MONITORING & EVALUTION OF BLYTH OFFSHORE WIND FARM

HEALTH AND SAFETY GUIDELINES

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AMEC Wind

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This is the fourth of seven reports to be published on specific areas covered by the monitoring and evaluation of the Blyth offshore wind farm project. The purpose of the reports is to evaluate and review the practical aspects of installation, access, operation and maintenance of the first UK offshore wind farm.

The other W/35/00563 reports are as follows:

- Installation and Commissioning REP/1
- NAVAID Requirements for UK Offshore Wind Farms REP/2
- Projected Capital Costs of UK Offshore Wind Farms Based on the Experience at Blyth REP/3
- Projected Operation and Maintenance Costs of UK Offshore Wind Farms Based in the Experience at Blyth REP/5
- Operational Aspects for UK Offshore Wind Farms REP/6
- Review of Wind Turbine Technical Performance REP/7

The overall planned duration for this monitoring and evaluation project is 24 months.

EXECUTIVE SUMMARY

1) THE AIM AND OBJECTIVES OF THE WORK

The purpose of this report is to review the practicability or impracticability of implementing the existing draft BWEA Guidelines using the construction and operation and maintenance of the Blyth Offshore wind farm project as a case study. The best practice guidelines have been drawn up with the support of a range of external organisations and in consultation with the Health and Safety Executive (HSE) with the aim of establishing a standard for health and safety on wind energy developments.

The purpose of the BWEA Guidelines is to offer some advice on health and safety issues that are specific to the wind energy industry. Satisfying the guidelines is not an indication of total compliance with the law. There is no substitute for knowledge of individual duties and legal requirements.

1) OVERVIEW OF THE PROJECT

The wind farm off the coast of Blyth, Northumberland, is the first offshore wind farm to be built in the United Kingdom. Two 2 MW wind turbines have been installed at a distance of approximately 1km from the coast, in a water depth, at low tide, of about 6m with a tidal range of approximately 5m. The completed project is the first in Europe to be exposed to the full force of the North Sea weather as well as a significant tidal range. The site is also subject to breaking waves.

The site location is on a submerged rocky outcrop. A chart showing the location of the turbines and the cable route is in Appendix A. Each wind turbine has been erected onto a steel pile (monopile) that was drilled and grouted into the rock. The 3.8m diameter holes for the pile were drilled from a jack-up barge and allowed to sink into the drilled socket. The monopile was then grouted into position and allowed to cure. When it had been confirmed that the monopile was secure in the hole, the sequence of erection was tower, nacelle and finally the rotor with the three blades attached.

The site has the benefit of all consents required for the installation of the turbines. An Environmental Assessment was produced and detailed site investigation studies were carried out and evaluated in order to complete the detailed design of the structure.

The Blyth Offshore Wind Farm has been developed by Blyth Offshore Wind Limited, a joint venture company between Powergen Renewables, Shell, Nuon and AMEC Wind. The diversity of experience and skills within these organisations has been brought together to pioneer the first project in what promises to be a new and exciting industry for the UK.

1) SUMMARY

The guidelines have been formulated for both onshore and offshore wind farms and much of the guidance is common to both. Throughout the guidelines the information relevant to both on and offshore sites is dealt with first followed by any additional guidance relating to the circumstances particular to offshore sites.

The draft BWEA Best Practice Guidance for Wind Energy Health and Safety were referred to during the construction, operation and maintenance of Blyth Offshore Wind Farm. In this report the guidelines are reviewed for their ease of use against the experience gained in putting the guidelines into practice.

1) CONCLUSION

The BWEA Best Practice Guidelines for Wind Farm Health and Safety is a very useful and thought provoking document. At the time of producing this report it was only available in draft form and had not yet been published. It is anticipated that they will be published in April 2002.

When released the final document will be an extremely useful tool to those involved at every stage of a wind farm project. From the experience gained in constructing, operating and maintaining Blyth Offshore wind farm it can also be said that the existing draft BWEA Guidelines should be implemented without any problems.

Throughout the planning, installation, commissioning and continuing through into operations health and safety has been the main priority. By working through and following legislation, guidelines, recommendations and continuously reviewing methods and procedures there have been no health and safety incidents at Blyth Offshore wind farm. The Health and Safety systems in place are working as they were intended.

As Blyth Offshore wind farm is only 1km offshore, some of the issues and recommendations detailed in the guidelines such as helicopter access and installing navigational aids on partially constructed turbines were never raised. However, they will clearly be of greater importance to larger wind farms that will be situated further offshore.

Finally it cannot be stressed enough that the guidelines are there to offer advice on health and safety issues and are not an indication of total compliance with the law. All parties involved in all stages of a wind farm project must still know and fully understand their individual duties and legal requirements.

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1 INTRODUCTION

1.1 Background

The wind farm off the coast of Blyth, Northumberland, is the first offshore wind farm built in the United Kingdom. Two 2 MW wind turbines have been installed at a distance of approximately 1km from the coast, in a water depth, at low tide, of about 6m with a tidal range of approximately 5m. The completed project is the first in Europe to be exposed to the full force of the North Sea weather as well as a significant tidal range. The site is subject to breaking waves.

