greater significance than construction effects that are of limited duration. Whereas fish species can avoid temporary disturbance by moving from an area experiencing effects such as elevations in suspended solids and underwater noise, an operational wind farm may have a design life of 20 years or more and any effects of operation will be long term. If adversely affected by noise and/or vibration, fish could move from an area permanently. In some species, fish larvae survival can depend upon an extremely short (2-3 day) window and if displaced from a suitable environment, high levels of mortality could result. Any potential effects on fish communities therefore need to be thoroughly understood.

During this study, it has not been possible to identify underwater measurements quantifying noise generated by wind turbines. However, it is understood that the Dutch company Haskoning are currently undertaking measurements at a nearshore wind turbine in the Ijsselmeer near Lelystad in the Netherlands. These measurements have been undertaken to characterise the frequency and sound power level of offshore turbines with monopiled foundations. The work, undertaken on behalf of Novem BV, involves measuring:

1. The underwater sound *power* level (see Section 4.4.4.7 for explanation of sound power level) in relation to the frequency and magnitude of the vibration levels in the tower[xxxiii].

2. The underwater sound *pressure* levels (see Section 4.4.4.7 for explanation of sound pressure level) at certain distances in relation to the frequency and magnitude of the vibration levels in the tower.

If the noise generated is of low frequency, as appears likely from available information, the noise may be audible to many fish species[xxxiv]. As a result, there is the potential for this to affect their navigation and behaviour. The degree of effect will be highly dependent upon the frequency, sound power level and duration.

Discussion with MAFF indicates that little research has been conducted into the effect of noise on fish behaviour[xxxv,xxxvi]. The nearest comparable research appears to be that assessing the effects of seismic exploration on fish, particularly the use of air-guns during seismic investigation[xxxvii]. These results vary according to the frequency and level of noise emitted from the source, and are considered to be of limited value as a result of the differences between seismic and wind turbine noise, in terms of frequency and duration.

Although there have been no studies in the UK relating to fish behaviour and wind farms, some consider that the noise generated from vibration of the turbines may repel fish, or alternatively act as artificial reefs, providing shelter for fish. As detailed in Section 4.4.4.4, test fishing at the Vindeby test pilot wind farm provides an indication that operational turbines do not detrimentally affect fish. However, it is understood that the Vindeby data were sparse and inconclusive. It is also anticipated that the majority of the turbines in the UK will have monopile foundations as opposed to the concrete gravity foundations used in Denmark. As a result, the Vindeby study provides insufficient data to reach a conclusion on the effect of operational turbines on fish species in the UK, as a result of the difference in foundation design and the different fish species that will be present in UK waters.

Therefore, further study to establish the magnitude of any effects on fish species is necessary. Actual measurements of underwater noise generated by offshore wind farms (frequency and sound power level) would also be useful, to enable a comparison to be made with known sensitivity thresholds for noise in UK fish species.

It should be noted that although the effects of vibration on benthic and fish species are highlighted as areas deficient in information and requiring further study, like their onshore counterparts, the design of an offshore support structure is driven by the overriding objective of avoiding resonance. Turbine machinery is normally designed for a life of at least 20 years which inherently means that vibration (intrinsically linked with wear and tear) must be designed out. Contractors have therefore devoted significant efforts to improve wind turbine technology and reduce vibration as far as possible.

4.4.4.6 Noise and vibration effects on marine mammals

Marine mammals, and cetaceans in particular, are vulnerable to interference from underwater noise, relying on sound to communicate, sense food and understand their local environment. Water-borne noise and vibration transmitted from the moving blades, through the tower and into the water column, could potentially disturb marine mammals.

When assessing whether water-borne noise from a particular wind farm is likely to be of concern, a number of issues will need to be addressed:

- whether there are sensitive receivers (e.g. cetaceans and other marine mammals) in the area. If there are none, the effects of noise on marine mammals will not be an issue;

- the sensitivity of any receiving marine mammals;

- information on the noise emitted by the noise source;

- the attenuation rate along the propagation path; and

- ambient noise levels near the marine mammals.

To answer the second point, a large volume of data is available characterising the sensitivity of marine mammals[xxxviii]. Many species will not be sensitive, if low frequency noise is generated, while others will.

Available information indicates that noise generated by offshore wind turbines will be in the same range of frequencies as those generated by existing sources such as shipping, fishing vessels, wind and waves. As such operational wind turbines may merely contribute to the background low frequency noise levels in this area. However, as discussed above (Section 4.4.4.5) actual measurements of underwater noise generated by offshore wind farms (frequency and sound power level) will enable a far better understanding of the likely effects of offshore wind farms on the marine environment. If wind farm developments go ahead within areas of importance to marine mammals, marine mammal monitoring programmes may also be beneficial to measure the response of marine mammals to offshore wind farms and mitigate activities if any adverse reactions are detected. These surveys, which use well established protocols, would potentially involve comprehensive surveys from vessels before, during and after construction and during operation.

4.4.4.7 Noise and vibration effects on humans

Noise will be emitted by an operational wind turbine in two principal ways, namely through the air, and down the pile and out through the water column. Air-borne noise propagating across the water will be a source of potential impact upon humans. The degree of noise effects will be dependent upon the:

- level and character of noise emitted (dependent upon turbine design);
- distance of the noise generating equipment from sensitive receivers (as distance provides geometric attenuation and air absorption);

- any barriers located between the sensitive areas which may lead to attenuation of noise (although it is recognised that barriers will be unlikely to cause much attenuation as a result of the height of the noise source);
- prevailing wind directions; and
- background noise levels that already exist.

One benefit of locating wind farms offshore is that the potential noise source is located away from humans and as such potential effects upon them will be reduced.

