The International Marine Contractors Association

Renewable Energy

Position Paper

www.imca-int.com

August 2005

The International Marine Contractors Association (IMCA) is the international trade association representing offshore, marine and underwater engineering companies.

IMCA promotes improvements in quality, health, safety, environmental and technical standards through the publication of information notes, codes of practice and by other appropriate means.

Members are self-regulating through the adoption of IMCA guidelines as appropriate. They commit to act as responsible members by following relevant guidelines and being willing to be audited against compliance with them by their clients.

There are two core activities that relate to all members:

- Safety, Environment & Legislation
- Training, Certification & Personnel Competence

The Association is organised through four distinct divisions, each covering a specific area of members' interests: Diving, Marine, Offshore Survey, Remote Systems & ROV.

There are also four regional sections which facilitate work on issues affecting members in their local geographic area – Americas Deepwater, Asia-Pacific, Europe & Africa and Middle East & India.

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This paper has been produced by a workgroup under the IMCA Europe & Africa Section, to provoke comment, discussion and consideration of techniques, processes and operations in the field of renewable energy.

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Renewable Energy Position Paper

August 2005

1 Executive Summary

IMCA has prepared this position paper to assist and inform its members with regard to offshore renewable energy. This paper gives an overview, outlining some of the important engineering, safety, commercial and contractual issues, and a number of the technological developments that are of interest to IMCA members. The paper touches upon the developing offshore renewables market, and the need for raising awareness amongst offshore renewables contractors about IMCA members, their expertise and their experience in marine construction. There is some discussion of the appropriate sharing of risk at contractual level between client and contractor, and the paper concludes by highlighting the need for a high standard of proactive safety culture, and a discussion of technical issues facing the industry today, including the important matter of 'marinisation' of land-based equipment for use offshore.

In conclusion, the main points of the paper can be summarised as follows:

- IMCA members support the development of offshore renewable energy;
- Clients could assume greater co-ordinating responsibility than exists at present between various contractors on site;
- The scale, timing and planning of construction of offshore renewable installations should be clearer to help the effective development and availability of marine spreads;
- High levels of safety awareness are key in this industry and already exist amongst IMCA members;
- The importance of 'marinisation' and adaptation of land based equipment and procedures for use in the offshore environment.

2 Introduction

2.1 Background

The field of renewable energy systems has featured highly recently due to various factors, including the steps taken to reduce our dependency on fossil fuels in the form of agreements to reduce pollution and undertakings to increase energy production from renewable resources. There are several areas under research and consideration at the moment:

- wind forces;
- tidal ebb and flow;
- wave energy;
- ocean thermal energy conversion (OTEC);
- photo voltaic generation;
- bio mass heat and gas production;
- solar heat absorption.

Whilst the current focus for the offshore sector is wind turbines, and by far the largest investment is being made in that area, this paper includes a review of wave and tidal power generation. Please see Appendix 1.

From initial sizes of around 500 kW, some manufacturers are developing theoretical designs for turbines capable of producing up to 20 MW with up to 220m turbine blade diameter, though deployment of such large blades would pose considerable technical challenges. Although there are various ways of assembling a tall structure offshore, a high hook height is often useful; there is no floating equipment available with a hook height greater than 150m above sea level. If such a hook height were essential, only the largest and most expensive oil and gas drilling jack-up rigs could reach this height if located in very shallow water.

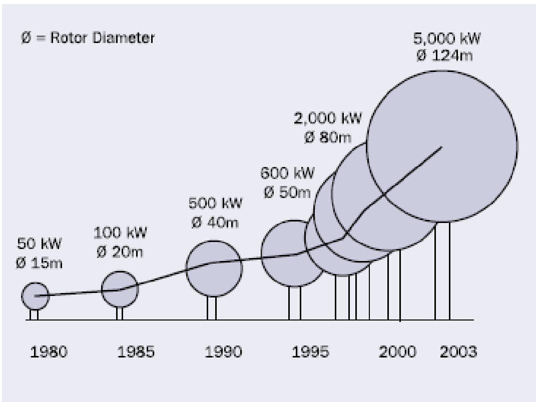


Figure 1 – *The development of turbine blade size and power generation capability over the last 25 years*
Source: "Wind Energy – the facts" by the European Wind Energy Association

Installation offshore has been undertaken by a variety of companies, some of them IMCA members. The shallow water depths of the developments have not allowed access for deeper draft vessels. IMCA's seminar on 11 June 2004 indicated that many members are watching developments in this market as the volume grows and projects move into deeper water.