The site location is on a submerged rocky outcrop. Each wind turbine has been erected onto a steel pile (monopile) that was drilled and grouted into the rock. The 3.8m diameter holes for the pile were drilled from a jack-up barge (the Wijslift), and the pile floated out and allowed to sink into the drilled socket. The monopile was then grouted into position and allowed to cure. When it had been confirmed that the monopile was secure in the hole, the sequence of erection was tower, nacelle and finally the rotor with the three blades attached.

The site has the benefit of all the consents required for the installation of the turbines. An Environmental Assessment was produced and detailed site investigation studies were carried out and evaluated in order to complete the detailed design of the structure.

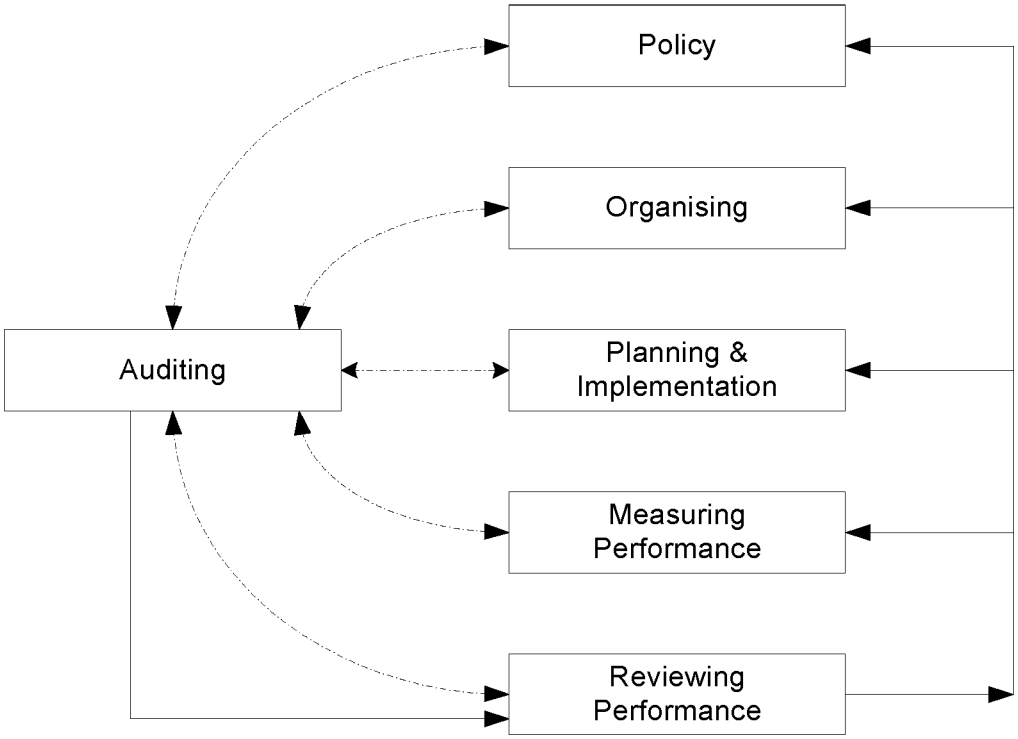
1.2 Aims & Objectives of this Report

The purpose of this report is to review the practicability or impracticability of implementing the existing draft BWEA Guidelines using the construction and operation and maintenance of the Blyth Offshore wind farm project as a case study. The best practice guidelines have been drawn up with the support of a range of external organisations and in consultation with the Health and Safety Executive (HSE) with the aim of establishing a standard for health and safety on wind energy developments.

The guidelines have been formulated for both onshore and offshore wind farms and much of the guidance is common to both. Throughout the guidelines the information relevant to both on and offshore sites is dealt with first followed by any additional guidance relating to the circumstances particular to offshore sites.

The purpose of the BWEA Guidelines is to offer some advice on health and safety issues that are specific to the wind energy industry. Satisfying the guidelines is not an indication of total compliance with the law. There is no substitute for knowledge of individual duties and legal requirements.

The HSE's publication HS(G)65 "Successful Health and Safety Management" sets out the principles for successful health and safety management.



Safety Management System Model (based on HS(G)65)

These elements have been identified as critical to the establishment of an effective safety management system for the management of any operation, including wind farms.

The draft BWEA Best Practice Guidance for Wind Energy Health and Safety were referred to during the construction, operation and maintenance of Blyth Offshore Wind Farm. In this report the guidelines will be reviewed for their ease of use against the experience gained in putting the guidelines into practice. In each section relevant extracts from the guidelines will be given first followed by comments/examples from the experience at Blyth.

The following people contributed to the BWEA guidelines:

- David Left (HSE)
- Dave Chaplin (HSE)
- Richard Boland (HSE)
- Matt Britton (Powergen)
- Peter Clarke (Powergen)
- Rod Blunden (National Wind Power)
- Niels Damm (Bonus)
- Anna Sturdy (Vestas)
- David Gardner (Scottish & Southern)
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- Simon Powles (RES)
- Peter Langcake (Peter Langcake Consultants)
- Steve Macken (Scottish Power)
- Alison Hill (BWEA)
- Richard Evans (Warwick Energy)
- Ian Ord (Setter & Associates)
- Joe Gray (Chartwell H & S)
- Bill Grainger (AMEC Wind)
- Alan Chivers (PMSS)

2 RISK ASSESSMENT

Guidelines

Risk Assessment is a key activity in the management of health and safety and is a legal requirement under legislation such as the Management of Health and Safety at Work Regulations 1999. The best way to decide what actions are needed to manage health and safety in the workplace is by the practical application of 'Risk Assessment'.

