Optimal techno-economic design of floaters and mooring systems in the Aegean Sea

Dimitris Manolas[1]

Mechanical Engineer, Partner

[1]iWind Renewables S.A.

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About

iWind Renewables is an engineering consulting company founded in 2015 by experienced engineers originating from the Greek-European wind energy research community. Our mission is to transfer advanced scientific knowledge to the wind energy market, bridging the gap between academia and industry.

DEVELOPERS, OPERATORS FINANCIAL INSTITUTIONS, CERTIFICATION BODIES

- Energy Yield Estimation
- Wind Farm Layout Optimization
- Technical Due Diligence
- Lifetime Extension
- Analysis of SCADA data
- Failure Root Cause Analysis
- Sector Management Evaluation
- Battery Energy Storage Systems
- Technical Support in Negotiations

OEMs

- IEC-Based Load Calculations
- Stall-Induced Vibration Mitigation
- Vortex-Induced Vibration Mitigation
- R&D - Technology Development and Evaluation
- Blade Damping Estimation
- Passive and Active Load Control

OFFSHORE

- Met-Ocean Conditions
- Hydro-Servo-Aero-Elastic Load Analysis, for all bottom-fixed and floating support structures
- Floater Preliminary Design & Analysis
- Mooring System Design & Analysis

OptHull.GR Joint Industry Project (JIP)

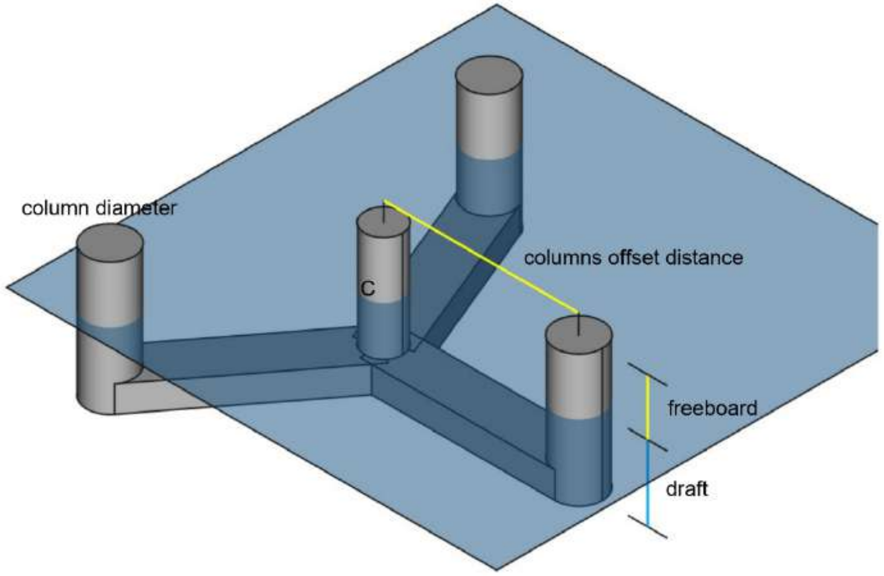
Optimize Semi-sub Hulls of FWT for Aegean Sea Met-ocean Conditions

Motivation: In the Aegean Sea where nearly all offshore wind projects will be developed in Greece, the wave characteristics match closer to OB-class (H_{S_50year}=6m) rather than OA-class (H_{S_50year}=10m) in the North Sea. As H_S is directly related to the fatigue and extreme wave loading on the offshore substructure, OB-class floaters are expected to be lighter and therefore cheaper than the OA ones, for the same service life.

Aim: to identify design areas where such mass savings are possible and quantify their cost saving potential. The work will be performed using a reference 15MW turbine supported by a semi-submersible steel floater.

- **Task 1: Met-ocean conditions**
- **Task 2: Global dimensions and serviceability → floater "footprint"**
- **Task 3: Intact stability and air-gap analysis → columns height**
- **Task 4: Dynamic performance and RAOs → material thickness**
- **Task 5: Time domain load calculations**