When operating, turbines generate mechanical noise as a result of the gearbox, generator and other equipment, and aerodynamic noise produced by the movement of the blades through the air. The level of noise is dependent upon the type of turbine installed. However, when compared with road traffic, trains, construction activities and many other sources of noise, the noise generated by wind turbines is extremely low[xxxix]. Increasingly, noise is being very successfully minimised through careful design and manufacture of the blades, and sound insulation of the gearbox and generator to the point where noise complaints are now rare. Within the DETR planning policy guidance note, it is stated that 'well designed wind turbines are generally quiet in operation'.

Noise is measured in decibels (dB). The decibel is a measure of the *sound pressure level*, i.e. the magnitude of the pressure variation (in air or water, both of which have different references). An increase of 10dB sounds roughly like a doubling of loudness. Measurements of environmental noise are usually made in dB(A) which includes a correction for the sensitivity of the human ear. However, the noise created by a noise source, for example a wind turbine, is normally expressed in terms of its sound *power* level, also expressed in decibels. This is not a measurement of the noise level that is audible to humans, rather of the noise power emitted by the machine.

Recommendations on land from the Wind Turbine Noise Working Group established by the DTI are that turbine noise levels should be kept to within 5dB(A) of the average existing evening or night-time background noise level, or alternatively where background levels are below $30dB(A)_{L90}$ fixed noise levels of between 35 and $40dB(A)_{L90}$ are recommended.

The sound *power* level from a single wind turbine is usually between 90 and 100dB(A), which creates a sound pressure level of 50-60dB(A) at a distance of 40 m from the turbine, i.e. about the same level as conversational speech. At a distance of 500 m from the turbine, the equivalent sound pressure level would be approximately 25-35 dB(A)[xl] when the wind was blowing from the turbine towards the receiver (i.e. under worst case conditions). Ten such wind turbines, all at a distance of 500 m would create a noise level of 35-45dB(A) under the same conditions, which is less than that of conversational speech (50-60dB). With the wind blowing in the opposite direction the noise level would be about 10dB lower[xli]. It should be noted that these figures are land based and that noise propagates differently across water. As a result, this information is not directly applicable to noise generated offshore. However, this currently represents the best available information as direct measurements from offshore wind farms are not available.

Although these figures are not directly applicable to offshore wind turbines, it is considered that when combined with the background noise created by wind and waves which will occur when the turbines have sufficient wind to operate, the noise generated by offshore turbines may not be distinguishable above background levels. National Wind Power has calculated that 50 x 1.5MW turbines situated 5 km from the coast will conservatively lead to a sound pressure level of 28dB (L_{a90}) at the beach. Any residential areas adjacent to the coast would also be subject to the noise of waves upon the shore, as well as any local industrial/transport noise during the daytime. Furthermore, wind turbines do not operate below the wind speed referred to as the cut-off speed and onshore wind data suggests that wind speeds are generally below this for approximately 30% of the time, although this figure may be reduced offshore. For a proportion of the time, therefore, the turbines will not generate any noise.

However, these preliminary conclusions are based upon land-based figures. In order to confirm whether they are correct, assessment of the noise generated by large offshore wind farms, particularly on adjacent shorelines, is required. Those measurements being undertaken by Haskoning (Section 4.4.4.5) should provide valuable information on the degree of potential noise effects. These may be conclusive or additional measurement may be required. If required, brief proposals for further study are presented in Section 5.

4.4.4.8 Potential risk of moving blades to vessels

Rotation of the operational wind turbine blades may represent a potential hazard to some marine vessels, for example small craft with tall masts or large commercial vessels with superstructure of a substantial height. The extent of the hazard will depend upon the dimensions of the turbines, and specifically the minimum height above sea level of the lower part of the trajectory of a swinging turbine blade (taking into account the tide height in areas where this is significant). It will be important that this potential risk is taken into consideration during wind farm development. The Royal Yachting Association has requested that sufficient technical details on the design, construction and operation of the turbines are provided during consultation with the sea users in the preliminary stages of any development, to ensure that practical points of this nature can be discussed.

It is considered that sufficient information will be available to assess this potential risk on a site by site basis and further research is not required.

4.4.4.9 Telecommunication/television

An operational turbine has the potential to cause interference with television and communications systems. In particular, radio (chiefly VHF radio) is an important communication and safety aid for recreational and other users of the sea, in both small and larger commercial craft. The power available to small recreational craft for radio operation is limited. As a result, relevant bodies including the British Broadcasting Corporation and the Radiocommunications Agency should be consulted during the scoping phase of an EA to identify potential conflicts. It is important that the potential effect of both transmission by and reception by VHF equipment is fully investigated before decisions are made to locate wind farms in important areas for marine traffic[xlii]. However, discussion with the Radiocommunications Agency[xliii] indicates that there is sufficient information available to assess the potential effects of any proposed wind farm development.

Routine maintenance activities

Routine maintenance will be undertaken throughout the lifetime of an offshore wind farm, which will involve vessel movement to and from an appropriate port to service equipment, as and when required. After commissioning, major servicing would be undertaken at intervals of approximately every six months to one year.

Under normal operating conditions there are expected to be no releases of chemicals from the wind turbines. No important effects are anticipated and so no further research will be required.

Operation of Ancillary structures

Potential important effects that may result from the operation of ancillary structures such as cables and pylons associated with an offshore wind farm are:

- visual effects of overhead transmission lines and poles connecting the wind farm to the local electricity grid;
- visual impact of substations;
- electric, magnetic, interference and heat effects on humans and marine organisms;
- corona discharge from overhead transmission lines; and
- potential hazards of onshore pylons to birds.

In the marine environment, during the operation of a cable conducting current there is the potential for heat emission. This will generally dissipate into the immediate backfill or sediment covering the cable. It is not anticipated that this would cause an increase in heat in the temperature at the surface of the seabed. However, this would require assessment during the EA process. Subsea cables also have the potential to interfere with navigational equipment on ships if the cable that connects the grid to the wind farm is direct current (DC). This is a well understood phenomenon that can be reduced by installing no more than two adjacent cables. Alternating current (AC) cables do not cause interference with navigational aids. Research is not required to enable assessment of these potential effects as sufficient information is available.