2.2 Scale

The World Offshore Wind Database, produced by consultants Douglas-Westwood, provides information on 192 projects with a total of 69GW of capacity, 17000 turbines and US$108 billion of expenditure, including 40,000km of subsea cabling.

The UK government has pledged 10% of its electrical power requirements to be met from renewable sources by 2010. Renewables accounted for 2.7% of the electricity generated in the UK in 2003 (*UK Energy in Brief*, July 2004).

Wind energy is expected to contribute around 7 to 8 per cent of electricity supply in 2010. Half of this is expected to come from offshore wind farms.

Other European countries have a similar approach. The EWEA has estimated that 5GW of the 60GW predicted for 2010 will be coming from the offshore sector. However, the track record is that only a proportion of the prospective projects go ahead.

3 Legislation and Guidelines

There is a considerable legislative burden to be negotiated wherever offshore wind farms are proposed. A good source on relevant legislation is the British Wind Energy Association (BWEA) and its publications, in particular *"Guidelines for Health and Safety in the Wind Energy Industry"*, though this refers primarily to the UK.

Please refer to Appendix 2 for further and more detailed information.

3.1 Depth of Burial of Power Cables

There is a difference in legislation in this area, between offshore oil and gas and renewables. The power cables for renewable energy projects are required to be buried deeper (1.5-2.5m instead of 0.6m approx.) This is possibly for reasons of coastal anchoring, shallow water scour or beach crossing requirements. Each of these concerns is normally smaller for offshore oil and gas projects.

4 Existing Wind Farms and Planned Wind Farm Developments

4.1 Existing Wind Farms

There are currently four offshore wind farms in the UK: a two-turbine 4 MW development at Blyth, a 30-turbine 60 MW development at North Hoyle off the coast of North Wales and a third 60 MW offshore wind farm at Scroby Sands, offshore Norfolk, which came on-stream in December 2004. The fourth is the 90 MW Kentish Flats wind farm, currently nearing completion, which should be commissioned during 2005.

In Europe, the Danes lead the field with seven wind farms with total capacity of 400 MW, generated by some 200 turbines, including the Horns Rev wind farm which alone has eighty turbines. It is to be noted that there were turbine problems during 2004 which necessitated the manufacturer removing all eighty turbines for repair, though this operation was completed by December 2004. Sweden has three wind farms generating 23 MW from 17 turbines. There are two wind farms offshore Holland, and one offshore of the Irish republic. (Source: BWEA)

4.2 Planned Wind Farm Developments

4.2.1 UK Round 1

These are projects in the planning stage, some of which have been constructed, but many have not. It is considered by some industry figures that appropriate financing is difficult to procure at this time for the construction of these planned wind farms, perhaps owing to institutional reluctance to invest in the offshore wind industry.

All the proposed Round 1 sites are in less than 20m of water, and no further than 12 nautical miles offshore (source: UK Crown Estate, *www.thecrownestate.co.uk/34_wind_farms_04_02_07.htm*).

4.2.2 UK Round 2

These are also projects in the planning stage, some of which are outside the 12 mile limit, in the Wash/offshore East Yorkshire, offshore North Wales and offshore Morecambe Bay, and in the Thames Estuary. These are all in water less than 30m deep.

4.2.3 Talisman Energy *Demonstrator* Project at Beatrice in the Moray Firth, UK

This summer (2005) Talisman Energy and Scottish & Southern Electricity will be starting construction of wind turbine structures in 35-45m of water, in the former Beatrice oilfield in the Moray Firth. It is considered that second phase of this wind farm, with many more turbines, will not be built on this site until 2009.

4.2.4 Summary

A summary of existing and future wind farm projects in Europe and in the UK is given in the following table.

