Semisubmersible floater design for a 10MW wind turbine

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Introduction

A floating platform concept has been developed for the INNWIND 10MW reference wind turbine [1] located at a 200m sea depth location.

The platform is designed in steel and consists of an equilateral triangle with three stabilizing columns, one in each vertex, joined by pontoons. The function of the pontoons is not only structural, but also hydrodynamic, damping the motion of the system. The wind turbine is located in one of the columns, to avoid the use of an additional central column. The number of elements in the water plane is reduced, minimizing the hull cross section area at the sea surface where wave energy is located. The material and construction cost is reduced avoiding bracings and other connecting structural elements. The center of gravity is lowered to increase stability through the use of sea water as ballast.

Figure 1. isometric view of the design

Main platform properties

The main dimensions of the platform are summarized in Table 1.

Main characteristics	
Distance between columns	66 m
Draft	25.5 m
Freeboard	12 m
Column diameter	14.5 m
Pontoon transversal dimensions	7 x 10.875 m
Buoyancy volume	24907 m^3
Center of buoyancy (below SWL)	17.32 m
Center of gravity (below SWL)	13.46 m
Pitch displacement at rated wind speed	3.5º

Table 1: main dimensions of the platform design

The resulting natural heave and pitch periods are higher than 20 s to avoid the periods with more energy of the typical wave spectra. The motion and forces RAO's present low excitation within the wave frequency range.

Structural dimensioning

The platform steel structure has been designed according to the DNV guidelines ([2], [3] and [4]). The configuration is based in frames with tanks and decks. The dimensioning considered all relevant elements as shells, webs, stiffeners, weldings or reinforcements. This calculation allowed to estimate the system mass as it is summarized in Table 2.

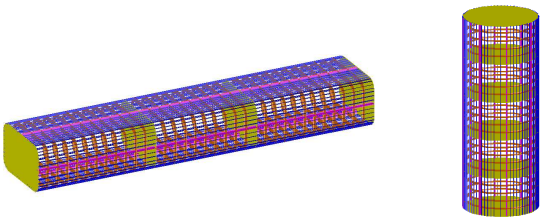

Figure 2. CAD models of the pontoon and column structures

System mass	
Wind turbine	$1.144 \cdot 10^6$ Kg
Unballasted platform	$3.745 \cdot 10^6$ Kg
Ballast	$1.829 \cdot 10^7$ Kg
Mooring system	$2.841 \cdot 10^5$ Kg
Total mass (m_{FOWT})	$2.346 \cdot 10^7$ Kg

Table 2: estimation of the system mass

Cost estimation

Based on the previous mass calculation, the CAPEX of the platform is estimated, assuming a cost of 3,000€ per ton of steel including manufacture and welding. The cost of each of the three anchors is estimated in 150,000€.

CAPEX estimation	
Cost of platform	11,235,000 €
Cost of mooring lines	852,300 €
Cost of anchors	450,000 €
Total cost	12,537,300 €

Table 3: CAPEX estimation

Summary

A new conceptual design of a floating platform for a 10MW wind turbine has been proposed. The motion and force RAO's show a good performance of the platform with moderate excitation in all the range of wave frequencies considered.

A structural design and calculation of the platform has been performed based in DNV's guidelines. Based on the calculation of the steel mass, a cost of 12.5MM€ has been estimated.

The performance of the design is promising and we plan to further develop it within the INNWIND.EU project and validate the concept with wave tank tests.

References

[1] C. Bak, F. Zahle, R. Bitsche, T. Kim, A. Yde, L. Henriksen, P. Andersen, A. Natarajan and M. Hansen, "Description of the DTU 10 MW Reference Wind Turbine," D1.21 INNWIND.EU, 2013.
[2] DNV, "DNV OS c103 Structural Design of Column Stabilised Units", 2012.
[3] DNV, "DNV OS j101 Design of Offshore Wind Turbines Structures" 2010.
[4] DNV, "DNV-OS-J103 Design of Floating Wind Turbine Structures" 2013.

Acknowledgements

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No.308974 (INNWIND.EU).