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Design and Analysis of an Array of Floating Wind Turbine Structures

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ABSTRACT

Global performance of an array of floating wind turbine structures is investigated through numerical analysis by using 9-node higher-order boundary element method. Multi-body hydrodynamic interaction between floating wind turbine structures is considered based on generalized mode approach. Connecting structures between floating wind turbines is devised and the performance evaluation was conducted considering elastic deformation of the connecting structures. Technical feasibility of such an array structures for floating wind farm is discussed based on global performance evaluations.

KEY WORDS: Floating Wind Turbine, Floating Wind Farm, Spar, TLP, Semi-submersible, Array of Floating Structures

INTRODUCTION

It is widely understood that the needs of renewable energy resources will be rapidly increasing due to limited oil and gas reservoirs, the one of most popular energy sources so far. EU countries such as UK and Germany have enthusiastic plans to provide more than 20% of total energy consumption from offshore wind energy by the end of 2015(EWEA, 2010).

To achieve this challenging goal it is necessary to use offshore wind resources rather than those on land and onshore.
Therefore the efforts to utilize offshore wind energy have led to floating wind turbine concept which makes it possible to install wind turbine tower structures in deeper water region where better wind quality is available compared with on land wind turbine.

The concept of using offshore floating wind turbines was introduced by Professor William E. Heronemus(1972). As of 2003, existing offshore fixed-bottom wind turbine technology deployments had been limited to water depths of 30 meters. It has been well known that worldwide deep-water wind resources are extremely abundant in deep sea areas with depths up to 600 meters(Wikipedia,2012).

Concerning to use of offshore wind, there have been a number of conceptual design studies on floating wind turbine structures, to name a few Jonkman(2010), Robertson et al.(2011), Myhr et al.(2011) and Shin(2011). Most of studies were on spar type structures like OC3-Hywind and variations of mooring system of spar platform, barge and semi-submersibles. Recently 'Windfloat' is emerging, which is based on semi-submersible design concept with high damping plate(Roddier et al., 2010).

In 2011 three floating wind turbine support structures were installed(Justin Wilkes et al., 2012). Blue H deployed the first 80 kW floating wind turbine 113 kilometres off the coast of Italy in December, 2007. The Blue H technology utilized a tension-leg platform design and a two-bladed turbine The first large-capacity, 2.3 megawatt floating wind turbine is Hywind, which was installed in the North Sea off of Norway in September 2009(Madslien, Jorn (2009-09-08)). In October 2011, Principle Power's WindFloat Prototype was installed 4km offshore of Aguçadoura, Portugal in approximately 45m of water. The WindFloat was fitted with a 2.0MW offshore wind turbine. This is the first offshore wind turbine installed in open Atlantic waters and make use of a semi-submersible type floating foundation.

As of September 2011, Japan plans to build a pilot floating wind farm, with six 2-megawatt turbines, off the Fukushima coast of northeast Japan where the recent disaster has created a scarcity of electric power. After the evaluation phase is complete in 2016, Japan plans to build as many as 80 floating wind turbines off Fukushima by 2020(Kinoshita, 2012). The US State of Maine solicited proposals in September 2010 to build the world's first floating, commercial wind farm. The RFP sought proposals for 25 MW of deep-water offshore wind capacity to supply power for 20-year long-term contract period via grid-connected floating wind turbines in the Gulf of Maine.

The theoretical feasibility of deepwater floating wind turbines is not questionable because the application of floating structures has been a proven technology in the offshore oil industries over many decades. As of October 2010, new feasibility studies showed that floating turbines are becoming both technically and economically viable in the UK and global energy markets. The economics of deepwater wind turbines will be determined primarily by the additional costs of the floating structure and power distribution system. So it is important to design economical and safe floating structure and mooring systems to enhance economics of floating wind farm. Using a very large floating structure was studied