Country	Location	Wind farm projects			Turbines	Total power (MW)	Remarks
		Approved	Planned	Build Date			
UK	Blyth			Dec-00	2	4	
UK	North Hoyle			Nov-03	30	60	
UK	Scroby Sands			Nov-04	30	60	
UK	Kentish Flats			Jun-05	30	90	nearly completed
UK		9			400	1016	
UK			17		?	7583	
Sweden	Bockstigen			1997	5	2.75	
Sweden	Utgrunden			2000	7	11	
Sweden	Yttre Stengrund			2001	10	5	
Sweden		3			88	244	
Sweden			8		584	2255	
Spain			6			2563	
Ireland	Arklow Bank			2003	7	25	
Ireland	Arklow Bank			2003	7	25	
Ireland			7		?	?	
Holland	Ijsselmeer			1994/6	32	19	
Holland		2			99	220	
Germany	Emden			2004	1	1	
Germany		9			730-3022	2700-14545	
Germany			28		7296	57086	Minimum
France			2		17	60	
Denmark	Vindeby			1991	11	5	
Denmark	Tuno Knob			1995	10	5	
Denmark	Middlegrunden			2000	20	40	
Denmark	Horns Rev			2003	80	160	
Denmark	Samso			2003	10	23	
Denmark	Frederickshavn			2003	3	11	
Denmark	Nysted			2003	72	165	
Denmark			2		160	200	Horns Rev II/ Nysted II
Belgium		1			60	300	

Table 1: *Existing Wind Farms and Planned Wind Farm Developments*

Source: "*Offshore wind – implementing a power house for Europe*", a document prepared by Deutsche WindGuard GmbH for Greenpeace. http://www.greenpeace.org/raw/content/international/press/reports/offshore-wind-implementing-a.pdf

4.3 Repowering

Another development which is of interest to IMCA membership is the European market for 'repowering', which is the practice of replacing older and smaller wind turbines with newer models of larger size and capacity. The European Wind Energy Association expects that this could contribute significantly to business in the longer term.

4.4 Conclusion on Market Size

Although the above discussion indicates a large, wide future market, the industry track record is that projects get delayed or cancelled. Project finance and the industry's capacity to deliver (manufacturing turbines and installation vessels are two examples) are both natural constraints.

5 Raising Awareness

Several companies (contractors and consultants) are members of both IMCA and the BWEA. It is possible that some of that membership in common may be able to assist in raising the profile of IMCA members within the renewable energy industry. An IMCA presence, either through one of the members or someone from the secretariat, at wind energy events would also help. Some form of liaison or representation from our members to the renewable energy industry would be fruitful in raising awareness of members, spreading knowledge of our members experience and resources in offshore construction, and perhaps dispelling any preconceived ideas of 'gold plated' offshore oil industry contractors. It is acknowledged that this process is not straightforward and may take some time.

The installation of several offshore wind farms has been performed by predominantly inshore oriented companies with smaller vessels, rather than offshore companies. However, recent initiatives, including the incorporation of a decommissioned oil field infrastructure, have seen the inclusion of established offshore contractors in this emerging market, particularly as the water depth increases and the facilities utilised involve traditional offshore service company clients.

6 The Market

The tasks involved in turbine installation and other marine operations include:

- Pre-project site survey

  The Offshore Site Investigations & Geotechnics Group (OSIG) of the Society for Underwater Technology (SUT) has developed guidelines for offshore site investigations. These can be found at http://www.sut.org.uk/htmfoldr/sutosig.htm#OSIG_Presentations
- Design and other services
- Transportation and installation
  - Barge/vessel transport
  - Heavy lift
  - Drilling or piling
  - Diving operations/ROV operations
  - Dredging
  - Sub sea engineering
- Cable design manufacture and installation
  - Cable laying
  - Cable burial/protection, including shore crossing
  - Cable Stabilisation
- Structural and foundations design
  - Site survey
  - Geological assessment – how many boreholes need to be drilled, and where and when to drill them
  - Tidal and environmental assessment
- Marine operations
  - Transportation of personnel/equipment
  - Maintenance
  - Safety and standby vessels

- Survey
  - Survey during works (liaison with all on-site contractors), for example: positioning of structures and construction vessels; Hydrographic survey of seabed (including scour and movements of sand banks) and jack-up spud-can footprints; cable route/burial survey, and as-built surveys.
- Removal and decommissioning

7 Research and Development

Research and development continues to corner a large part of the industry current expenditure. Methods of transportation, transfer and installation continue to be developed to meet the needs of increased size and financial prudence. Current installation practice is to use a jack-up platform and recent efforts have seen the introduction of purpose-built jackable vessels. R&D on the installation side has been led by sub-contractors but increasingly interest has been shown by the main contractors as the financial size and water depth of projects increases.