The other environmental effects listed may result from the terrestrial ancillary structures. However, this report aims to focus on nearshore and coastal issues. Although the environmental effects associated with these terrestrial ancillary developments will require assessment within any offshore wind farm EA, they are well understood and covered comprehensively by terrestrial environmental assessment techniques. Further coverage in this report is not considered necessary.

Emergency repair of the turbines

During the lifetime of an offshore wind farm there will be the potential for emergency events such as collision of vessels with the turbines, particularly during maintenance, and any associated accidental pollutant release. It is recommended that Emergency Response Plans are developed for each offshore wind farm such that the lines of responsibility and reporting are clear and predefined, so that necessary action can be taken as soon as possible to minimise any potential risks to human life and the environment.

WIND FARM DECOMMISSIONING

Background

Existing offshore wind farms have a design life of approximately 20 years. Methods for reusing existing foundations are being investigated by developers but it must be assumed that decommissioning and removal will take place. Aspects of the decommissioning activities that may lead to environmental effects are:

- removal of foundation, tower, nacelle, blades;
- reuse/disposal of foundation, tower, nacelle, blades; and
- removal of cables and associated ancillary structures.

The potential effects of each stage are considered below.

Potential Effects

The Crown Estate, the UK seabed owner, has indicated that upon decommissioning it will require the most thorough and acceptable removal of foundations possible. Its role is to protect its own long term interests and well as ensuring responsible environmental practice. The most appropriate method may differ from site to site, depending upon factors including the nature of the foundations and the ground conditions.

The latest decision under OSPAR (98/3) requires that disused oil and gas structures above seabed level must normally be wholly removed to land for disposal. Whilst this decision was not taken in the context of wind energy infrastructure, in the spirit of this agreement MAFF consider that complete removal should be the favoured option on abandonment. Some forms of foundations (cement or steel gravity) can more readily be removed completely, returning the seabed to its original state. Discussion will be required with the regulators on a site by site basis to determine the most appropriate decommissioning methods.

Removal of the wind farm may lead to varying degrees of temporary disturbance of the seabed and associated communities, particularly where buried structures such as cables and foundations are removed. These should be mitigated as far as possible through choosing careful removal methods and the most appropriate season for any biological communities present.

Where possible, the options for reuse or recycling of the wind farm components and materials should be considered. During the EA process, the potential site-specific environmental effects of removing or leaving *in situ* the cables associated with the development should be weighed and decided upon, based upon best available information. As stated in the FoE guidelines to wind farm developers[21], the responsibilities for decommissioning of the site and removal of turbines should be stated clearly in contract agreements between Contractors and the Crown Estate to avoid conflicts. These however will not preclude statutory requirements as a result of development consents from the Government Departments concerned.

Decommissioning may therefore lead to a variety of temporary disturbance effects. It is considered that these are well understood effects, which can be effectively minimised on a site by site basis. Additional research is not required to enable assessment of these.

CONCLUSIONS AND RECOMMENDATIONS

This Project has identified a number of generic issues that are likely to be of key importance/concern during wind farm development although the degree of effect will be highly dependent upon the site-specific characteristics. Some of these issues are well understood as a result of experience gained through other existing offshore industries, such as the oil and gas, telecommunications (submarine cables) and marine aggregate extraction industries. Other issues are unique to this industry, such as the visual effect of turbines, noise and vibration effects and the potential for birds to collide with rotating blades.

Existing information and expertise means that those issues that are already well understood can be readily assessed on a site by site basis and mitigated with available techniques without the need for further industry-wide research. However, additional work is required in the areas listed below with an outline of the proposed scope of work where possible.

In producing the list of research requirements, the comments and views of a broad range of consultees (Appendix B), who were sent a working draft of the present report, were taken into account.

1. Checklist on marine environmental issues associated with offshore wind farms

Annex 4 of the TWA Guide to Procedures provides a generic checklist of aspects that require assessment in an EA to support an application for an order. However, the list was not developed with the offshore wind farm industry in mind and so does not cover certain aspects of this kind of development. An official list tailored specifically for offshore wind farms by the regulators (the Department of Trade and Industry (DTI); the Department of Environment, Transport and the Regions (DETR); the Ministry of Agriculture, Fisheries and Food (MAFF)), and drawing on the findings of the present Project, would be useful to both developers and regulators.

2. Full characterisation of the noise and vibration generated by offshore wind farms

A study is required to enable a better understanding of the noise and vibration emitted by offshore wind turbines, and the potential for effects upon sensitive receivers (humans and biological), as there are insufficient data available.

The study should firstly characterise the nature of the noise and vibration at source (i.e. in the immediate vicinity of the turbines) quantifying the frequency and sound power level emitted both above and below the waterline. The study should measure noise generated by a single turbine, and a number of turbines operating simultaneously so that cumulative effects can be measured. While it is unknown whether underwater noise emissions from wind turbines are of relevance, the aspects of under water sound and its propagation should receive the same emphasis as sound in air.

Measurements should also be taken to determine the level of background noise (above and below the surface) generated by wind and waves in the vicinity of offshore turbines situated in a variety of water depths, and on a variety of seabed substrates, during periods that the turbine blades are rotating. This will enable an assessment of the contribution of wind farms to the background noise conditions.

The attenuation of noise from wind turbines over and under water then needs assessment. This could combine measurement with modelling techniques, and should investigate in a variety of weather conditions from turbines located at various distances from shore (for example at 1 km, 2 km, 3 km, 4 km, 5 km, 6 km, 7 km, 8 km, 9 km, 10 km from the coast). This will enable an assessment of the potential noise levels reaching the coast and any human receivers present.

