Topic:

6. Innovations in methods and key components (not floating concepts) paving the way to a competitive LCoE

Title of the presentation:

A new approach for the prediction of the non-linear hydro-elastic behaviour of large floating wind turbines

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Abstract:

Floating wind turbines can be submitted to very large hydrodynamic loads in rough seas. However, today's design methods decouple the hydrodynamics from the structural models: the environmental loads are computed on a rigid platform model and applied as external loads to the hull during structural analysis. As offshore wind turbines grow in size, the hull flexibility could be an important parameter, as for other (very) large floating structures.

Few models have been developed to analyse internal responses in the hull considering flexibility [1]. They use either the linear potential flow theory [2], or the generalised Morison formula. The former assumes small waves and small motions of the floater. Several methods have been tested and show relatively good agreements with experimental measurements on rigid hulls [3] [4], except in extreme conditions where non-linear effects can be important. The latter is more adapted for slender bodies and traditionally uses linear wave fields based on Airy theory. Non-linear wave kinematics however have been shown to affect the response of a floating wind turbine [5].

To address this challenge, the HeLoFOW project [6], financed by WEAMEC and lead by the LHEEA laboratory of Centrale Nantes (France) in partnership with the NTNU (Norway), focuses on the non-linear and strongly coupled hydro-elasticity of large floating wind turbines. As part of this project, a new simulation tool has been developed by coupling the weakly non-linear hydrodynamic solver *WS-CN*, based on the weak-scatterer theory and developed at the LHEEA laboratory, and a modal analysis solver. The fluid states and the equation of motion of the flexible platform are solved jointly in a single system of equations, integrated in the time domain using a Runge-Kutta 4th order scheme. The strong coupling between the two theories accounts for large platform motions and strong hydro-elastic interaction including, for example, hydrodynamic loads induced by platform deflections.

A first study examines a bottom-fixed offshore wind turbine based on a monopile foundation. A second study considers a floating spar foundation submitted to a variety of sea states. The results of WS-CN are compared with simulations using the Morison formula.

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[2] M. Borg, A. M. Hansen et H. Bredmose, «Floating substructure flexibility of large volume 10MW offshore wind turbine platforms in dynamic calculations,» *Journal of Physics: Conference Series,* vol. 753, 2016.

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[5] K. Xu, M. Zhang, Y. Shao, Gao, Z. et T. Moan, «Effect of wave nonlinearity on fatigue damage and extreme responses of a semi-submersible floating wind turbine,» *Applied Ocean Research,* vol. 91, p. 101879, 2019.

[6] WeAMEC, «HeLoFOW,» 2019. [En ligne]. Available: https://www.weamec.fr/blog/record_project/helofow/.