OFFSHORE ENERGY – WIND, WAVES AND CURRENTS

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1. INTRODUCTION

The driving force behind the need to develop alternative sources of energy to those of fossil fuels has been the recent concern over global warming rather than concerns over the amounts of fossil fuels still available. While global warming and cooling is not unusual in geological terms and even in recent history i.e. the Thames was frozen over in the Middle Ages sufficient to allow bonfires to be lit on it, the recent rise in temperature appears to be related closely to the increase in carbon dioxide emissions. The current predictions by the International Panel on Climate Change (IPCC), indicate temperature rises of up to 3° to 5°C by the end of this century. Current predictions by others give a higher figure and undoubtedly there will be a significant change in the world climate by 2100 if nothing is done to reduce carbon dioxide emissions.

Glaciation (the presence of ice sheets) has been experienced in the past geological eons and, for example, Antarctica has been glaciated for the last 34 million years. However, its ice sheets have fluctuated, producing significant changes in sea level (up to 200m) and climate throughout the Cenozoic. The Artic and Global Climatic System programme is investigating the link between its climate and the oceans using ice cores dating back some 10,000 years BP. This is because it has been found that Antarctica is closely coupled to the global climate system and that it, together with the Southern Ocean, are the main heat sinks. While only 20% of the heat is carried by the Ocean, the Antarctic Circumpolar Current inhibits the poleward flux of heat and thus plays an important part in keeping the Continent cold. It has been found that El Nino events brings cold dry conditions to the Antarctic Peninsular and higher levels of precipitation over the coastal region.

The most obvious impacts of this general warming of the globe has been a rise in sea levels, mainly resulting from the heating of the oceans (70%), but with a significant contribution of some 30% from the melting of the ice caps on the poles and from glacial melt. This has a very significant potential impact for coastal flooding and, indeed, very large proportions of the worlds population do in fact live in coastal zones. This paper however, will not look at the consequences of global warming, which include climate change, but of ways of producing energy which are carbon dioxide free.

The alternatives to Carbon based energy are:

- Water – dams etc
- nuclear
- waves
- barrages
- wind
- solar
- bio
- steam

2. WIND ENERGY

The need to develop energy from the wind is something that has been recognised for the last 20 or so years and has led to a significant development of wind farms in the last 10 years. Indeed, the use of wind power is an old technology with many examples of windmills developed since the Middle Ages being seen throughout the world, both in terms of grinding flour and pumping water.

Initially in the UK wind turbines were developed to produce electric power in a number of land sites in areas exposed to generally strong winds (see Figure 1). As such, a number of remote areas were used for the development of wind farms in both Scotland and Wales together with Cornwall.

Figure 1- Onshore Wind Farms, 2003

While the need to produce energy from wind is recognised by the general public, there is growing resistance to the development of wind farms on land because they are considered to be a visually unattractive, spoiling the areas of natural beauty in which they have been placed. One other disadvantage is that because they tend to be developed in relatively remote areas, the power from them has to be taken over quiet large distances to the areas where it is needed. While wind power has produced quiet significant inputs into the grid at a cost of about 5.5p/kWh, obviously when there is no wind then there can be no generation ie they need an average wind speed of 18 to 21kph, and this is also considered to be a disadvantage. It is also unlikely that wind power will achieve the Government's target of providing 10% of our energy needs by 2010 or even 2020 (20%). At present wind power provides about 4%.