The present Project has identified that relevant work on this topic involving measurements at sites offshore is currently being undertaken in Holland. The findings of this study will help determine what additional work is required. The methodology should be developed in conjunction with noise, benthic, fish and marine mammal specialists to ensure that the characteristics of noise and vibration that are most likely to cause an effect on these sensitive receivers are being measured.

3. Further study of the effect of noise and vibration on the biological environment

In addition to direct measurements of the wind farms, study is required of the effect these emissions have on the surrounding environment. Limited study has been undertaken of benthic and fish communities before and after commissioning of an offshore wind farm. However, more comprehensive research to investigate the reaction of benthic, fish and marine mammal species to operational offshore turbines is required. Studies should pay particular attention to temporal aspects, such as important breeding, nursery or feeding periods. Ideally, such studies should span at least 1 annual cycle, with additional long term monitoring to check the conclusions of the 12 month study.

During the development of future offshore wind farms, the benthic and fish communities should be sampled prior to and after construction, to determine any changes in species abundance and composition. During operation, benthic and fish communities should then be monitored and compared with the baseline data collected prior to construction, and where possible at a control site (i.e. a similar location unaffected by the wind farm), using standard protocols approved by MAFF. Agreement should also be sought from specialists in benthic and fish species behaviour to ensure optimum monitoring programmes.

4. Strategic review of potential effects upon fisheries – positive and negative

It is considered that the wind farm industry could benefit from a strategic fisheries study aimed at identifying the specific effect of offshore wind farms on various types of fishing techniques and fisheries activities. This study should review the potential effect of a variety of wind farm layouts and foundation designs on all major fishing techniques and equipment used in UK waters. It would provide valuable information to enable developers to interpret the results of the site-specific fishing intensity studies and identify which fishing methods are likely to cause potential conflicts or concern.

5. Study to assess visual aspects of offshore wind farms for use in future EAs and public information exercises

It is considered that a generic study that investigates and develops a selection of appropriate options for wind farm layouts, arrays and designs would be beneficial. This could assist developers by highlighting the most visually acceptable 'footprints' and designs, although these would have to be modified on a site-specific basis. It is considered appropriate that this strategic study be undertaken by visual impact assessment specialists able to utilise visualisation techniques to effectively communicate their findings to developers.

It is understood that the BWEA Offshore Core Group is currently considering visual effects. Any visual impact study should therefore ensure that any findings presented by the BWEA are fully reviewed and incorporated.

6. Further assessment of the effect of operational wind farms on birds

In order to expand the knowledge of the effects of offshore wind farms on as wide a variety of bird species as possible, monitoring should be undertaken for new developments (both before and after) and continue for existing ones. Internationally recognised methods agreed with the Royal Society for the Protection of Birds (RSPB) should be used. In particular, future studies should focus on:

- continued assessment of the effect of operational wind farms, to gather information on as wide a variety of bird species as possible;

- information on which seabirds use which particular areas for feeding or during parts of their seasonal movement cycles. Much of this information is already available through the JNCC Seabirds at Sea team. However additional work may be needed in some areas and at certain times of year. This could be complemented by developing a coastal sensitivity atlas, similar to that developed by JNCC for the offshore oil industry;

- analysis of information about known migratory routes of birds across Europe in relation to the height at which each species migrates;

- the reaction of birds to wind farms and risk of collision under varying weather conditions, both at day and night. Specifically, the precise way in which birds react to wind farms during foggy or rainy conditions requires assessment. Monitoring is required to determine the level of risk from collision in these circumstances and whether there are ways that any risks can be mitigated through lighting, noise or other means.

- the effect of disturbance from maintenance ships; and

- the effect of large scale wind parks.

1. Assessment of the effects of wind farms on sediment transport and wave climate

The physical presence of wind turbines in the marine environment will cause diffraction or focusing of waves and currents between the turbines, and may cause reductions in the wave energy reaching the coast and changes in local wave patterns. Wave diffraction around gravity base structures is a local effect which also influences associated processes such as local scour and deposition. The degree of the effect will depend upon the size of the foundations, the distance between them, and the wavelength and direction of the incident waves.

To quantify the scale of the likely effects, it is considered that a generic study should be undertaken to determine the significance of the interference of the physical presence of wind turbines on waves and currents. This would involve wave refraction modelling (frequently used, for example, to identify metocean design criteria for offshore oil and gas installations and assess beach erosion).

2. Review of the degree of interference of wind turbines with radar

The scale of interference with radar caused by wind farms is unclear. It is understood that the MOD has undertaken a number of trials to determine the precise extent of interference with radars from wind turbines. It is considered that this information should be made available to developers to enable them to fully understand the implications of radar interference, so allowing them to locate their proposed developments in areas that avoid these issues. Depending upon the extent of these trials, additional study may also be required to expand upon the existing data and to further quantify the effects on radar. MOD is best placed to advise upon and potentially undertake this work.

3. Chemical notification scheme

Within the oil and gas industry, operators have agreed a voluntary code of practice for chemical usage, which contributes to minimising the environmental effects of their operations. It is recommended that this scheme be adopted by offshore wind developers, to demonstrate a commitment to minimising the effects (particularly during construction) upon the marine environment.

A study is recommended to determine the most appropriate way of implementing this. Consultation with the UK Offshore Operators Association (UKOOA) and the DTI is recommended to examine their operating methods, identify the costs and benefits to the wind industry, and define a strategy to implement the scheme.

4. Cumulative environmental assessment of offshore wind farms

> Developers must ensure that their EAs consider the cumulative effects of offshore wind farms, taking account of any other such developments or plans in the vicinity of their site.

There are various options for funding the studies outlined above. These include funding by bodies such as DTI or through the Marine Foresight Programme, or alternatively by members of the offshore wind industry themselves. An example worth noting is the way in which research is often funded in the oil and gas industry. The trade body of UKOOA acts as a forum for information exchange, pooling resources of the oil and gas developers and commissioning work that is of benefit to the industry as a whole. The operators pay fees to UKOOA in proportion to the number of exploration licences that they hold. In addition to avoiding a duplication of effort for researching environmental issues, UKOOA has served to promote the oil and gas companies as a proactive industry in terms of addressing environmental concerns. It is recommended that discussion be held between UKOOA and the BWEA to investigate the working practices of the former that could be beneficial to the offshore wind energy industry.