Current focus seems to be on the need for vessels to transport and install several turbines without the need to return to shore between installations. However the return on investment required to finance the design and build of such a vessel without a guaranteed return in this developing market is a risk that few are willing to take, consequently existing assets are also being modified and operational procedures developed to accommodate client needs.

Sub-structure design has followed the early route of substructures for offshore oil and gas, with every possibility put forward: steel mono pile; four-leg platform, tripod; concrete/steel gravity and floating. The trend is, perhaps, towards mono-pile, either drilled and grouted or driven. Mono-piles appear economical in shallow water depths, but water depths of 25-40m will require more sophisticated sub-structures.

8 Contracting

IMCA has recently published its Contracting Principles, a discussion document that it believes will serve the long-term interests of all participants in the oil and gas industry by encouraging an equitable contractual balance based on the parties' respective risks and rewards. This, in turn, should improve relations, increase efficiency and reduce overall costs. These principles are equally applicable to the renewable energy industry. At the heart of the principles are risk allocation goals with the very apt acronym 'FAIR':

- **F**air (not equal) and realistic distribution of risk in proportion to relative rewards
- **A**llocation of risk - to the party best placed to assume
- **I**nsure - sufficient scope of cover
- **R**easonable - avoid "duplicate" assumptions of risk and minimise potential for dispute

This new industry has not yet established a 'typical' contracting method, e.g. turnkey or multi-contract. Nor has it spawned a 'typical' lead contractor, e.g. the turbine supplier, the fabricator or the installation contractor. Some parallels exist with the offshore oil and gas industry where concerns have emerged recently about inequitable contracts and risk sharing. IMCA has undertaken to be proactive in this area.

On some offshore wind farm construction projects, the manufacturer of the wind turbines has taken on the entire contract for the installation, and then sub-contracted the building and installation to sub-contractors.

In the Horns Rev installation, there were discussions between the turbine designers and the cable installers to address a number of issues, including

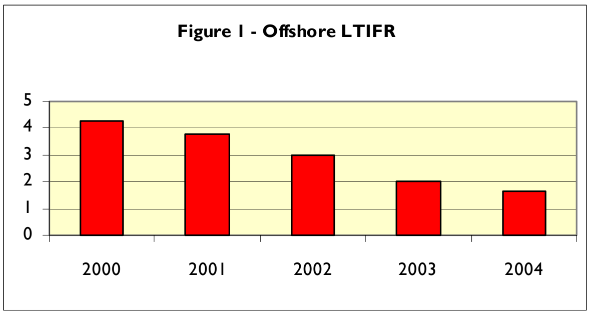
- Safe tower access
- J-tube design
- Pulling methods and appropriate fittings on the tower
- Access to power and lighting on the tower during construction
- Protection of the tower and platform from the elements

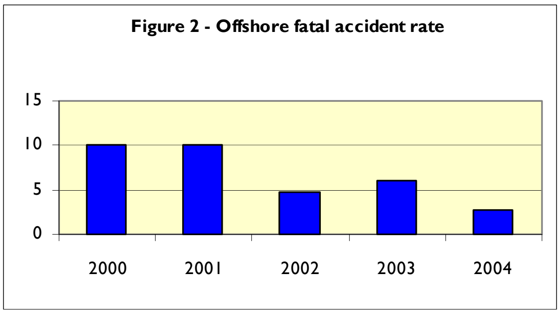
However, other projects have reported that co-ordination between the various contractors regarding project interfaces could have been better. Good co-ordination improves efficiency, avoids waste and improves safety.

9 Safety and Environment

Safety remains a key issue for all IMCA members and it will remain so in the offshore renewable energy installation market. Offshore oil and gas operators have developed high standards of safety and have great experience, garnered over many years, of a proactive approach to safety awareness. It is appropriate that the benefit of these high safety standards and proactive approach to safety is brought to the players in the offshore Renewables marketplace.