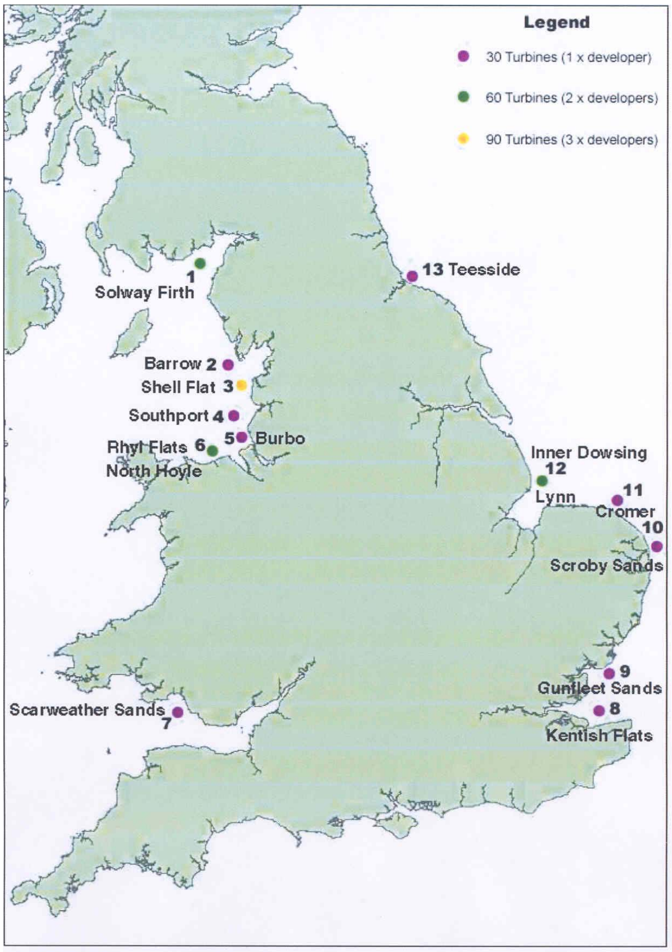

Figure 2- Offshore Wind Farms

Since the development of wind turbines in the 1980's, the size and power output from them has increased steadily and even on land some of these generators can produce up to about 3.2 megawatts. The present generation of wind turbines have a propeller diameter of some 20m and stand to 70m above the ground. An example of a recent development is on the Hoyle Bank off North Wales, which cost £80M. It lies 6km from the coast, has thirty 2MW turbines, a turbine spacing of 800m by 350m, can power 41,000 homes and saves some 160,000t of carbon dioxide.

Partly because of the visual impact of the land based turbine fields and the need for energy sources free from carbon dioxide, the Government has been keen to develop wind farms in the offshore areas. A number of these sites have been developed (see Figure 2), an example of which is Scroby Sands, which lies off the coast of Great Yarmouth. This wind farm contains some 30 turbines (2MW), separated from each other by some 500m by 375m. The units were installed in 2004 by Van Oord on 4.2m diameter piles, weighing some 200t. The field will produce 60MW and supply 41,000 homes.

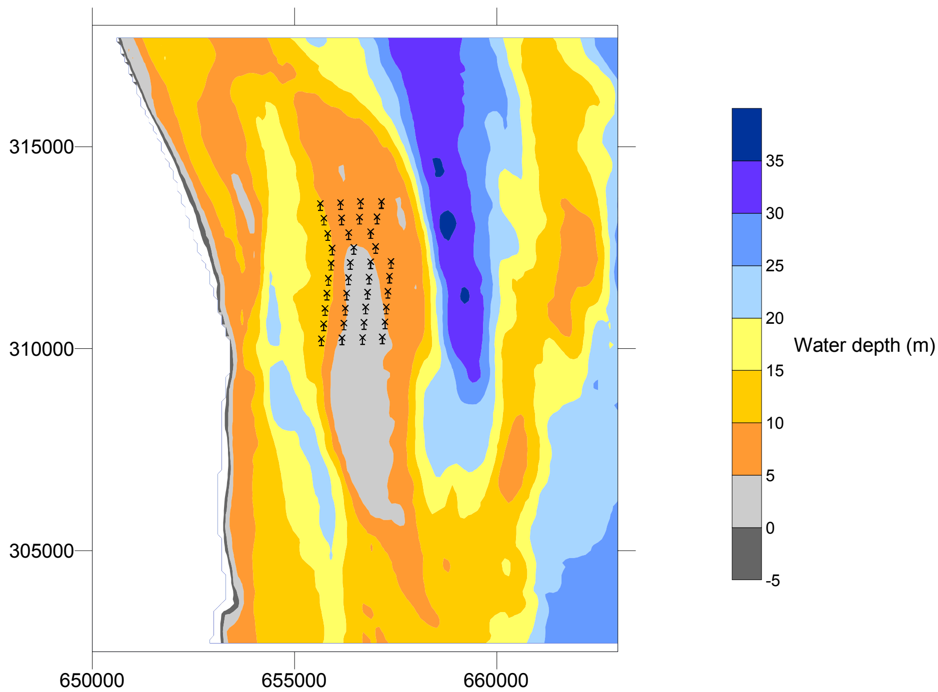

Figure 3- Predicted Bank Morphology at Scroby Sands in the year 2050

Offshore wind farms are not without their detractors and many studies and approvals have to be obtained prior to construction. An example of the type of detailed studies required were those by Halcrow at the Scroby Sand site in order to establish what the likely impacts the construction plant might have on sand movement, current flows and waves. Halcrow also carried out a statistical analysis of the bathymetric surveys of Scroby Sand, looking at the changes in the bank's morphology over a period of some 150 years.

This was done so that predictions could then be made as to how the bank might change during the 30 year life of the wind farm in order to ensure that the turbines were not exposed to wave conditions that they were not designed to withstand (see Figure 3).