It is essential to adopt a systematic approach and decide who has the required experience to carry out a risk assessment.

The following headings are suggested as a guide:

Assessment of Risk for…..

- Activities
- Hazards identified
- Who might be harmed and how?
- Are there any existing control measures?
- Are further control measures needed?
- Record
- Review

Identifying and listing out the various activities involved enables the hazards that could result in significant harm to workers to be identified.

There is also a set of guide words that can be very useful in systematically identifying hazards, e.g. electricity; working at height; moving parts of machinery, substances etc.

Experiences at Blyth

Method Statements were produced by Vestas and AMEC Marine, for the turbine installation and the installation of the monopile respectively. Generic risk assessments were produced by AMEC Wind, they cover the following:

- Lightning
- High Voltage Electrical Plant
- Low Voltage Electrical Plant
- Manual Handling
- Foghorn Noise inside the Turbine (proven not to be an issue once installed)
- Lifting Tools and Materials into nacelle from boat

An example of one of the risk assessments is shown in Appendix B.

A HAZID (Hazard Identification) workshop was also held during the final planning stages of the project. Health and Safety was covered as part of the

workshop but there were no new items raised. All Health and Safety issues had already been covered.

During the installation of the first turbine the various activities were reviewed at each stage to evaluate the method of working but more importantly to review the Risk Assessments. The outcome of this review was to transport some of the turbine components on the crane barge instead of the dumb barge to make lifting easier. The turbine installation method statement needed modification to reflect this change but there were no new Health and Safety issues.

3 SITE DEVELOPMENT & PLANNING

3.1 Legislative Requirements

Guidelines
Important legislative requirements to consider at this stage will include:

- Health and Safety at Work, etc. Act 1974
- Electricity at Work Regulations 1989
- Electricity Supply Regulations 1988
- Noise at Work Regulations 1989
- Construction (Design and Management) Regulations 1994

Experience at Blyth
When developing the Blyth Offshore site it was very important to consider the Coast Protection Act 1949 on top of the other main legislative requirements as this was the main difference to developing onshore sites specifically:

- Section 34 – Restriction of Works Detrimental to Navigation

No person shall without the consent of the Secretary of State for Environment, Transport and the Regions:

- construct, alter or improve any works on, under or over any part of the seashore lying below the level of mean high water springs;
- deposit any object or any materials on any such part of the seashore, or
- remove any object or any materials from any part of the seashore lying below the level of mean high water springs,

if the operation causes or is likely to result in obstruction or danger to navigation.

The Secretary of State may, as a condition of considering an application for consent under this section, require to be furnished with such plans and particulars of the proposed operation, as he may consider necessary.

If the Secretary of State is of opinion that any operation will cause or is likely to result in obstruction or danger to navigation, he may refuse consent or give his consent, subject to conditions, having regard to the nature and extent of the obstruction or danger.

The legislative requirements referred to above were adhered to. A reference to this legislation was added to the BWEA guidelines after working on Blyth Offshore wind farm.

3.2 Wind Farm Layout

Guidelines
When selecting the position of wind turbines the usual items should be taken into consideration.

For offshore sites the following will also need to be considered:

- Shipping lanes
- Fishing grounds
- Dredging areas
- Pipelines
- Telecommunication cables
- Wrecks
- Explosive and other dumping grounds
- Military activity zones
- Coastal erosion

Experience at Blyth
These areas were checked extensively when selecting the position of the wind turbines at Blyth. It is very important to have accurate information at this stage. Not only to ensure good positions for the turbines but also to ensure safe working environment for the installation and also the operation of the wind farm.

The main concern at Blyth was the fishing grounds. Initial investigations showed that the other areas were not applicable.

Guidelines
The following site specific weather conditions will also need to be considered

- Any requirements for collection of oceanographic data
- Salt burdens in the atmosphere
- Oceanographic conditions, i.e. tides and likely wave conditions

The properties of the seabed and subsoil will need to be taken into consideration.

It is particularly important to obtain information on oceanographic conditions to evaluate safe access methods and working conditions for vessels during the construction and installation and also to enable accurate risk assessments and access procedures to be drafted for the safe operation of the wind farm.

The properties of the seabed and subsoil are primarily most important when selecting turbine positions but is also very important to know what conditions the vessels have to work in to produce accurate method statements and risk assessments.

Experience at Blyth
The Wijslift 6 (a six leg jack-up barge equipped with a 250t capacity crane) was used during the installation of the wind farm. The jack-up legs were lowered on the sea bed to raise the vessel above the water. The personnel operating the vessel needed to know the details of the sea bed conditions to enable them to fully assess their operational procedures, method statements and risk assessments. The jack-up procedure was fully tested on site before any work was carried out to ensure the safe working practice of the Wijslift in the conditions at Blyth.

