BASIC DESIGN OF THE STABILIZATION SYSTEM OF A SEMI-SUBMERGED FLOATING OFFSHORE WIND PLATFORM

V Marine Energy Conference
November 13th, Bilbao

1. INTRODUCTION

Currently the main challenge of offshore wind energy, in order to unlock the untapped wind potential, is to enter the deepest seas, where fixed supports are not viable. NAUTILUS has developed a semi-submersible floating substructure which includes an auxiliary system for stabilizing it against mean wind disturbances. One of the critical points of floating offshore wind turbines (FOWT) is their cost. In the case of the NAUTILUS concept, incorporating this system makes it possible to build a smaller and more compact substructure, reducing the amount of steel, which means a reduction in cost (one of the main items of the LCOE – Levelized Cost of Energy).

In the present study, the basic design of the ballast stabilisation system of the NAUTILUS platform for the 10 MW DTU wind turbine in the Gulf of Maine (USA) is proposed. Based on the ballast system used on cargo ships and on oil and gas (O&G) platforms, a hydraulic circuit has been dimensioned, capable of filling (by free flooding) and emptying (by pumping) in half an hour the 500 tons of water that each of the active ballast tanks can store. These tanks are located in each of the four columns of the NAUTILUS floating platform. The distribution of ballast water and the geometric configuration of the NAUTILUS platform provide rigidity in any wind direction and speed to the FOWT.

It has been proven that, thanks to this system, by reducing the average inclination of the platform, it is possible to generate around 340 MWh more per year (assuming a wind turbine of 10 MW). This new stabilisation system is expected to help make floating offshore wind power generation a competitive option.

2. CASE STUDY

Site: Gulf of MAINE (USA)
The metocean conditions defined:
- wind and wave conditions
- sea water and air characteristics

FOWT: NAUTILUS-DTU 10MW
RNA: (Rotor-Nacelle assembly): diameter 178 m;
10 MW nominal power; 877 tons
Tower: height 107 m; 879 tons
4-column platform + pontoon + main deck: height 26 m;
base 60x60 m; 900 tons
Sea water active ballast in each of the 4 columns
Concrete passive ballast in the pontoon: 3,900 tons

3. DESIGN PROCESS

Case study characterization
Floating stability assessment
Analysis of alternatives
Dimensioning of the system
Basic design of the final solution

4. RESULTS

1. Capacity of active ballast tanks: 500 tons of sea water each one. Value obtained from the critical wind thrust condition: direction at 45° and maximum thrust force.
2. Floating stability of the platform: in any operating condition, the metacentric height is clearly positive. Phenomena of “free surface effect” and oscillation due to the waves are negligible.
3. Hydraulic circuit design:
   • Sea water active ballast tanks fill and empty in less than 30 minutes.
   • The speed of the seawater in the pipes does not exceed 3 m/s (2 m/s at the suction of the pumps).
   • Pumps are located to be easily accessible and do not cavitate.

5. CONCLUSIONS

➢ As a result of the design restrictions established, different alternatives appeared. The final solution proposed was chosen on the basis of technical feasibility.
➢ The stabilisation system will make it possible to reduce the size of the platform without losing stability, with the concomitant reduction in steel costs.
➢ With the active ballast system, the average inclination of the FOWT will be reduced by approximately 4°, which means an estimated gain in power generation of 340 MWh per year.

6. FUTURE WORKS

➢ Through the technology of ballast systems is quite mature in shipbuilding and O&G industries, it will be subjected to a Failure Mode and Effects Analysis (FMEA) for its application in the NAUTILUS FOWT.
➢ Develop the control strategy of the active ballast system.

REFERENCES
❖ J. Galvan et al., Definition and Analysis of NAUTILUS-DTU10 MW Floating offshore Wind Turbine at Gulf of Maine. Experiments at Sintef Ocean & PolMi. Report published at Research Gate
❖ A. Krieger et al., D7.2 Design basis. DNV GL; IBERDROLA; TECNALIA R&I; Public LIFES50+ D7.2; Nov. 2015
❖ C. Bak et al., Description of the DTU 10 MW reference wind turbine. DTU Wind Energy Report-1-0092, Denmark, Jul. 2013

Contact Information:
Diego Lanz Lasheras
Tel.: +34 658 870 245
diegodlanz.92@gmail.com