ABBREVIATIONS

AC	Alternating current
BWEA	British Wind Energy Association
CAA	Civil Aviation Authority
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CCW	Countryside Council for Wales
CO_2	Carbon dioxide
CPA	Coast Protection Act 1949
dB	Decibels
DC	Direct current
DETR	Department of Environment, Transport and the Regions
DTI	Department of Trade and Industry
EA	Environmental Assessment
EEC	European Economic Community
ES	Environmental Statement
ETSU	Energy Technology Support Unit
FEPA	Food and Environment Protection Act 1985
FoE	Friends of the Earth
GLVIA	Guidelines for Landscape and Visual Impact Assessment
JNCC	Joint Nature Conservancy Council
µT	Microtesla
MAFF	Ministry of Agriculture, Fisheries and Food
MOD	Ministry of Defence
MW	Megawatt
NATS	National Air Traffic Services

NOx	Nitrogen oxides
NRPB	National Radiological Protection Board
OCNS	Offshore Chemical Notification Scheme
OSPAR	Oslo and Paris Commissions
PEXA	Practice and Exercise Area
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
S.I.	Statutory Instrument
SO_2	Sulphur dioxide
SOAEFD	Scottish Office of Agriculture, Environment and Fisheries Department
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
TWA	Transport and Works Act 1992
UKOOA	UK Offshore Operators Association
V/m	volts per metre
VOC	Volatile organic compounds
ZVI	Zone of visual influence

TABLE

			(The table below assumes a fixed monopiled seabed foundation, although it is possible to tow out and sink a concrete caisson -	
			the difference in potential effects would not be substantial.)	
Aspects of the project which may lead to environmental effects		**Activity** *(Normal, Abnormal, Emergency)*	**Description of possible effects**	**Overview of importance**
1	**CONSTRUCTION**			
1.1	**Construction of turbines/transportation**			
	Manufacturing turbines (foundations, tower, nacelles, blades, gearbox, generator etc)	N	Potential disturbance effects of manufacturing - noise, waste, atmospheric emissions. Increased demand for construction materials leading to declines in natural resources. Creation of jobs in manufacturing.	The turbines are likely to be constructed at an existing facility where environmental considerations have already been taken into account. Regulatory consents and management systems should already be in place to manage impacts arising from this activity. There may be major beneficial effects as the number of jobs created could be significant.
	Transport turbines from site of construction to port	N	Increase in traffic (road or rail). Contributions to background noise and atmospheric emissions.	Temporary and minor increase in traffic. At some locations, a traffic survey may be required during the Environmental Assessment to quantify traffic effects.
	Storage of piles etc at the quayside	N	Visual impact, commercial benefit to port.	Temporary and limited impact as such facilities are designed and designated to store cargo.
	Move installation equipment (drilling/piling barge/jackup pontoon) to location	N	Disruption for other vessels. Atmospheric emissions and wastes resulting from normal vessel operation.	Temporary and minor localised environmental effects could result. The degree of potential site specific effects should be assessed during the Environmental Assessment.
	Transportation of foundation, tower, nacelles and blades to site of installation on boats	N	Disruption to other sea users in the area. Physical obstacle for navigation. Visual effects on sensitive receivers.	Temporary effects on navigation which can be managed through liaison with the local harbour authority. Possible visual disturbance as sensitive receivers react to the first signs of the actual scale of the development. This will need assessment in the Environmental Assessment.
1.2	**Installation of turbines**			

	Physical presence of installation equipment (drilling/piling barge/jackup pontoon) (inc. anchor mounds)	N	Other sea users (e.g. fishermen, shipping, yachting, water sports, recreational fishing, marine dumping and aggregate extraction vessels) will be prevented from using the area around the drilling equipment. Disturbance to seabed and benthos will result from anchors and anchor wires. Some fish and marine mammals may avoid the area during construction, whereas others may be attracted to the area to feed on animals exposed by disturbing the seabed. Minor release of atmospheric emissions/wastes from drilling barge.	These disturbance effects will be temporary and localised. Any disturbance to the seabed should recolonise readily, recruiting from the surrounding area.
	Drilling socket (if required by substrate) or piling foundations into position for pile foundation	N	Ecological impact/disturbance effects of underwater noise from piling/drilling/vessels on marine mammals, fish, and benthic organisms particularly during spawning/nursery season. Possible disturbance to archaeological artefacts, wrecks, etc.	Depends upon the size of the local marine mammal/fish population and their relative sensitivity (including temporal sensitivity).
	Use of grouting and/or cementing material during installation	N	Potential release of grouting and cementing materials. Elevations in suspended solids and release of associated compounds (e.g. heavy metals, nutrients) i.e. deterioration in water quality and contamination of the marine environment.	These disturbance effects will be temporary and localised provided the materials released do not lead to toxicity effects for marine organisms. Selection of suitable construction materials should be made at the project design stage and these should be approved for marine use by MAFF.
	Disposal of spoil from drilling, if applicable	N	If spoil is disposed of on seabed, physical smothering of organisms may occur depending upon particle size and local hydrological conditions (i.e. strength of local currents) with elevations in suspended solids and associated compounds (i.e. a deterioration in water quality). If disposed of on land, the spoil may use up valuable landfill space.	Depositing spoil on the seabed could alter the community structure at the site, depending upon the nature of spoil, although this would be over a relatively small area. However, sediment movement in the coastal environment can be considerable so spoil could rapidly be dispersed.
	Minor fuel and oil leaks from construction vessels (drip trays etc.)	A	Contamination of marine environment.	The volumes released will be small and are likely to disperse rapidly. Procedures should be put in place to minimise/prevent spills from entering the marine environment.
	Installation of foundation, tower, nacelles, blades, generator etc	N	Potential atmospheric emissions and wastes from the supporting vessels, which may lead to increases in greenhouse gases and deterioration in water quality. Visual effects from 'first site' of wind farm.	The air emission volumes emitted will not contribute significantly to global warming. Activity is temporary/short duration and pollutants should disperse rapidly. Emissions and discharge should be assessed during the Environmental Assessment process.
	Dropped objects from vessels	E	Damage to seabed organisms. Potential interference with other sea users.	Low probability of occurrence. Any impact to the seabed communities are likely to be negligible.
	Chemical/diesel spills from construction vessels	E	The environmental impact could be localised but severe in the immediate vicinity, affecting local seabirds. There is the possibility of diesel reaching shore and reducing water quality at bathing waters etc.	Impact would be determined by the type and quantity of material spilt. Contingency plans should be put in place to ensure the containment and efficient clean up of any spills.