To define the sea limits 0.5m marks were painted on the legs of the Wijslift in view of the Atlas transport barge so that the sea state could be measured.

3.3 Electrical System

Guidelines
With regard to the electrical system, the guidelines state that the considerations are

- Consultation with Distribution Network Operators (DNOs).
- Reference to British and European Standards on equipment supply
- Details of potential gradient and pH of soil and seabed in the case of an offshore site
- Capability to isolate, earth and lock off installed equipment as appropriate
- Establishment of short circuit levels
- Voltage regulation
- Suitable protection systems, e.g. fault clearance times, discrimination
- The details of potential gradient and pH of the seabed and subsoil
- Suitable arrangements to prevent damage to subsea cables

Experience at Blyth
All of the requirements for the electrical system were systematically worked through and fulfilled. An example of this is that the switchgear onshore enables us to isolate, earth and lock off the entire high voltage network to the wind farm allowing any work on the high voltage side to be carried out safely.

3.4 Site access

Guidelines
One of the most important areas to be taken into consideration when planning an offshore wind farm is the arrangements for site access.

- Access by specialised vessels, e.g. barges and lifting vessels, during the construction of bases and erection of turbines;

- Access by vessels and suitable arrangements for transfer of personnel and equipment to and from the vessel to the wind turbines for maintenance operations;
- Likely sea states.

When considering the siting of an offshore wind farm, it should be recognised that due to the nature of the environment, at certain times of the year it may not be possible to reach the wind farm for several days due to weather and sea state.

Experience at Blyth

All of the site access arrangements were looked into in great detail during the planning stage of Blyth Offshore wind farm and a great deal of research was carried out into what vessels and craft would be available at all stages of the project. Refer to 5.3 for more detail.

4 DESIGN, ASSEMBLY, MANUFACTURE & SPECIFICATION

4.1 Legislative Requirements

Guidelines
According to the BWEA guidelines the most important legislative requirements covering the design phase include:

- Health & Safety at Work etc. Act 1974
- Supply of Machinery (Safety) Regulations 1992
- Provision & Use of Work Equipment Regulations 1998
- Lifting Operations and Lifting Equipment Regulations 1998
- Workplace (Health, Safety and Welfare) Regulations 1992
- Electricity at Work Regulations 1989
- Construction (Design and Management) Regulations 1994
- Construction (Health, Safety and Welfare) Regulations 1996
- Electricity Supply Regulations 1988
- Ionising Radiation Regulations 1999
- Confined Spaces Regulations 1997

Experience at Blyth
All of the legislative requirements had to be considered by all parties involved in the design of the Blyth Offshore wind farm to ensure that everything specified complied with regulations and that the design had been carried out with Health and Safety as top priority.

4.2 Site Data

Guidelines
The following information is required by the designer:

- Detailed analysis of wind conditions, e.g. survival wind speeds;
- Other relevant weather/climatic information, e.g. incidence of freezing conditions;
- Risk of lightning;
- Soil conditions, e.g. resistivity, pH
- Ground conditions, e.g. mine workings
- Properties of the seabed and subsoil
- Details of the tides and currents
- Detailed analysis of historical data with respect to wave height and periodicity

Continuing needs for information about site conditions may require the installation of meteorological instruments and also the installation of instrumentation for the recording of oceanographic conditions.

Experience at Blyth
Detailed site investigation studies were carried out and evaluated in order to complete the detailed design of the structure and method of installation.

The ground investigations at the site revealed a different formation in the rock at the location of the second turbine and resulted in the second monopile being designed to be 2m longer than the first.

4.3 Wind Turbine / Associated Hardware Design

Guidelines
For offshore sites the following specific design issues need to be taken into account:

- Potential damage not only from wave and weather but also ship collisions;
- Access to the base of the wind turbines from a vessel, whether by mooring alongside a landing stage or by personnel basket transfer. Specialised commercial access systems and craft are available for this type of operation and fitting such a system should be considered at the design stage;
- Access by helicopter. The Civil Aviation Authority (CAA) publication CAP437 Offshore Helicopter Landing Areas: A Guide to Criteria, Recommended Minimum Standards and Best Practice provides comprehensive guidance on the design, construction and operation of offshore helidecks.
- Provision of accommodation, including shelter, heating, emergency power and supplies of food and water in case it is not possible to recover a maintenance crew due to weather or sea conditions;
- Storage for survival suits;
- Precautions for working over water;
- Provision of rescue/recovery arrangements for persons falling into the water;
- Provision of appropriate navigation aids, i.e. lights and foghorn;
- Provision of appropriate systems for communication between the wind farm and attendant vessels, with the shore and with the Maritime and Coastguard Agency in case of emergency.
- The need to undertake diving operations either during the construction or operational phases;
- The need to undertake sea remotely operated vehicle (ROV) operations during the construction or operational phases.

Experience at Blyth
Not all of these design considerations were applicable to Blyth as the site is only 1km offshore. Items 3, 5 and 11 were not applicable to Blyth as access is

by vessel, the survival suits are stored onshore and no ROVs were used. They would however, be extremely important to sites further offshore.

