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TECHNOLOGY OF OFFSHORE WIND ENERGY

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Abstract: Conventional methods of generating electricity burn fuel to provide energy to drive a generator, usually by using the heat to produce steam to drive a turbine. These technologies use fossil fuels (coal, oil and gas) or nuclear fuel. Fossil fuels create pollution such as oxides of sulfur and nitrogen, which are a cause of acid rain, and carbon dioxide, which contributes to global climate change. Although conventional sources of power dominate the energy needs of the world, wind energy is growing rapidly as it is a renewable as well as clean energy resources. Furthermore its resources are plentiful and will not run out. Therefore, wind energy has become the least expensive renewable energy technology in existence. In addition wind energy leaves no harmful emissions or residue in the environment. Wind turbines only produce energy when the wind is blowing and energy production varies with each gust of wind. Now days, according to the Danish electrical power companies, the energy cost per kilowatt hour of electricity from wind is the same as for new coal-fire power stations. Although wind turbine design has become a high technology industry, wind turbines can easily be installed in developing countries, and serviced and maintained locally. The wind industry is becoming more multinational, as the industry matures and more manufacturing is established in new markets. While wind energy is already economic in good onshore location, wind energy is about to cross another frontier, with the fact that wind speeds are often significantly higher in offshore than onshore. Having said this, it should be added, that of course it is generally an advantage to have a stable power output from the offshore wind turbines. Thus the effective use of wind turbine generating capacity will be higher at sea than on land. Therefore, the aim of this paper is to introduce the offshore wind energy, which can be applied at the sea of Asian region especially in Malaysia.

Keyword: Technology, Offshore Wind Energy, Malaysia

INTRODUCTION

The Malaysian Government has emphasized that the alternative renewable energy become a fifth fuel as a energy resource in government policy. Furthermore, the programmes for renewable energy development and application are included in the Eighth Malaysian Plan (2001-2005). Most of the previous studies published particularly in Malaysia are focused on the renewable energy resources such as solar, wind (on land), biomass, wave, tidal power, geothermal and Ocean Thermal Energy Conversion (OTEC). The primary objective of the paper is to introduce and conduct a preliminary study on the offshore wind energy especially in Malaysian region. It is a relatively new subject and is substantially affected by a wide range of environmental, political and strategic considerations. For example there are two offshore pilot wind farms of 5 MW each have been built in Denmark by the electric utilities using conventional wind turbines: Vindeby in 1991 and Tunoe Knob in 1995. One of the primary reasons for moving wind energy development offshore is the lack of suitable wind turbine sites on land. This is particularly the case of Malaysia, where it geographic physically is mountain and forestry, these will create an obstacles to the wind as a result decrease wind speeds significantly and eventually they create the turbulence. It is also the fact that wind speeds are often significantly higher offshore than onshore, and thus higher energy production at sea. The marine environment gives more stable winds with less turbulence and less wind shear, facilitating the design of cheaper turbines with a longer lifetime. Another argument in favour of offshore wind power is the generally smooth surface of water. This means that wind speeds do not increase as much with the height above sea level as they do on land. The temperature difference between the sea surface and the air above it is far smaller than the corresponding difference on land, particularly during the daytime. This means that the wind is less turbulent at sea than over land, will produce a lower mechanical fatigue load and thus longer lifetime for turbines located at sea rather than land.

THE CHALLENGES OFFSHORE WIND ENERGY

The primary problem implementing offshore development of wind energy is a cost, mainly foundations and grid connection. For instance, the latest Danish offshore wind farm at Tunoe Knob (1995), wind turbines are place at 5 to 10 meter water depth. The foundation costs per turbine were at the level of 23 per cent of projects costs while grid connection costs were around 14 per cent of project cost. Preliminary indications that, 35 per cent decrease in foundation costs, due to the use of steel rather than concrete foundations. While concrete platforms tend to become prohibitively heavy and expensive to install at water depths above 10 meters. The concept of floating structures offshore wind energy is used for the case of very deep water for example between 50 to 400 m. Corrosion protection of steel foundations can be done electrically, using so called cathode protection requiring little or no human intervention after the system is installed. Wave, current as well as wind are the most important factors determining the required strength and weight of offshore foundation for wind turbines.