	Disposal of waste from construction vessels	N	No impact if waste handling procedures are adhered to. Waste should be segregated and disposed of according to waste regulations. If waste handling procedures are not in place, waste entering the marine environment may cause a visual impact/water quality deterioration at local bathing waters etc. Use of valuable landfill space.	Provided appropriate waste management procedures are followed, there should be no effect on the local area.
1.3	**Installation of cables (between turbines and to shore)**			
	Cable installation (trenching operations (sediment plume from jetting or ploughing)) or laying on seabed and any associated rock dumping and mattresses that may be required	N	Disturbance to, smothering of and removal of benthic organisms. Possible increased feeding of large mobile species on benthos disturbed. Deterioration in water quality (increases in suspended solids and associated compounds, possibly sediment plumes).	The effects of cable laying should be temporary and disturbed areas recolonising within a few years, if disturbed material is uncontaminated. However, if a large number of turbines are installed this could affect a relatively large area, so methods which minimise disturbance should be employed.
	Presence of cablelay and trenching vessels	N	Normal vessel operations will result in atmospheric emissions and wastes, which may lead to increases in greenhouse gases and deterioration in water quality. Obstacle to other marine users.	The quantities of emissions should not lead to a detectable change in environmental quality in the area. Procedures should exist for the correct handling and disposal of solid wastes. Liaison with other sea users will be required to minimise disturbance effects.
1.4	**Construction of ancillary buildings etc**			
	Construction vehicles travelling to site	N	Increase in traffic (road or rail). Contributions to background noise, emissions to air from construction vehicles reducing air quality and contributing to global warming .	These effects will be temporary and should lead to no long lasting effects. Site specific impacts should be assessed during the Environmental Assessment
	Construction activities	N	Potential disturbance effects of construction - noise, dust, waste (wind blown litter, sewage, general refuse, construction waste).	Adherence to general house keeping, and waste management procedures should minimise any adverse effects.
2	**OPERATIONS/MAINTENANCE**			
2.1	**Operation of wind turbine**			
	Physical presence of tower	N	Obstacle to other sea users potentially including certain fishing methods/ shipping/ navigation/ MOD practice areas/anchorage areas. Risk of collision from other users and associated pollution incidents. Alterations to wave climate and local geology (sediments, foundations etc) leading in turn to geomorphological changes/coastal erosion. Visual changes to landscape/seascape, effects upon tourism and the amenity value of adjacent beaches/cliff tops. Obstacle to aviators particularly during abnormal weather conditions. Interference with microwaves if in line of sight between path to path links (dishes).	Detailed consultation will be required to avoid major disturbance of other sea users. The visual impact of the developments require further assessment to investigate potential footprints and designs of offshore wind farms and identify the degree of visual effect, taking into account effects on land and seascapes. Risk management plans should be put in place to enable immediate, effective response in case of emergency. Liaison with operators using microwaves (mobile phone operators) required to ensure that wind farm not obstacle to path to path microwave links.

	Rotation of wind turbine blades	N	Interference with radar installations, EMI/radio reception. Potential for bird strikes from rotating blades. Noise impact on local users of the surrounding area and transmitted underwater noise effects on marine organisms.	The degree of potential effect of wind turbines on radar requires quantification, preferably by MOD. Interference with radar EMI/radio reception could result in the developer compensating local residents. The likelihood and possible extent of these effects therefore requires investigation. The potential for bird strike will depend upon the proximity of the site to areas of importance for birds, including migratory paths. This will require assessment on a site by site, species basis. Potential noise effects on sensitive receivers requires investigation.
	Generation of electricity by turbines	N	Power generation resulting in zero CO_2 and other atmospheric emissions.	This form of electricity generation results in considerable savings in terms of CO_2 emission when compared with other generation methods, and is essentially sustainable. This in term contributes towards UK targets for CO_2 reduction, and prevention of global warming.
	Routine maintenance of equipment	N	Temporary localised seabed disturbance caused by maintenance vessels anchoring in the area. Potential spillage and deterioration in water quality as gearbox oils, hydraulic fluid and transformer oils are emptied from drip trays/bunded areas within the turbine during maintenance, and removed from site.	Seabed disturbance very localised and temporary. Procedures should be put in place to ensure any oil/fuel spills do not contaminate the marine environment.
	Emergency repair of the turbines	E	Temporary localised disturbance caused by repair vessels anchoring in the area.	These disturbance effects will be temporary and localised. Any disturbance to the seabed should recolonise readily, recruiting from the surrounding area.
	Disposal of bunded materials	N	Potential for contamination depending upon disposal option chosen.	In the event of a spill of these bunded materials, the volumes would be small and should have no long term detectable effect on the local environment. However, procedures should be put in place to prevent these materials from entering the marine environment.
2.2	**Ancillary operations**			
	Physical presence and operation of grid connections (likely to be at 132kv) with long onshore grid lines above and below ground.	N	Obstruction, potential for bird strike and disturbance to migratory flight paths. Visual effects of overhead transmission lines, poles and substations connecting the wind farm to the local electricity grid. Electric, magnetic, interference and heat effects on humans and marine organisms. Potential hazards of onshore pylons to birds. Corona discharge from overhead transmission lines	Potential long term visual effect and long term use of land which may have supported ecological communities. The importance depends upon the location and will require detailed assessment. Issues associated with operation of the overhead transmission lines will require detailed assessment, and careful addressing.
	Maintenance vessels and ancillary buildings (new onshore substation).	N	Potential to produce localised reduction in air quality, including contributing to global warming. Potential to generate wastes (oily wastes, special wastes and general refuse), and associated degradation of local area if released.	Vehicle emissions from additional traffic should be negligible. Procedures should be in place to ensure any wastes generated during this activity are handled and disposed of correctly
3	**DECOMMISSIONING**			

