id	session code	title	Presenter name	Affiliation
35	B-4-1	A new concept of tension leg platform for a floating offshore wind turbine	Dr. Hidero Hayashi	Obayashi Corporation
71	B-4-2	A study on the joint probability distribution of wind and wave	Dr. Jun Tanemoto	The University of Tokyo (current affiliation: Wind Energy Institute of Tokyo Inc.)
102	B-4-3	Development of Offshore Wind Turbine Floating Structure	Mr. Masao Komatsu	Mitsubishi Heavy Industries, LTD
188	B-4-4	Collective Pitch Feedforward Control of a 10 MW Floating Wind Turbines Using Lidar	Dr. David Schlipf	Stuttgart Wind Energy
144	B-4-5	At-sea Demonstration Test for Cost-reduction of Mooring System for Floating Wind Turbine	Prof. Tomoaki Utsunomiya	Kyushu University
122	B-4-6	Engineering aerodynamic models for floating offshore wind turbine	Mr. Qi Qi	Goldwind and Unversity of Strathclyde
119	B-4-7	The importance of design verification of floating offshore wind projects	Mr. Carl Sixtensson	DNV GL

A new concept of tension leg platform for a floating offshore wind turbine

Hidero Hayashi[1] and Hideyuki Suzuki[2]

[1]Obayashi Corporation, [2]The university of Tokyo

Abstract:

Obayashi in cooperation with University of Tokyo has developed a new concept of tension leg platform (TLP) for floating offshore wind turbines. It minimizes the cost of energy in deep water offshore wind sites, because it provides integrated solution of support system, a complete assembly at quay sides and favorable dynamic responses to sea conditions which maximizes turbine performance. The support structure consists of proven technology with floating concrete structures and suction anchors. Furthermore TLP is an environmentally friendly installation because of small footprint. The main features of this concept are as follows.

The floating concrete structures have been widely adapted in the oil and gas industry, bridges and harbor structures due to robustness and excellent durability. The newly developed reinforcement can contribute higher performance such as durability and water tightness than before. The concrete construction tends to increase the high local content.

The suction anchor is proved to have potential of significant cost reduction in not only cohesive but noncohesive soils. The installation and pull out behavior of suction anchors has been tested in the offshore subsoil, where the large resistance to upward load is confirmed due to reverse bearing capacity even in sands.

The dynamic response to waves has been evaluated by both the tank test with a scale model and numerical analysis with a sophisticated code. These response data agree fairly well and they demonstrate the nonlinear effect “set-down”, which is a typical behavior of tension leg platforms. The numerical response analysis also provides stress resultants for the structural design of floating structures and applied loads on mooring systems.

A study on the joint probability distribution of wind and wave

Jun Tanemoto[1] and Takeshi Ishihara[2]

[1]The University of Tokyo (current affiliation: Wind Energy Institute of Tokyo Inc.), [2]The University of Tokyo

Abstract:

A model for joint probability distribution of wind and wave is proposed and relations between wind speed, wave height and wave period at deep water near the Choshi offshore wind demonstration site are derived by using 10 years simulation data, which are obtained from mesoscale and third generation wave models. Mean values, standard deviations, probability distributions of wave height and wave period are expressed as functions of wind speeds and modeled by combined models of wind wave and swell, linear functions and log-normal distributions, respectively. The correlation coefficient between wave height and wave period is also modeled as a function of wind and expressed by a hyperbolic tangent function. Monte Carlo simulation is conducted, and wind speeds, wave heights and wave periods are generated based on proposed models. Predicted joint probability distributions show satisfactory agreement with observations.

Development of Offshore Wind Turbine Floating Structure

Masao Komatsu, Hitoshi Kumamoto, Makoto Ohta, Hiroshi Tanaka, Hideo Mori and Satoshi Miyazaki

Mitsubishi Heavy Industries, LTD

Abstract:

In the "Fukushima Floating Offshore Wind Farm Demonstration Project" in which Mitsubishi Heavy Industries, Ltd. (MHI) has taken part, the 7MW floating offshore wind turbine developed by the company was installed off the coast of Fukushima, and its demonstration operation phase is under way.

In this article, concerning the design of V-shaped semi-submersible floating structure and the adopted construction and mooring method therefor, the actual work in the stages from construction to installation were reviewed and verified for validity, and based on the findings obtained from the review and the results of the in-house research that has been separately conducted, the future commercialization was studied. The verification results showed that the V-shaped semi-submersible floating structure has the expected performance, construction properties and mooring workability and offers superior economic efficiency. On the other hand, a study of future mass production and commercialization revealed that there is plenty of room for the improvement of the design and comprehensive cost reduction through a review of the mooring method, construction procedures, etc.

Collective Pitch Feedforward Control of a 10 MW Floating Wind Turbines Using Lidar

David Schlipf, Frank Lemmer and Po Wen Cheng

Stuttgart Wind Energy

Abstract:

In this work a collective pitch feedforward controller for a 10 MW floating wind turbine is presented. The feedforward controller provides a pitch rate update to a conventional feedback controller based on a wind speed preview. The feedback controller is designed based on state-of-the-art techniques. The feedforward controller is designed similar to the one for onshore turbines, which has proven its capability to improve wind turbine control performance in field tests. The turbine design used for this study is publicly available as well as the floating platform. It is a concrete semi-submersible with catenary mooring lines. The concept has already been tested in a wind-and-wave basin in spring 2016 and will be further developed in different research projects.

A hydro-aero-servo-elastic model is the basis for the evaluation of the feedforward control performance. For the design and verification of the theoretical performance a simplified, linearized coupled model is applied. It includes a structural model, simplified aerodynamics, simplified time-domain hydrodynamics and a quasi-static mooring line description.