Tower diameters should preferably not exceed 4.2 or 4.4 meters, if they are to be transported in normal sections by road or rail. The optimum size for an offshore park appears to be around 120 to 150 MW. The present offshore wind parks in Denmark are placed on reinforced concrete foundations built onshore and floated out to sea where they are filled with gravel and sand. One of the newer technologies offers a similar method, but using a cylindrical steel tube placed on flat steel base on the bottom of the sea. Such a foundation is considerably lighter, allowing barges to transport and install many foundations rapidly, using the same fairly lightweight crane used for the erection of the turbines. These foundations are filled with olivine, a very heavy mineral, which gives the foundation sufficient weight to withstand waves, current and wind.

Other foundation technologies include mono pile foundations, effectively extending the turbine tower under water, and drilling or ramming it into the seabed. For larger water depths, instead of floating large structure, three legged steel platforms similar to offshore oil rigs are being investigated. These foundations have the advantage that they require less protection against erosion than other types of foundations. The example for the foundation Technology for the offshore wind energy can be seen in figure 1.

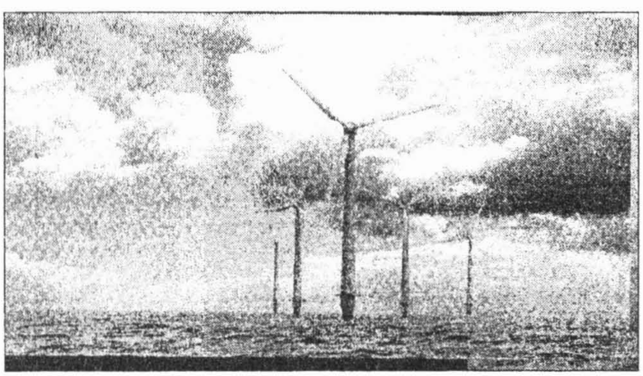

Figure 1: The Offshore wind energy (foundation Technology)

The floating hull concept already well proven in the oil-industry, namely the semi-submersible designs as shown in figure 2. The main structure of the vessel is located below the ocean surface giving a number of advantages over traditional structures with hull forms close to the water surface. These include reduce wave loads, (since the wave kinematics decay exponentially with depth) and longer natural periods of motions (hence reduce response motion). These vessels have typical dimensions of from 80 to 120 m and displacements of from 12,000 to 40,000 tonnes. However the floating wind energy turbine application requires considerably large semi-submersible structures with deeper drafts and larger displacements.

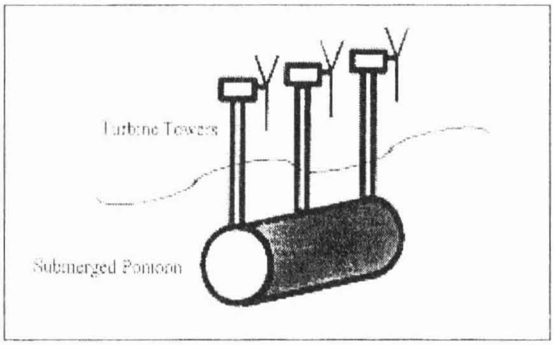

Figure 2: The Semi-submersible Concept

In the motion of a floating vessel it was shown that waves contribute the majority of the rigid-body motion-inducing dynamics loads of a large floating structure. A simple and accurate method of calculating the normal forces, F, is the Morison equation (figure 3). This is an empirically based equation and was developed in the 1960s for wave loadings on piles in shallow water.

$$dF = C_M . \rho . dV . U + C_D . \frac{1}{2} . \rho . ds . |U| . U$$

where C_D, C_M = coefficients of drag and inertia loading
S = projected area (to waves)
U = Wave velocity
V = Volume
ρ = fluid density

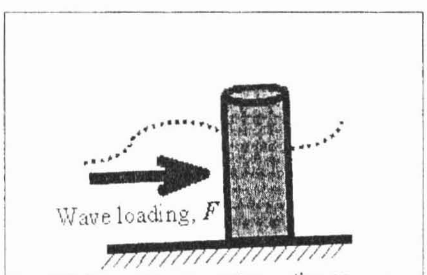

Figure 3: Diagram for the Morison's equation

Calculation of loads on turbine is developed by calculate the effect that movement of the turbine base has on the turbine loads and power output. These are predominantly due to two sources: the aerodynamics of blade, nacelle, tower inertia and gravity. The loads are initially calculated in a two-dimension state-space domain, representing blade azimuth angle and vessel motion respectively. The aerodynamics loads are calculated using standard aerodynamic-momentum theory, inertia and gravity loads are generally of an equal or greater magnitude than the aerodynamic loads, and in the case of a floating turbine, this tendency is strengthened. The loads are found by applying Newton's II law to the acceleration vectors.