Offshore wind farms have been developed in a number of areas and are capable of generating quiet significant amounts of electrical power. However, as mentioned earlier, all such turbines are dependent on wind and thus cannot be considered a simple replacement for the more conventional of power generation.

An exciting development onshore is the use of superconductors in Calgary (Canada), which is required to meet local voltage control standards.

3. WAVE AND CURRENT ENERGY

Wave and current energy have an advantage over wind in that, normally, they can be considered a more reliable source of potential power. In the case of currents, these are tidally generated and as such can be considered as a constant source, which will vary depending on the time of the tidal cycle i.e. the strongest currents will occur on spring tides with the weakest ones on neap tides. At Lynmouth a tidal power unit will produce 300kW of 'renewable' energy. In the case of the waves, as they are generated by winds, they might be considered to have similar drawbacks to wind generators. However, in many areas of the UK, especially along the western coasts, these waves have been generated over long distances and as such are more reliable in terms of their potential generating power and reliability than any wind source.

While several attempts have been made over the years to develop wave energy as a source of power, these have been very much experimental and similar comments can also be made regarding tidal currents. However, there is increasing interest in these sources of power, partly because of their increased reliability. Indeed, the Government (DTI) has recently made available some £42M for large scale demonstration projects in wave and tidal power generation. The idea of tidal barriers e.g. in the Severn Estuary and Morecambe Bay have always been attractive in terms of energy generation, but such projects are unlikely to gain approval because of the changes to the environmental conditions that would accompany them.

As part of the recognition of the potential sources of wave and tidal power, the South West Wave Hub project is to be developed in Cornwall. The Wave Hub is envisaged as an offshore electrical "socket" into which a number of wave energy converters can be plugged. The Hub is intended to attract developers, with its main attraction being its reduction of the risk of finding a suitable site for installation.

The initiative for the Wave Hub is being promoted by the South West Regional Development Agency (SWRDA), which was formed in 1999. It is envisaged that the scheme has the potential to bring substantial environmental, social and economic benefits to the region, which has a strong commitment to renewables.

The South West of England is seen as a good location for the development of wave energy technology because it has a favourable wave climate, but without the extreme conditions of some other locations. It also has good access to the National Grid and specialist skills for such energy are available.

The team for the project is led by the Employer (SWRDA), with the technical feasibility study being carried out by Halcrow under the direction of Peter Stothert. The Client's overall project programme shows development proceeding in 2005 with delivery in 2006. Halcrow is working together on the marine installation with Global Marine Systems.

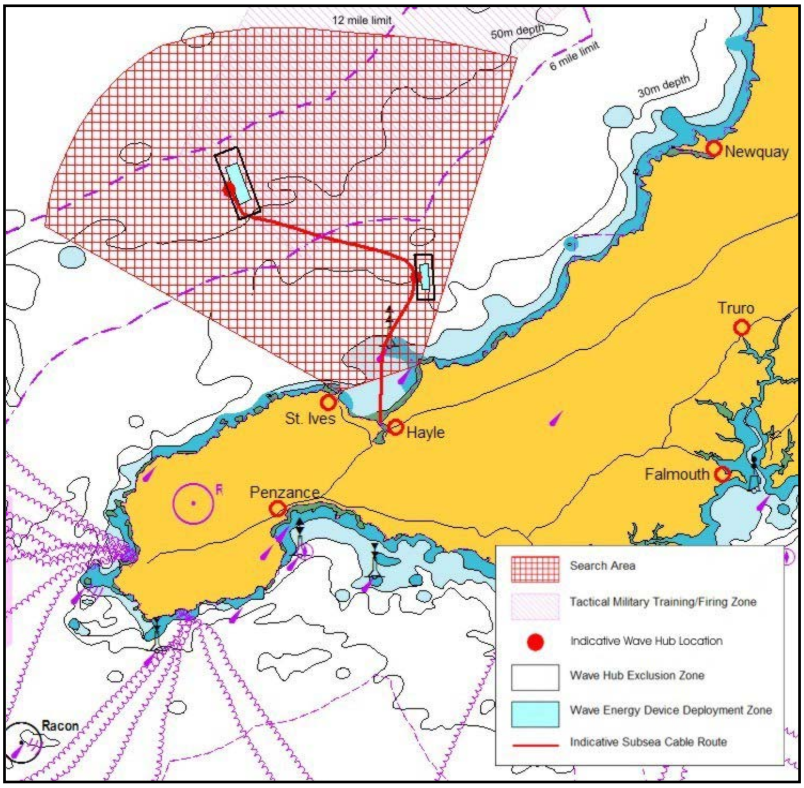

Figure 4- Showing the proposed Location of the Hub and Cable Landfall

Halcrow's study has concentrated on the north Cornwall coast and it was found that the wave energy, in terms of the annual mean wave power, suddenly diminishes from around 25kW/m of wave crest off St Ives, to around 15kW/m off Hartland Point. To the east of Hartland it decreases more rapidly. The chosen site is in fact off the Hayle Estuary where there is also a disused power station which can accept 30MW to 132kV in through the grid (see Figure 4).