Tasks 2-5 represent the steps of the first iteration of a floater design



**OptHull.GR Joint Industry Project is jointly performed by iWind Renewables and SAS Marine.*

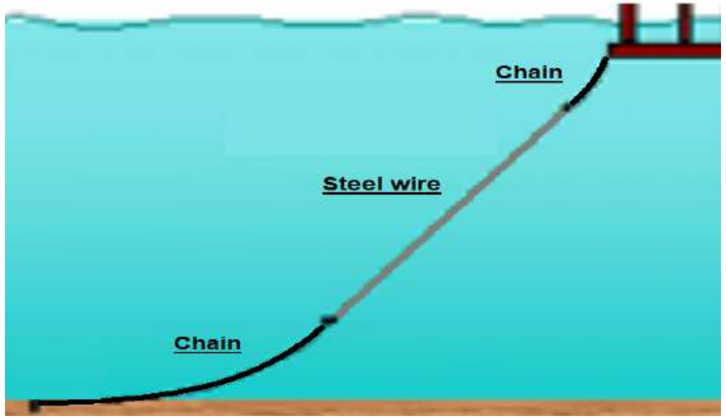
Conclusions from the OptHull.GR JIP

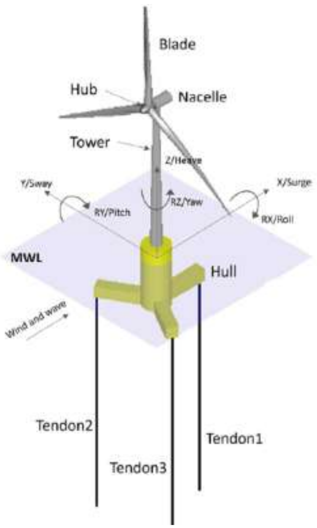
- Task 1: wave characteristics obtained from statistical analysis of meso-scale data indicated that in the Aegean Sea, wave heights are approximately half of those in the Atlantic Ocean and the North Sea, while wave periods are about 20% shorter. The average wind speeds are high, ranging from 8.6 to 9.8 m/s.
- Task 2: did not achieve a reduction in the steel mass of the reference floater. The "footprint" of the reference design is nearly optimum and the examined global geometric parameters L and R are primarily dependent on the rated rotor thrust rather than the met-ocean conditions.
- Task 3: three floater designs with a draft of 15.0 m, 17.5 m, and 20.0 m were tested that satisfy the intact stability and air-gap requirements. Expected floater mass reduction of **6-12%** is achieved due to the shorter column height .
- Task 4: indicated an expected floater mass reduction of **at least 24%**. This reduction is attributed to the combined effect of the shorter column height and the reduced material thickness resulting from the lower wave heights at the OB-class site in the Aegean Sea, compared with its OA-class counterpart in the North Sea.

Industrial Project on Hybrid Mooring Systems for Floating Offshore Wind Turbines (FOWTs)

Scope: Design and comparison of mooring systems with **steel wire ropes** vs. **synthetic ropes** for the station keeping of floating wind turbine solutions on the basis of specified KPIs (i.e. mooring line tension and cost, floater motions, tower and blade combined moments, hub acceleration).

Objective: Identify possible **cost benefits by using steel wire ropes**, as compared to the synthetic ones and their dependence on the floater type, water depth and met-ocean conditions. Conventional systems made of chains shall be designed, if applicable, to define the "basis" in terms of design specification.





Floater Type`	Met-ocean conditions		Mooring type per water depth	
Semi-sub	OA	OB	200 m • Chain • Steel rope • Polyester rope	1,000 m • Steel rope • Polyester rope • Hybrid rope
Spar-buoy	OA	OB	300 m • Chain • Steel rope • Polyester rope	1,000 m • Steel rope • Polyester rope • Hybrid rope
TLP	OA	OB	200 m • Steel rope • HMPE/Dyneema	

**The project was jointly performed by iWind Renewables and NTUA.*

Conclusions

- All examined mooring system designs are technically viable, exhibiting similar dynamic behavior of the coupled floating structure.
- All tested rope materials—steel, polyester, and HMPE (Dyneema)—can be effectively employed for station-keeping in 10 MW semi-submersible, spar-buoy, and TLP floaters, with the exception of polyester ropes for TLPs because of insufficient axial stiffness.
- Hybrid catenary systems offer significant cost savings, especially at deep water depths, with steel wire and polyester ropes showing comparable economics, although steel wire ropes provide superior offset performance.
- For TLPs, steel wire ropes outperform HMPE (Dyneema) due to higher stiffness and lower cost.
- Site-specific met-ocean conditions primarily affect semi-submersibles. At OB-class sites, chain diameters can be reduced by 6–13%, resulting in **10–22% material cost savings**.

Thank you

www.iwind.gr

info@iwind.gr

linkedin.com/company/iwind-renewables-sa