IMCA publishes a variety of safety guidelines and pieces of information. These focus on preventative measures and incident limitation measures. In the last few years IMCA's safety statistics tell the story and show the results achievable when sufficient emphasis is placed on safety and 'buy-in' is achieved. But the effort is never-ending – one accident is too many, and new ideas and ways of communicating the message of safety continue to be sought. IMCA is discussing common approaches with the BWEA Safety Committee.





Above in Figures 1 and 2 are IMCA members' offshore LTIFR and Fatal Accident Rate (FAR) for recent years, demonstrating the tangible benefits in reduced accidents of a proactive approach to health, safety and environment. (source: IMCA 2004 safety statistics)

This prudent approach to safety, planning and operational efficiency generally makes good commercial sense, and in terms of marine contracting, cannot be regarded as 'gold plating'.

Safety considerations during design and installation procedure development should remain the primary focus. Issues to be studied include personnel access, preparation of installation aids and sharing knowledge between contractors in the field. On the Horns Rev project, one of the contractors considered joint safety and co-ordination meetings between all the contractors to be important. These meetings included such matters as:

- scheduling of offshore operations;
- on-site vessel co-ordination;
- sharing of safety resources (diver decompression facilities, standby vessels, etc.);
- incident reporting and lessons learnt;
- emergency procedures.

Environmental issues, whilst well addressed on a global front, are still to be fully developed on a local basis.

9.1 Personnel Access

Whilst the use of small boats for personnel transfer is no longer permitted in the North Sea oil industry, it will probably be employed for access to offshore wind turbines. The risk of accidents during access is high, particularly at the time of transfer to and from the small boat to the turbine tower, as this could be affected by waves, marine growth or significant tidal variation. Many persons with little, if any, maritime experience could be working on the structures. Estimates published for the Talisman project at Beatrice in the Moray Firth suggest that there will be the need for five 'interventions' per turbine per year. When consideration is given to the fact that 200 turbines are proposed, this adds up to a great deal of access.

9.1.1 Personnel Transfer at Sea

During the Horns Rev wind farm construction offshore Denmark, a number of aspects of personnel transfer were an issue, including between boats, on and off the turbine towers and on and off the accommodation vessel. Obviously wind farms are necessarily sited where wind – and hence sea conditions – are frequently high. In shallower water (on sand banks), short or breaking waves are also an issue for small vessels.

9.1.2 Transfer of Personnel onto the Turbine Towers

The Horns Rev construction contractor found that design of the docking station on the turbine tower was an issue, as was ladder and back-up ladder positioning. Alternative methods of access became an issue too, as did the robustness of the docking area and platform. Such matters as the strength of the flooring, availability of space, lighting and power, and protection and paintwork were all potential challenges. All of these problems occurred because the working area at the foot of the tower was designed for maintenance access, not the needs of the installation contractors.

The Horns Rev installation contractor had to consider the possibility of 'survival packs' in the turbine towers, should any staff be trapped there by weather or sea conditions for more than a few days.

R&D is being conducted into a boat access solution to facilitate safe personnel access to offshore installation. See http://www.caley.co.uk/Pages/boat.htm

9.2 Cable Tensions During Installation

The Horns Rev installation highlighted the need for monitoring cable tensions whilst the cable is being pulled through the J-tube assembly. Also highlighted were the issues of cable drum movements and transfer of cables offshore during construction.

9.3 Beach Safety During Construction

During the construction of the North Hoyle wind farm offshore North Wales, electrical cables for the grid connection had to be buried under a busy urban beach near Rhyl. The installation contractor was faced with the challenges of maintaining a safe working environment and protecting the public on that beach whilst the installation work was going on, without actually closing the beach to public access.

9.4 'Punch-Through' and Platform Leg Footprints

There are risks involved in jack-up platform operations. The platform will leave a 'footprint' on the seabed which may restrict the positioning of subsequent platforms owing to the nature of the footprint crater. Also, there is the possibility of 'punch-through' where the leg of a jack-up platform can suddenly penetrate a hard surface layer of seabed into softer material underneath, causing the platform legs and structure considerable stress. These issues need to be guarded against in the context of wind farm installation.