The site does have some constraints such as an Marine MoD exercise area adjacent to it and there are coastal SSSI/AOMB/SAC/SAM sites together with shoreline cliffs, shipping lanes etc.

The functional specification for the installation was developed through a combination of consultation with developers and a review of the offshore renewable sector. Cabling is likely to include fibre optic data transmission, capability to allow discrete device performance monitoring. An early decision was that the transmission voltage from the deployment zone would not be practical at less than 33kV. It was concluded that, while the largest devices may be able to house on board transformation up to this level, many could not and this had the consequence that step up transformation would be required offshore as part of the Hub, unless multiple cables were used. Four main options were considered i.e. multiple cables, wet Hub (sub-marine transformer technology), floating Hub and Platform. Of these options, the wet Hub was considered favourite. It requires a sub-sea transformer capacity of approximately 30MBA and submersible transformers have indeed been used for several years in offshore oil and gas industry. These sealed life submersible transformers can be considered as maintenance free for long periods of time, up to 10 years or more. Typically, the weight of the conventional transformer is some 20t and added to this would be the submersible jacket and connectors. Energy losses from the transformer would be slightly higher than a convention transformer, but not significantly so with each transfer being backed by conduction and not by the use of pumped circulation system. While the development of a single 30MVA sub-sea transformer was considered, the use of multiple smaller units is preferred.

The seabed at the proposed site would be in the 50 to 60m depth range. Its sediments consist mainly of coarse sand with patches of very coarse sand and fine gravel, overlaying rock. The sediments in the region raised two principle issues i.e. the transmission cables are likely to need armouring and that they would provide relatively poor holding for conventional anchorage systems.

To date an environmental scoping study has been undertaken, simply to identify and rank key concerns and determine the extent of further studies. However, the findings were used to help decide on the position of the Hub. The impact of cable laying and placing of device anchorages on the benthos ecology is thought to be minor, due to the ongoing fishing activity. The effects of the devices themselves have yet to be fully established and will be the subject of further study, but the exclusion zone around may prove to have positive impacts on fish stocks. The effects of electromagnetic fields induced by the transmission cables is one area of uncertainty and will require further studies. The cable land fall adjacent to the Hayle estuary runs through a high energy tidal zone which will quickly recover from cable burial. At this stage directional drilling is being considered to minimise both damage to the local dune system and disturbance of any contaminants or the creation of additional pathways for leachates known to be present on land.

The concise process will require compliance with numerous legislation including the Electricity Act 1989, Food and Environment Protection Act 1985, Coast Protection Act 1949, Town and Country Planning Act 1990 and Transport and Works Act of 1992. Strategies have been developed to ensure that the project is act compliant at all times.

The DTI have made it clear that future offshore renewable projects will only proceed within the context of a Strategic Environmental Assessment (SEA). In the future offshore-strategy framework for the offshore wind industry (2002) they state *although the directive is not in force, carrying out a formal SEA will provide helpful support to the development and refinement of plans for expansion of offshore wind farm industry. The Government has therefore decided to act within the spirit of the directive, and has commissioned the first phase of SEA work, focusing on the three strategic regions for round two.* On the marine renewables, the Government has adopted a phased programme, focusing initially on the three regions proposed for Round 2 wind farms -15 sites, which could contain 250 units and yield 5.4 to 7.2 GW. However, a number of representations are understood to have been made to the DTI to the effect that experimental or demonstration wave energy devices should be exempt from the SEA process currently being undertaken. This will result in a DTI consultation paper.

4. CONCLUSIONS

While the development of onshore wind farms has now been almost completed, the potential for further development of wind farms offshore in the Round 2 licences are presently underway. It does not, however, appear that there are significant further areas to be developed and the expansion of wind generation offshore may in part be reliant on the development of larger and more efficient generating units.

The use of wave and tidal power, which has been a long time in coming, does have real potential for further development. An exciting project in this regard is the South West Wave Hub Project, which will enable developers to reduce the risk of finding a suitable location for installation. There would for example be no up front capital costs in establishing the grid linkage, the consenting process would be significantly eased and the consequence risk to programme would be reduced.