Guidelines

For offshore sites designers should aim to maximise the amount of fabrication, commissioning and testing work that can be done on shore in order that the amount of work to be done offshore can be minimised. This is an extremely important point and cannot be stressed enough.

The guidelines advise that consideration should also be given to the potential need to interrupt the offshore operations because of weather and sea state factors. The design should include an erection sequence that allows the partially erected structure to be left in a safe condition whilst waiting on weather. It is best to avoid the need for a prolonged weather window, which may be difficult to obtain during much of the year at many sites around the UK.

Experience at Blyth

The installation of Blyth Offshore was in fact interrupted by bad weather. The monopiles had been installed but then storms hit the site and prevented the tower installation from following straight on. This did not cause any problems or damage to the monopiles as consideration had been given to this problem when designing the wind farm components.

Guidelines

It will be extremely important to fit and commission navigation aids to the wind turbines at the earliest opportunity particularly on larger offshore wind farms.

Experience at Blyth

During construction of the Blyth Offshore wind farm the installation vessels were always at the site of one of the two turbines and therefore it was very clear where they were. On larger sites further offshore the installation vessels could be working on turbines that are quite a distance away from ones that have already been installed which is why the navigation aids should be fitted and commissioned at the earliest opportunity.

Another point that is made in the guidelines and one which was at the forefront of the minds of those selecting the contractors for Blyth Offshore is that offshore wind farm sites present very different hazards to onshore ones. Therefore it is important when selecting contractors to choose those with competence in the construction, operation, maintenance and removal of offshore structures.

5 CONSTRUCTION, COMMISSIONING, DISMANTLING & DEMOLITION

Guidelines
Throughout construction, commissioning, dismantling and demolition phases communication links will be required between:

- Client, designer, planning supervisor, principal contractor and contractors;
- With Statutory Bodies, e.g. HSE, HMIP;
- With Emergency Services, e.g. Police, Fire Brigade, Ambulance;
- To ensure relevant information is provided to sub-contractors and the self employed;
- with the Maritime Coastguard Agency and shore bases.

Experience at Blyth
Before and during installation of the Blyth Offshore wind farm the relevant notices were posted to the statutory bodies informing them of the project. The local emergency services were kept informed and also a meeting was held with the Maritime and Coastguard Agency to brief them and to clarify their emergency procedures. Also regular weekly project meetings were held with all parties involved to discuss the progress of the wind farm and also to keep everyone informed.

5.1 Emergency Arrangements

Guidelines
Offshore emergencies present different problems to those found onshore. Any emergency will have to be dealt with using the resources available offshore or on an attendant vessel. An emergency response plan for dealing with all foreseeable emergency situations, e.g. persons falling into the water, will need to be drawn up and subject to regular desk top exercises and drills. The emergency response plan will need to clearly set out the roles and responsibilities of everyone together with the actions to be taken to deal with all reasonably foreseeable scenarios requiring an emergency response. The plan should also address the need for the taking of persons to a place of safety, which means somewhere where medical treatment and other facilities are available. Any pollution risks will need to be identified and appropriate procedures established to deal with any pollution incident.

Experience at Blyth
The Health and Safety Plan implemented during the installation of Blyth Offshore wind farm covered all foreseeable emergency situations and different response plans. E.g. persons falling into the water were to be picked up by a boat if there was one already in the water but if not, then the Wijslift also had a 22ft RIB rescue boat that was ready to be lowered straight into the water in an emergency.

5.2 Temporary Facilities

Guidelines
For offshore sites, suitable sleeping accommodation for the workforce may have to be provided. Initially this might be on a vessel but at a later stage, depending on the nature of the base, it may be possible to provide accommodation on the farm itself. Such accommodation will need to include shelter, heating, emergency power and supplies of food and drinking water. In the latter case, the need to evacuate personnel in an emergency needs to be addressed and included in the scenarios covered by the emergency response plan.

Experience at Blyth
Blyth Offshore is located only 1km offshore so accommodation during installation was not an issue. Emergency supplies have been placed in each turbine at Blyth (including sleeping bags, food, drinking water etc.) should any persons working in the turbines have to stay there overnight. Any work on the turbines has to be carried out in daylight hours, but if the weather and sea state were to change to the point where the persons could not be safely removed from the turbines then the supplies are in place.

5.3 Site Access

Guidelines
Site access to offshore wind farms will be by vessel and will be dependent on the state of the tide and other factors. For construction of offshore wind farms, the transport, storage and handling of materials will involve the use of various vessels and careful thought will have to be given to their choice, taking into account water depth, currents and likely sea states.

Experience at Blyth
A dumb barge was used to transport the turbine components to the site at Blyth and they were then lifted into position by the crane on the Wijslift. The Wijslift was always jacked-up above the swell and it would have been preferable to have had a flat barge that could also be jacked up during lifting operations. The advantage being that if the barges were jacked up way above high water the lifting operations would not be subjected to any problems caused by swell.

Another point to note is that the barges used at Blyth were not self-propelled and had to be towed to site by tugs. While this did not cause any problems in the relatively short journey that had to be made from the storage facility to site, it would have implications for larger offshore sites. Towing barges to a site further offshore would have an impact on the time that it would take to travel to site from port. Self-propelled barges would take less time to move to and from site.