9.5 Sand Banks, Rubble and Other Debris on the Seabed

Close inshore, and especially on the sea-bed around former oil-fields, it is possible that there will be debris of various kinds on the seabed which could hinder the operation. This debris could form a hazard to divers and/or vessels and jack-ups. Debris could include scour protection, pipelines, drill cuttings and other material from the platform.

9.6 Ordnance

Unexploded ordnance, including mines, shells and bombs, can be and has proved to be a hazard which marine contractors need to consider.

9.7 Diver Access

Tidal action in coastal waters is often considerable; on some installation operations in heavy tidal waters, the divers have had only a few minutes access time at slack water. Sea state must be considered also, as wind farms are generally situated where it is windy! In general, projects benefit from good planning to avoid diver intervention as much as possible.

9.8 Sea Bed Scouring Caused by Tidal Action

There is considerable current to deal with in the areas marked out for wind farm development, and sea-bed scouring could prove a problem, insofar as currents can and do exert considerable force over material at the sea bed, for example, dragging away construction material, or in the long term, exposing the foundations and piles of a turbine tower, putting the installation in danger, exposing buried high tension power cables or affecting navigation channels.

10 Technical Issues

10.1 Cable Laying

Laying power cables for wind farms is complex, primarily in terms of the short distances involved. Contractors are experienced in laying longer cables, perhaps 3-4 km in length, but the requirements for a wind farm are typically of the order of 500m, with perhaps 30 separate legs of this length. This could be complex for a cable layer, and research into a better way of cable laying might be called for.

10.2 J-Tube Design and Cable Pulling Operations

Recent installations mean that there is some expertise in laying and connecting cables on offshore wind farms. Some of the issues that have already been faced are

- design of messenger wire and plug in the J-tube;
- water ingress;
- J-tube bell mouth design;
- winches and power packs;
- pulling cable from the vessel;
- pulling brackets and padeyes on the turbine tower;
- access and working space on the tower.

10.3 Installation Vessel Design

The contractor must consider what form of installation vessel to employ, perhaps depending on the sea water depth at the site. The primary choices faced have been between jack ups, spudded barges and floating ships/barges. Issues to consider as well as the draught and motion of these vessels are the size, the manoeuvrability and deck spread of such vessels.

10.4 Diving

Owing to the strong tides and currents found in areas chosen for offshore wind farms, diving will be limited to slack water. This would become an even bigger issue for the installation of tidal energy generators since these would of necessity be installed in areas of greater tidal variation.

In theory the construction of offshore wind farms should be made as diver-less as possible, and it is interesting to note that Talisman Energy intends to make use of diver-less tie-in to the turbines on the Beatrice Demonstrator Project (source: Talisman Energy). Nevertheless diver-less installation could pose difficulties to construction contractors.

In the Horns Rev installation there was discussion of techniques for reducing diver operations, including redesigning the J-tube bell mouth, how to recover the J-tube pull messenger wires, and appropriate design of J-tubes to remove risk of blockages.

10.5 Maintenance and Plant Life

Equipment primarily designed for use on onshore wind farms will need robust 'marinising' to achieve reliability with low maintenance, because access to the wind turbine will be expensive and difficult. Turbine towers should be equipped to offer appropriate temporary shelter and nourishment to maintenance crews should they be trapped by weather and sea conditions.

11 Conclusion

In conclusion, IMCA members support the development of renewable energy, and are increasingly involved in offshore renewable construction projects. However, there are a number of offshore renewable energy contractors who are not members of IMCA. Some of these organisations are members of the British Wind Energy Association (BWEA), whilst others are members of both IMCA and the BWEA. There exists some synergy between the BWEA, IMCA and a number of other trade associations, and IMCA is resolved to work together with the BWEA in the offshore renewables industry. The purpose of this paper has been both to inform IMCA members, and to solicit feedback from the industry, reflecting the fact that knowledge sharing will be beneficial to the industry.

The paper has highlighted areas where further R&D expenditure may be necessary, and areas where commercial development has further to proceed. The variety of tasks involved in the offshore renewables marketplace is reflected in the paper, as are a number of relevant technical and commercial issues, including cable laying, J-tube and installation vessel design, diving, and personnel access.