	Physical removal of pile/tower/nacelle/blades from seabed	N	Possible temporary and localised removal/disturbance to benthic organisms surrounding the structure, as a result of the jackup barge and associated anchors. The barge/vessel could create temporary obstacle to other sea users. Vessels associated with decommissioning will contribute to background noise in area.	Localised disturbance over small area. The area should rapidly recolonise. Not important unless rare community/organism will be disturbed/destroyed.
	Disposal of pile/tower/nacelle/blades	N	Disposal of components could potentially result in contamination of the local marine environment and use of landfill space	Chemical spill and waste handling and disposal procedures should be in place. Methods for reuse/recycling should be investigated to avoid using valuable land fill space.
	Presence of decommissioning vessels	N	Vessel activity in area could result in temporary and localised seabed disturbance, reduction in air quality, including contributing to global warming, an increase in noise levels and potential hazard to other sea users.	Impacts to seabed environment, noise and emissions should be assessed during the Environmental Assessment. Vessel presence and movements should be similar to construction operations.

ANNEX A

CHECKLIST OF RANGE OF ISSUES WHICH MAY NEED TO BE CONSIDERED BY THE APPLICANT IN PREPARING AN ENVIRONMENTAL STATEMENT (ES)

This checklist is not intended to imply that all environmental statements should cover every aspect of a project's potential environmental effects at the same level of detail. Whilst every environmental statement should provide a full factual description of the project, the emphasis of Schedule 1 of the Transport and Works (Applications and Objections Procedure) Rules 1992 is on the main or significant environmental effects to which a project is likely to give rise. In many cases, not all of the aspects set out in the checklist will be significant or will need to be covered in any great depth in the statement. Issues which are of little or no significance for the particular project in question will need only very brief treatment to indicate that their possible relevance has been considered. This is not, of course, to say that incomplete or inadequate Environmental Statements will be acceptable. Discussions with the local planning authority and with other bodies at the pre-application stage will help to define the scope and range of issues which the ES will need to cover.

The environmental effects of a development during its construction and commissioning phases should be considered separately from the effects arising whilst it is operational. Where the operational life of a development is expected to be limited, the effects of decommissioning or reinstating the land should also be considered separately.

SECTION 1

Information describing the project

1.1 Purpose and physical characteristics of the project, including details of the proposed access and transport arrangements, and of numbers to be employed and where they will come from.

1.2 Land use requirements and other physical features of the project
(a) during construction;
(b) when operational;
(c) after use has ceased (where appropriate)
1.3 Production processes and operational features of the project:
(a) type and quantities of raw materials, energy and other resources consumed;
(b) residues and emissions by type, quantity, composition and strength including:
(i) discharges to water
(ii) emissions to air
(iii) noise
(iv) vibration
(v) light
(vi) heat
(vii) radiation
(viii) others.

(i) discharge to water
(ii) emissions to air
(iii) noise

(iv) vibration
(v) light
(vi) heat
(vii) radiation
(viii) deposits/residues to land and soil
(ix) others

1.4 Outline summary of main alternative sites and processes considered, if any, and reasons for final choice.

SECTION 2

Information describing the site and its environment

PHYSICAL FEATURES

2.1 Population – proximity and numbers
2.2 Flora and fauna (including both habitats and species) – in particular protected species and their habitats
2.3 Soil: agricultural quality, geology and geomorphology
2.4 Water: aquifers, water courses, shoreline, including the type, quantity, composition and strength of any existing discharges
2.5 Air: climatic factors, air quality etc
2.6 Architectural and historic heritage, archaeological sites and features, and other material assets
2.7 Landscape and topography
2.8 Recreational uses
2.9 Any other relevant environmental features.

THE POLICY FRAMEWORK

2.10 Where applicable the information considered under this section should include all relevant statutory designations such as national nature reserves, sites of special scientific interest, national parks, areas of outstanding natural beauty, heritage coasts, regional parks, country parks, national forest parks and designated areas, local nature reserves, areas affected by tree preservation orders, water protection zones, nitrate sensitive areas, conservation areas, listed buildings, scheduled ancient monuments, and designated areas of archaeological importance. It should also include references to structure, unitary and local plan policies applying to the site and surrounding area which are relevant to the proposed development.

5.1Reference should also be made where relevant to international designations, eg those under the EC 'Wild Birds' Directive, the World Heritage Convention, the UNEP Man and Biosphere Programme and the Ramsar Convention.