5.4 Weather Conditions

Guidelines
Before any work starts the project team and all parties involved in the construction and commissioning of the wind farm have to discuss, agree and hence define the wind, weather and sea state conditions that will stop work.

The operators and crew of all vessels and craft should know what conditions they can operate safely in and the turbine manufacturer should state what conditions the turbine components can be safely installed in.

The adverse weather policy, method statements and procedures should clearly define under what conditions work should cease. Once the conditions have been defined they should be continually assessed throughout the project as some unexpected difficulties may arise.

Experience at Blyth
To carry out the installation of the wind farm safely the Blyth Offshore project team agreed the weather and sea state limits for the various operations. The limits were agreed based on the experience of the vessel operators and the turbine manufacturer.

On site the wind speed was measured on the anemometer on the jib of the Wijslift. Limiting factors were set so that grouting operations could only take place during wind speeds of 10m/s or less in a swell of 0.5m or less. Lifting operations could only take place on site in wind speeds of 8m/s or less and in a swell no greater than 0.5m.

For personnel transfer to and from the Wijslift the main access ladder could be utilised at all states of the tide up to a deck level of +14.0m.

5.5 Communication

Guidelines
When persons are at work it should be ensured that contact can be maintained with 'key personnel', e.g. by mobile phones or radios. Procedures should be established for persons working alone or in small groups and it should also be made certain that workers from foreign companies can understand instructions and information.

Appropriate systems for communication between the wind farm and attendant vessels, with the shore and with the Maritime and Coastguard Agency in case of emergency, will need to be provided.

Experience at Blyth
Prior to construction at Blyth a meeting was held with the Maritime and Coastguard Agency to discuss the wind farm, methods of communication and emergency procedures. Radios were used throughout the lifting operations

and mobile phones were used to maintain contact between the team onshore, the personnel on the vessels and the transfer craft.

5.6 Lifting & Handling

Guidelines
For offshore sites, when selecting cranes, account should be taken of the marine environment and the additional stresses imposed on such equipment when lifting loads from a moving vessel. The additional difficulties associated with such operations should also be taken into account when assessing the competence of those involved, i.e. crane drivers and banksmen.

Loads to be sent offshore need to be suitably packed and secured for transport by sea, e.g. in purpose built containers or, in the case of large items, secured by appropriate sea fastenings to the deck of a barge or vessel. The need for sealed bags, flotation aids and recovery ropes on loads should also be addressed.

Experience at Blyth
All components that were loaded on to the Atlas barge for transportation were secured with sea fastenings. The turbine nacelles were transported and lifted in a special frame which provided protection as it left the floating barge.

During transportation of the rotor, the blades were rested on wooden frames and edge protectors were installed prior to any strapping of the blades. Tip packing was placed on the deck and the sea fastening chains were secured at the hub. The tag-lines that were needed during the lifting of the rotor from horizontal to vertical at site were attached to each blade tip before the barge sailed.

5.7 Information, Training & Supervision

Guidelines
For offshore sites, training in offshore survival techniques will be necessary. Appropriately trained and competent crew will be required for any vessels used to transport personnel and equipment to and from offshore wind farms.

Experience at Blyth
A Marine transfer Training Course was attended by all key project and maintenance personnel. The main purpose of this course was to give training in the techniques necessary to ensure safe access and transfer from the boat to the turbines and vice versa. The course covered personal protective equipment and workwear, the dangers of falling in the water and man overboard procedure as well as the safe method of access.

The course gave everyone involved the chance to gain confidence in transferring from a boat (moving vessel) to a static structure before any work started at Blyth. It was found to be very useful but for future wind farms

where access methods might be different, a revised course will probably be needed.

5.8 Safe Systems of Work

Guidelines

For offshore sites, appropriate procedures need to be devised and implemented for:

- The management of vessel movements, especially when several may need to be in the vicinity simultaneously;
- The transfer of personnel to and from a vessel to the wind farm;
- Tracking personnel between the wind farm and an accommodation vessel;
- Unloading and back loading supply vessels.

Experience at Blyth

As there was only one main vessel used for the installation of Blyth Offshore the management of the vessel movements and the transfer of personnel involved relatively simple safe systems of work.

A T-card system was used to track personnel during the installation. Each member of the team had a card with their name on it. There were two racks in the project office onshore and the cards were placed in the racks. The card was moved from one rack to the other by the person as they went offshore and moved back into the other rack when they returned. Basically it was a way of tracking how many people were offshore at any one time. A permit system utilising offshore access permits was used during commissioning.

6 OPERATION & MAINTENANCE

6.1 Legislative Requirements

Guidelines
The most important legislative requirements to consider will include:

- Health & Safety at Work etc. Act 1974
- Management of Health & Safety at Work Regulations 1999
- Electricity at Work Regulations 1989
- Electricity Supply Regulations 1988
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995
- Control of Substances Hazardous to Health Regulations 1999
- Provision and Use of Work Equipment Regulations 1998
- Workplace (Health, Safety and Welfare) Regulations 1992
- Personal Protective Equipment at Work Regulations 1992
- Manual Handling Operations Regulations 1992
- Confined Spaces Regulations 1997
- Fire Precautions (Workplace) Regulations 1997

Experience at Blyth
All legislation and legislative requirements are adhered to for the operation and maintenance of Blyth Offshore wind farm. If work needs to be done which has not previously been carried out then the risks are assessed and a method statement written referring to the relevant legislation.