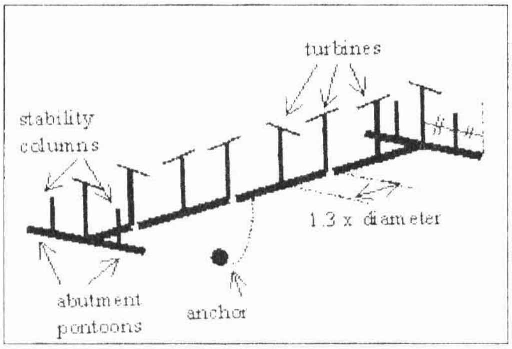

Figure 4: Floating wind Energy (Weathervaning designs)

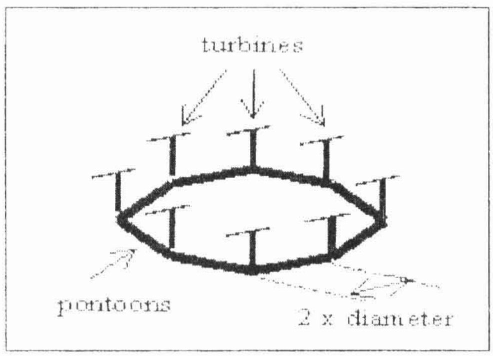

Figure 5: Floating wind Energy (Non-Weathervaning designs)

There are two vessel designs namely a weather-vaning and a non-weather vaning configuration depending on whether a more expensive design with rotating turret-mooring joint would be used [Andrew Henderson 1999]. The design criterion used in the analysis is to minimize fatigue damage experienced by the turbine at the worst location such as at the North Sea. A weathervaning vessel will be able to rotate so that it is always facing into the wind. A non-weathervaning vessel cannot rotate to face into the wind, hence turbines will inevitably operate in another turbines wake at times. If the distribution of wind direction is uniform (unlikely), a symmetrical design is required, i.e. the turbines should be located in a ring and analysis undertaken for how they should be connected.

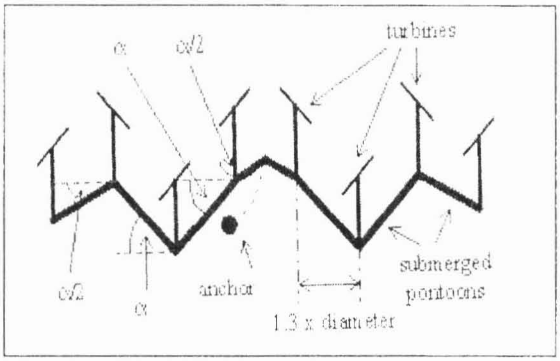

Figure 6: Layout WW for minimizing nacelle motion.

Andrew Henderson (1999) has reported that a linear layout and a polygon layout were found to be most suitable for the weathervaning and non-weathervaning configurations respectively as shown in figure 4 and 5 above. These vessel designs are optimized for typical North Sea wave and wind conditions.

CONCLUSION

Offshore wind energy is clearly an economically viable technology for the 21st century. Offshore wind energy is very competitive comparison with onshore wind, and in comparison with other generating technologies. Offshore wind energy can make a significant impact on the emission problems related to conventional power generation technologies, since the offshore wind resource base is huge and it technology is cost competitive. Offshore wind energy opens a new frontier of technological challenges in terms of manufacturing, installation, surveillance and maintenance. Therefore it would be a new technology for the Malaysian researchers to exploit and carried out preliminary studies as well as tried to apply it in the contact of the Malaysia region.

REFERENCES

1. Andrew R. Henderson and Minoo H. Patel. 1998. Floating Offshore Wind Energy. *BWEA Conference 20*, Cardiff University: (1-8)

2. Andrew R. Henderson, Minoo H. Patel. 1999. Multiple Turbine Floating Offshore Windfarms. University of College London.

3. Andrew R. Henderson. 2000. Analysis Tools For Large Floating Offshore Wind Frams. PhD Thesis, University College London.

4. www. Wind Power.dk. Danish Wind Turbine Manufacturers Association.

5. Buletin Bulanan Jurutera Malaysia.October 2000. Renewable Energy Changing Mindsets.

6. Shahidul. I.Khan, Md. Shah Majid, et al . 1999. Renewable Energy Resources Of Malaysia. Conference Prooceeding Universiti Teknologi Malaysia.