The important matter of safety is dealt with in some detail, and the paper highlights the tangible benefits in reduced accidents of a proactive approach to health, safety and environment, conducted through a wide range of preventative measures and mitigation mechanisms. IMCA will continue to work in tandem with the BWEA Safety Committee in this area, as we find new ideas and ways of communicating the message of safety.

The scale, timing and planning of offshore wind farm installations is not yet completely predictable. The position paper suggests that though the market-place for offshore renewables may become larger in the future, at the present time project finance and industry capacity to deliver may constrain development. IMCA members continue to monitor developments in the market as volume grows and projects move into deeper water.

IMCA members can look forward to contributing to the offshore renewables market, which should grow in the medium-term future, and are in a position to bring considerable technical expertise and safety experience to a new and growing industry.

References

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Other Offshore Renewable Energy

Wave Energy

There are three main types of wave power machines, some of which sit on the shoreline while others are free-floating.

- **Oscillating Water Column**

  An oscillating water column is a partially submerged, hollow structure that is installed in the ocean. It is open to the sea below the water line, enclosing a column of air on top of a column of water. Waves cause the water column to rise and fall, which in turn compresses and depresses the air column. This trapped air is allowed to flow to and from the atmosphere via a Wells turbine, which has the ability to rotate in the same direction regardless of the direction of the airflow. The rotation of the turbine is used to generate electricity. The LIMPET installation on the island of Islay in Scotland (see conclusion below) is an example of this device.

- **Buoyant Moored Device**

  A buoyant moored device floats on or just below the surface of the water and is moored to the sea floor. A wave power machine needs to resist the motion of the waves in order to generate power: part of the machine needs to move while another part remains still. In this type of device, the mooring is static and is arranged in such a way that the waves' motion will move only one part of the machine.

  A form of this device now undergoing tests offshore Portugal, is the Archimedes Waveswing. For more details see *http://www.waveswing.com/*

- **Hinged Contour Device**

  A hinged contour device is able to operate at greater depths than the buoyant moored device. Here, the resistance to the waves is created by the alternate motion of the waves, which raises and lowers different sections of the machine relative to each other, pushing hydraulic fluid through hydraulic pumps to generate electricity.

Wave Energy in the UK – Conclusion

There are two installations generating wave energy; the first is the Land Installed Marine Powered Energy Transformer (LIMPET), an oscillating water column on the Scottish island of Islay (see *http://www.wavegen.co.uk/what_we_offer_limpet.htm*).

The second, the 750-kilowatt Pelamis sea snake offshore Orkney, is an example of a hinged contour device. It is the first deep-water grid-connected trial and is currently installed at the European Marine Energy Centre in Scotland, where it is undergoing testing (see *http://www.oceanpd.com/*)

The main problem with wave power is that the sea is a very harsh, unforgiving environment. An economically-viable wave power machine will need to generate power over a wide range of wave sizes, as well as being able to withstand the largest and most severe storms and other potential problems such as algae, barnacles and corrosion.

Tidal Power

Tidal energy exploits the natural ebb and flow of coastal tidal waters. A variant of tidal energy is tidal stream (or marine current) technology, which exploits fast sea currents created by the tides and magnified by topographical features. Tidal stream technology is still in its infancy and there are no projects currently contributing to electricity supplies in the UK; however, development work is still ongoing.

Source (section 13): DTI, *http://www.dti.gov.uk/renewables/*

Legislation and Guidelines

United Kingdom Legislation

The following is a summary of applicable UK legislation. Similar or other requirements may apply elsewhere. A high proportion of upcoming offshore wind projects are around the UK coast.

Two further issues of note. First, changes are due this year to the Health and Safety at Work Act, Article 8, *"Applicability outside the UK"*, which will extend the coverage of the HSAW act to "energy devices", which could include wind turbines and wave and tidal energy devices that lie outside the 12 mile limit but on the United Kingdom Continental Shelf (UKCS).

Secondly, the Energy Act 2004 (Part II, chapter 1) will require a safety zone to be established around renewable energy installations.

- **Electricity Act 1989**

  Under section 36 of the Electricity Act 1989, the consent of the Secretary of State for Trade & Industry is required for the construction and operation of an offshore wind farm that will have an export capacity of more than 1 MW.