6.2 Safe Systems of Work

Guidelines
The BWEA Guidelines state that for offshore wind farms, appropriate policies and procedures need to be devised and implemented with respect to site visits, distinguishing between planned maintenance visits and unplanned intervention visits in the event of a breakdown. The former can be carefully planned to ensure that such activities are undertaken during the summer when weather and sea conditions are likely to be at their most benign and more daylight is available. However, intervention visits may be necessary during the winter months and the policies and procedures should clearly reflect the adverse weather policy for the particular site to ensure that such visits are properly planned and only undertaken when conditions are considered to be safe.

Experience at Blyth
The Blyth Offshore access policy and procedure gives details of different levels of access and conditions for the different personnel that may visit the turbines. For instance persons needing to access the turbines for 'one-off' visits can access the turbines only if the weather and sea-state conditions are extremely good and also only if they are accompanied by someone who has completed the marine transfer training course. Where as maintenance

personnel who have completed the marine transfer training course can access the turbines at any time during daylight hours providing the weather and sea-state conditions are in within the limits given in the access procedure.

Anyone going out to the turbines at Blyth must always complete an offshore access permit before travelling out to the turbines. On this permit they must give the name of the person leading the party as well as the contact mobile telephone numbers and estimated duration of the work. Once the party is back on shore the permit can then be signed off.

6.3 Site Access

Guidelines
Site access by vessel will be dependent on the weather, tide and other factors. Appropriate policies and procedures need to be devised and implemented with respect to the transfer and personnel and equipment to and from a vessel to the wind farm. Careful thought will need to be given to the selection of vessels to be used. Specialised commercial access systems and craft are available for this type of operation.

Experience at Blyth
The method of access to the turbines at Blyth is by boat from Blyth Harbour. The boat that is used is shaped so that it can pull right up against the fenders on the monopile to achieve a stable position. The person waiting to transfer from the boat on to the turbine stands on the deck using a handrail for security and watches the motion of the boat until the wave pattern is understood. They then step across to the access ladder and climb to the main platform.

The weather and tide etc. must be within the limits set out in the Blyth Offshore Access Procedure before any working party can travel out to the turbines. The limits and the access method are reviewed regularly with all parties involved and are still found to be the safest way of working for this wind farm. Future wind farms may have different methods of access or even more than one depending on weather and sea conditions, number of turbines and location.

6.4 Communication

Guidelines
When persons are at work ensure that:

- They know exactly what they are permitted to do
- Installed equipment cannot be remotely started
- Someone knows when work is taking place on site
- Procedures are established for 'Lone Workers'
- Proper levels of 'supervision' are established
- Workers can be contacted in an emergency

For offshore wind farms, appropriate systems for communication between the wind farm and attendant vessels, with the shore and with the Maritime and Coastguard Agency in case of emergency, will need to be provided.

Experience at Blyth
Any working party going out to the turbines at Blyth must have at least one mobile phone and this number is recorded on the offshore access permit as contact number. Communciation between the working party, the boat and the shore is by mobile phone, but an offshore marine band radio is located in the turbines in case of emergency. The Maritime and Coastguard Agency can be contacted either by phone through the 999 service or on Channel 16 using the radio.

At Blyth Offshore lone working is not permitted, the working party must consist of a minimum of 2 persons.

6.5 Lifting & Handling

Guidelines
For offshore sites, when selecting cranes, account should be taken of the marine environment and the additional stresses imposed on such equipment when lifting loads from a moving vessel. The additional difficulties associated with such operations should also be taken into account when assessing the competence and training requirements of those involved, i.e. crane drivers and banksmen.

Loads to be sent offshore need to be suitably packed and secured for transport by sea, e.g. in purpose built containers or, in the case of large items, secured by appropriate sea fastenings to the deck of a barge or vessel. The need for sealed bags, flotation aids and recovery ropes on loads should also be addressed.

Experience at Blyth
Any equipment, materials or replacement parts (which are lifted from the boat to the turbines at Blyth) have to be contained within sealed bags. This is particularly important with regard to lifts of oil or similar materials. The bags must be capable of surviving a drop from nacelle height without spilling their contents.

6.6 Safety Equipment

Guidelines
In the case of offshore wind farms, consideration needs to be given to the provision of such items as survival/immersion suits, lifejackets, buoyancy aids, throwing lines and personal location beacons.

Experience at Blyth
At Blyth Offshore all operation and maintenance personnel must wear a flotation suit and lifejacket when going to and from the turbines. When

climbing the access ladder to the access platform they must also wear a safety helmet with a chinstrap. There is also some additional safety equipment stored in each of the turbines including first aid kits, throwing lines, lanterns, hypothermia blankets and food, drinking water, sleeping bags etc. in case there is a dramatic change to the weather and the personnel are unable to get off the turbines.