In a first design step, perfect wind preview and a calm sea is assumed. Under these assumptions the feedforward controller is able to compensate almost perfectly the effect of changing wind speed to the rotor speed of a full aero-hydro-servo-elastic model over the entire full load region.

In a second step, a nacelle-based lidar is simulated scanning the same turbulent wind field which is used also for the aero-hydro-servo-elastic simulation. With model-based wind field reconstruction methods, the rotor effective wind speed is estimated from the raw lidar data and is used in the feedforward controller after filtering out the uncorrelated frequencies. Simulation results show that even with a more realistic wind preview, the feedforward controller is able to significantly reduce rotor speed and power variations. Furthermore, structural loads on the tower, rotor shaft, and blades are decreased.

In a third step, a realistic sea-state is added to the simulation in order to investigate if the obtained results can be maintained in a more realistic setup.

A comparison to a theoretical investigation using coupled linearized models shows that the spectra from the simulations meet the expected theoretical spectra. The linearized models are obtained from a reduced nonlinear model including the relevant modes.

In future studies the feedforward controller will be extended to include wave preview.

At-sea Demonstration Test for Cost-reduction of Mooring System for Floating Wind Turbine

Tomoaki Utsunomiya[1], Koji Gotoh[1], Katsutoshi Kita[2], Iku Sato[3], Hirofumi Takano[4] and Toshiya Iwashita[4]

[1]Kyushu University, [2]Tokai University, [3]Toda Corporation, [4]Nippon Kaiji Kyokai

Abstract:

The development and demonstration relating to the reduction of mooring costs in the floating wind turbine facility will be presented. This is adopted as demonstration project funded by the Ministry of the Environment, Japan.

In this project, the following matters will be demonstrated.

1) to apply a suction anchor for mooring system of floating wind turbine suitable for the actual situation around Japan,

2) to apply a synthetic fiber rope for mooring system of floating wind turbine

3) to develop a method for evaluation of wear amount in the mooring chains of floating wind turbine, and

4) to summarize the above matters as the guideline for mooring system of floating wind turbine.

Engineering aerodynamic models for floating offshore wind turbine

Qi Qi[1], Nigel Barltrop[2], Rongfu Li[3] and Xingang Zhang[3]

[1]Goldwind and Unversity of Strathclyde, [2]University of Strathclyde, [3]Goldwind

Abstract:

There has been a significant interest in floating offshore wind turbine from the world wind industry companies and governments especially for Japan and Scotland. For Japan one driven factor is the nuclear accident in 2011 and another one is that 80% of its wind resources are in deep water (50 meter+). Scotland is also in great suitability for floating wind turbine, like Japan, it has high wind speeds near the shore with deep waters. Since Scotland has had a long running experience in the offshore oil and gas industry it places itself as a strong leader for offshore wind turbines.

While several prototypes of floating wind turbines have been installed, numerical tools for analysing the dynamics of floating wind turbines are still being developed and validated. The uncertainty of the aerodynamic load is an important factor of

offshore wind turbines especially for floating offshore wind turbines. The wave driven forces and displacements on the floating platform add additional unsteadiness to the rotor therefore the fidelity of existing wind turbine aerodynamic

theories should be evaluated. The paper has drawn out the limitations on commonly used bladed element momentum theory (BEM) and the generalized dynamic wake theory (GDW) when they are applied to floating wind turbines in unsteady conditions. A free vortex wake theory (FREWK) has been integrated to FAST v7, a widely used numerical tool for the dynamics of floating offshore wind turbines. This enables the tool to model the floating wind turbine with large flexible blades in a more physical way. Firstly, the validation tests have been carried out according to the NREL UAE and MEXICO wind tunnel test database using BEM, GDW and FREWK models, where the BEM falls short for the yaw and dynamic inflow cases. The GDW has better performance than BEM but still predicts less accurate result than FREWK model in dynamic inflow condition which occurs regularly when the blade is pitching. The fidelities of existing corrections on BEM theory for skew wake and dynamic inflow have been evaluated in floating cases according to the free wake and experimental results. The aerodynamic damping of the first fore and aft tower mode is also studied from the three different aerodynamic methods.

The research has highlighted the uncertainties and capabilities of different aerodynamic theories for floating offshore wind turbine loads calculation. The findings can be considered and used in future design to reduce the cost of floating wind turbine.

The importance of design verification of floating offshore wind projects

Carl Sixtensson and Johan Slätte

DNV GL

Abstract:

The importance of design verification of floating offshore wind projects

Developing an offshore wind project is a challenging task. DNV GL has for decades assisted developers, designers and other stakeholders to face these challenges by offering support through third party design verification. The design verification aims to confirm that the design of the projects is robust and should provide comfort to all parties that a project is designed in accordance with sound engineering practise.

DNV GL will in this presentation describe the value of the design verification process and why it is of importance for Japanese offshore wind developers. The presentation aims to answer key questions often asked, like

- What is design verification, and why is it important?
- Why do we need design standards, and what constitutes a good standard?
- How can design verification help drive commercialisation of floating wind technologies?

DNV GL did in 2012 and 2013 develop the world’s first fully-fledged design standard for floating offshore wind turbine structures, the DNV-OS-J103. The standard was developed together with several industry players, including a few from Japan. Following issuing the standard, it has been used by developers in design of their technologies, and also in design verification projects by DNV GL.

DNV GL will based on experience of verification work undertaken for offshore wind developers provide our thoughts on how developers proactively could address challenges and risk in their projects through the design verification process.