- **Coast Protection Act 1949**

  Consent is also required under section 34 of the Coast Protection Act 1949 (CPA) if the works are below mean high-water springs and they will cause, or are likely to cause, an obstruction to, or otherwise endanger, navigation. Applications are made to the Secretary of State for Transport.

- **Food and Environment Protection Act 1985**

  A licence may also be required from the Department for the Environment, Food and Rural Affairs (DEFRA) under section 5 of the Food and Environment Protection Act 1985 (FEPA) for the placing of structures below mean high water springs to ensure protection of the marine environment. The provisions of both the CPA and the FEPA extend beyond the UK territorial water limit.

- **Town and Country Planning Act 1990**

  Planning permission may be required under section 57 of the Town and Country Planning Act 1990 for cables and grid connections above the mean low-water mark. The consent of the Environment Agency may also be required if structures and/or cabling is erected in any designated main river.

- **Environmental Impact Assessment (EIA) Directive**

  The Environmental Impact Assessment (EIA) Directive requires an environmental assessment to be made of the effect of certain public and private projects, including energy projects. Offshore wind farm developments are 'Schedule 2' projects, which means that developers must prepare an environmental statement (ES) in relation to the development where it is likely to have a significant effect on the environment. It is the policy of the UK Department of Trade & Industry (DTI) to require ESs for most offshore wind farms within territorial waters. A separate ES does not need to be prepared for each consent application – provided the scope is sufficient to embrace the range of environmental issues that each authority needs to consider, a single document should suffice.

- **Conservation (Natural Habitats etc) Regulations 1994**

  In these regulations, which implement the EU Habitats Directive, the Secretary of State also has to consider the effect of the development on any European site in considering whether to grant a section 36 consent. Where the proposal will, or is likely to, adversely effect the integrity of the European site, consent cannot be granted unless the Secretary of State is satisfied that there is both an imperative overriding reason in the public interest to grant the consent and that there is no alternative site available.

- **The DTI Offshore Renewables Consent Unit**

  In an attempt to streamline and simplify the existing consent procedure, the DTI has established the Offshore Renewables Consent Unit, which is intended to serve as a focal point for offshore wind farm applications. The unit works closely with the Marine Consents Environment Unit, which was jointly established by DEFRA and the Department for Transport (DfT) to handle applications under the CPA, FEPA and the T&W act. However, the simplified consent procedure is only available where the Electricity Act route is followed and still involves the various applications being considered by up to three government departments; the Unit merely has a co-ordinating role. Perhaps not surprisingly, there is no obligation on developers to lodge applications with the Unit.

Legislation in Other Countries

The recent Horns Rev project showed that management of regulatory issues in Danish waters, as in the UK, remains complicated to say the least.

Guidelines from Other Bodies

- **DNV**

  DNV has developed a number of rules and guidelines for the wind energy industry. It considers that the wind energy industry requires cost-effective design for offshore wind turbine structures to make the projects economically viable. When moving offshore, the stresses on the structures change from wind to wave dominated. Existing standards created for traditional oil and gas offshore structures are therefore not truly applicable.

  In order to bridge this gap in standards, DNV worked to develop an offshore standard code covering risks in offshore wind farm projects with a 'cradle to grave' approach.

  DNV released its standard for "Design of Offshore Wind Turbine Structures," DNV-OS-J101, in June 2004, with the intent of following this with standards covering turbine blades and electrical and mechanical components of the turbine, such as the gearbox.

- **BWEA**

  The BWEA has produced various guidelines for best practice in offshore wind farm construction, including best practice, covering such topics as technical and commercial considerations, environmental considerations, and dialogue and consultation; health and safety in the wind energy industry, and consultation best practice for the wind energy industry. These and other helpful documents can be found at *http://www.bwea.com/ref/reports-and-studies.html*

- **Germanischer Lloyd Wind Energie GmbH (GL Wind)**

  GL Wind is an internationally operating certification body for wind turbines and carries out examinations and certifications. It is actively involved in the development of national and international standards. Some of the guidelines published by this organisation can be found at:
  http://www.gl-group.com/industrial/glwind/3780.htm

- **Danish Energy Authority**

  The Danish Energy Authority has created an approval scheme for the erection of windmills in Denmark. Documents and guidelines can be found at *http://www.ens.dk/sw14294.asp*