6.7 Maintenance Programmes

Guidelines
Periodic maintenance/inspection/testing procedures should be established for:

- Installed safety devices, e.g. overspeed devices, electrical protection
- Safety features, e.g. attachment points for safety harnesses
- Installed lighting and emergency back up
- Electrical earthing and lightning conductors
- Equipment installed with high integrity, e.g. blade fixings
- Access plant and equipment
- Mechanical handling equipment
- Cathodic protection and coating systems
- Seabed scour, etc
- Foundation integrity

Experience at Blyth
As part of the operations and maintenance contract Vestas are responsible for arranging the maintenance programmes, which include checking and maintaining the safety features.

7 CONCLUSION

The BWEA Best Practice Guidelines for Wind Farm Health and Safety is a very useful and thought provoking document. At the time of producing this report it was only available in draft form and had not yet been published. It is anticipated that they will be published in April 2002.

When released the final document will be an extremely useful tool to those involved at every stage of a wind farm project. From the experience gained in constructing, operating and maintaining Blyth Offshore wind farm it can also be said that the existing draft BWEA Guidelines should be implemented without any problems.

Throughout the planning, installation, commissioning and continuing through into operations health and safety has been the main priority. By working through and following legislation, guidelines, recommendations and continuously reviewing methods and procedures there have been no health and safety incidents at Blyth Offshore wind farm. The Health and Safety systems in place are working as they were intended.

As Blyth Offshore wind farm is only 1km offshore, some of the issues and recommendations detailed in the guidelines such as helicopter access and installing navigational aids on partially constructed turbines were never raised. However, they will clearly be of greater importance to larger wind farms that will be situated further offshore.

Finally it cannot be stressed enough that the guidelines are there to offer advice on health and safety issues and are not an indication of total compliance with the law. All parties involved in all stages of a wind farm project must still know and fully understand their individual duties and legal requirements.

Appendix A – TURBINE LOCATIONS & CABLE ROUTE

(NB - Map available only in hard copy)

Reproduced from Admiralty Chart 1626 by permission of the Controller of Her Majesty's Stationery Office & the Hydrographic Office's of France & United Kingdom.

Key
Darkest shaded areas have a depth of 5m or less
Mid shaded areas have a depth of 5-10m
Lightest shaded areas are deeper than 10m
(All depths are taken at Lowest Astronomical Tide)

Appendix B – HEALTH AND SAFETY RISK ASSESSMENT

AMEC WIND
Health and Safety Risk Assessment

Done by	Date 28 January 2002	Assessment No
Bill Grainger	Review Date 28 January 2004	16

Hazard **Marine Transfer**

- moving from quayside into small vessel and then from vessel to offshore wind turbine (and vice versa)
- falling between the vessel and a structure
- falling onto a vessel from a height
- drowning

People at risk

Anyone accessing an offshore wind turbine

Measures to control risk

Design

- fenders provided to stop boat crushing someone on ladder
- no climbing harness to attach and cause delay in danger zone

Access control

- weather and water state to be assessed before visits and access only allowed if these meet specified criteria
- no access at night
- access ladders to be assessed for oil and marine growth and cleaned before visit if necessary
- only authorised personnel and restricted number of visitors allowed to make transfer
- only approved boats to be used

Training

- authorised personnel to be trained in Marine Transfer and in accessing each offshore wind farm
- training reviewed regularly and updated every three years

PPE

- lifejackets and flotation suits to be worn
- gloves, helmets and boots to be worn
- nothing to be carried, all equipment to be hauled separately

FOLLOW BOWL ACCESS PROCEDURE, ONLY AUTHORISED PEOPLE WHO HAVE EXPERIENCE OR TRAINING CAN LEAD A PARTY

Measures to reduce risk further

Boat positioning

- whenever possible, boat to stand-off a little as ascent is made up the ladder
- whenever possible, access to be made at high tide

HAZARDS IDENTIFIED

MECHANICAL	FIRE/EXPLOSION
TRANSPORT	RADIATION
ACCESS **yes**	BIOLOGICAL
ELECTRICITY	ENVIRONMENTAL **yes**
SUBSTANCES/CHEMICALS	ORGANISATIONAL
HANDLING **yes**	INDIVIDUAL

A	HARM/CONSEQUENCE		1	2	3	4	5	RISK(A*B)=
						X		
B	LIKELIHOOD		1	2	3	4	5	
					X			

Likelihood	Harm/ Consequence				
	Minor	<3 days	3 days+	Major	Death
12/25	1	2	3	4	5
1 Extremely unlikely	1	2	3	4	5
2 Unlikely	2	4	6	8	10
3 Likely	3	6	9	X	15
4 Very Likely	4	8	12	16	20
5 Certain	5	0	15	20	25

C	FREQUENCY OF EXPOSURE	0	1	2	3	4	5	EXPOSURE FACTOR (C*D)=
							X	
D	NUMBER OF PERSONS EXPOSED	0	1	2	3	4	5	10 / 25
				X				

SUMMARY / INTERPRETATION

This risk is present every time an offshore wind turbine is accessed. Training and close supervision are required to minimise the risk.