SECTION 3

Assessment of effects (including direct and indirect, secondary, cumulative, short, medium and long-term, permanent and temporary, positive and negative effects of the project)

EFFECTS ON HUMAN BEINGS, BUILDINGS AND MAN-MADE FEATURES

3.1 Change in population arising from the development, and consequential environmental effects
3.2 Visual effects of the development on the surrounding area and landscape
3.3 Levels and effects of emissions from the development during normal operation
3.4 Levels and effects of noise from the development
3.5 Effects of the development on local roads, rights of way and transport
3.6 Effects of the development on buildings, the architectural and historic heritage, archaeological features, and other human artefacts, eg through pollutants, visual intrusion, vibration

EFFECTS ON FLORA, FALINA, AND GEOLOGY

3.7 Loss of, and damage to, habitats and plant and animal species
3.8 Loss of, and damage to, geological, palaeontological and physiographic features
3.9 Other ecological consequences

EFFECTS ON LAND

3.10 Physical effects of the development, eg change in local topography, effect of earth-moving on stability, soil erosion etc
3.11 Effects of chemical emissions and deposits on soil of site and surrounding land
3.12 Land-use/resource effects:
- 3.□ quality and quantity of agricultural land to be taken
- 3.□ sterilisation of mineral resources
- 3.□ effect on surrounding land uses, including agriculture
- 3.□ waste disposal

EFFECTS ON WATER

3.13 Effects of development on drainage pattern in the area
3.14 Changes to other hydrographic characteristics, eg ground water level, water courses, flow of underground water
3.15 Effects on coastal or estuarine hydrology
3.16 Effects of pollutants, waste etc on water quality

EFFECTS ON AIR AND CLIMATE

3.17 Level and concentration of chemical emissions and their environmental effects
3.18 Particulate matter
3.19 Offensive odours
3.20 Any other climatic effects

OTHER INDIRECT AND SECONDARY EFFECTS ASSOCIATED WITH THE PROJECT

3.21 Effects from traffic (road, rail, air, water) related to the development
3.22 Effects arising from the extraction and consumption of materials, water, energy

or other resources by the development

3.23 Effects of other development associated with the project, eg new roads, sewers, power lines, pipelines, telecommunications etc

3.24 Effects of association of the development with other existing or proposed development

3.25 Secondary effects resulting from the interaction of separate direct effects listed above

SECTION 4

Mitigating measures

4.1 Where significant adverse effects are identified, a description of the measures to be taken to avoid, reduce or remedy those effects, eg

(a) site planning
(b) technical measures, eg
(i) process selection
(ii) recycling
(iii) pollution control and treatment
(iv) containment (eg bunding of storage vessels)
(v) noise mitigation

(c) aesthetic and ecological measures, eg
(i) mounding
(ii) design, colour etc
(iii) landscaping
(iv) tree planting
(v) measures to preserve particular habitats or create alternative habitats
(vi) measures to safeguard historic buildings, ancient monuments and archaeological remains and their settings
(vii) recording of historic buildings, ancient monuments and archaeological remains

4.2 Assessment of the likely effectiveness of mitigating measures

SECTION 5

Risks of accidents and hazardous development

5.1 When a proposed development involves materials that could be harmful to the environment (including people) in the event of an accident, the environmental statement should include an indication of the preventive measures that will be adopted so that such an occurrence is not likely to have a significant effect. This could, where appropriate, include reference to compliance with the Health and Safety at Work Act 1974 and its relevant statutory provisions.

5.2 The Applications Rules require applicants to notify the Health and Safety Executive and hazardous substances authority (as defined in the Planning (Hazardous Substances) Act 1990) where they intend to make an application in respect of an operation which requires hazardous substances consent under that Act.

5.3 It is desirable that wherever possible the risk of accident and the general environmental effects of developments should be considered together.

ANNEX B

ORGANISATION/COMPANY
Associated British Ports Research
Association of Noise Consultants
Bond Pearce
Border Wind Ltd
British Trust for Ornithology
British Wind Energy Association (BWEA)
Centre for Environment, Fisheries and Aquaculture Sciences (CEFAS)
Civil Aviation Authority: Directorate of Airspace Policy
Countryside Commission
Countryside Council for Wales
Crown Estate
Danish Energy Agency
Danish Wind Turbine Manufacturers Association
Denmark Vindmolleforening
DETR:- Countryside Division, (Coastal Policy Branch) Environmental Protection, Strategy & Europe Division Environmental Assessment Division Ports Division Shipping Policy 3 Division Transport & Works Processing Unit
DTI-office of science and technology (marine foresight programme)
Dove Marine Laboratory
Dutch Bureau for Renewable Energy
English Heritage
English Nature
English Tourist Board
Environment & Heritage Service (Northern Ireland)
Environment Agency

ORGANISATION/COMPANY
European Wind Energy Association
Fawley Aquatic Research Laboratory Ltd
Foreign and Commonwealth Office
Fred Olsen Ltd
Friends of the Earth
Greenpeace
Hammond Suddards Solicitors
Haskoning Consulting Engineers and Architects
Health and Safety Executive
Hydrographic Office:-
Hydrographer of the Navy Wrecks Officer
Joint Nature Conservation Committee
M & N Wind Power Ltd
MAFF:-
Environmental Protection Division Fisheries Division III Fisheries Laboratory Flood & Coastal Defence Division Rural & Marine Environment Division - Marine Resources & Licensing
Marine Conservation Society
Marine Safety Agency
Ministry of Defence:
Directorate of Safety, Environment and Fire Policy
National Federation of Fishermen’s Organisation (NFFO)
National Trust
National Wind Power
NEG Micon
Oldbrecht Oil & Gas Services Ltd
PowerGen Renewables Ltd
Renewable Energy Systems Ltd

ORGANISATION/COMPANY
Radio Communications Agency
Royal Yachting Association
Royal Society for the Protection of Birds
Runge, Dr Karsten
Scottish Natural Heritage
Scottish Office
Scottish Power
Sea Fisheries Inspectorate
Sea Mammal Research Unit
Shell Renewable Energy
Trinity House Lighthouse Service, General Lighthouse Authority
UKOOA (United Kingdom Offshore Oil Association)
Vestas
Welsh Development Agency
Welsh Office
West Coast Energy
Western Windpower
Wind Prospect Ltd
WRE Generation Ltd
Worldwide Fund for Nature

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