Designing FWT mooring system in shallow water depth

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INTRODUCTION

Floating Wind Turbine (FWT) prototypes and pilot farms are located in shallower zones than most of the studies in the literature about moored FWT.

➡ For water depth > 150m , studies have been successful in defining a conventional catenary mooring system with heavy chains.

➡ For shallower water depth, solutions like taut or semi-taut configurations using material elasticity of synthetic ropes could be attractive for Marine renewable energy devices [1].

Design and comparisons of conventional catenary mooring chain systems and Taut mooring systems using synthetic fibres are done at 65m.

➡ Comparisons in terms of **Key Performance Indicators**

➡ Importance of **mooring modelling hypotheses** for line tensions and floater horizontal motions.

Numerical model

5MW – CSC Semi-submersible [2]
NEMOH + OrcaFlex

Hydrodynamics :
Potential theory + Drag forces

Aerodynamics :
Drag forces on rotor and tower

Moorings :
Lumped-mass model and non-linear load-strain curve

METHODOLOGY

Key Performance Indicators (KPI)

- **CAPEX**
  - **Procurement Cost**
  - **Installation Cost**

  k€
- **Operation And Maintenance (OAM)**
  - **Preventive maintenance**
  - **Heavy maintenance**
- **Environmental Impact and risk (EI)**
  - **Footprint on seabed**
  - **Touchdown point excursion**
- **Station keeping performance**
  - **Maximum floater excursion**

KPI range : 1 (Low score) to 5 (High score).

Design Methodology

Mooring configurations defined parametrically covering design space

Several Checks for each mooring configuration :
✓Admissible Draft in static position
✓Admissible eigen periods at steady positions
✓Tension criteria according to DNV – OS – J103

Static → Frequency Domain → Time Domain

Reduced number of **Design Load cases (DLC)** with operating and parked wind turbine cases.

	Dir. (°)	Hs (m)	Tp (s)	Uc (m/s)	Uw (m/s)
DLC 1	247.5	11	15	0.7	44
DLC 2	187.5	7	15	0.6	44
DLC 3	247.5	11	15	0.3	11.4
DLC 4	187.5	7	15	0.2	11.4

X 2 depth (EWLR) w/ and w/o Marine Growth

Table 1 : Limited number of Design Load Cases

Site conditions

Shallow water:
Representative of planned pilot wind farm site around Groix Island on Atlantic French Coast.

Depth : $LAT \sim 62{,}5m$; $HAT \sim 67{,}5m$

Waves conditions :47° 30 N, 3° 30 W from HOMERE [3]

$(H_s, \theta_{wave})_{50years}$ contour calculated with Peak Over Thresold (POT) and fitted Generalized Pareto Distribution (GPD)

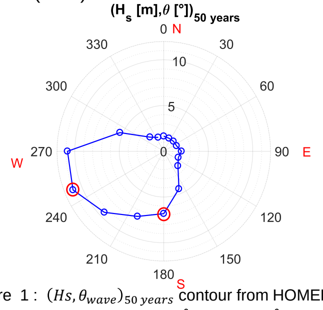


Figure 1 : $(Hs, \theta_{wave})_{50\ years}$ contour from HOMERE with POT + GPD for point 47° 30N and 3° 30 W

KPI Preliminary Evaluation

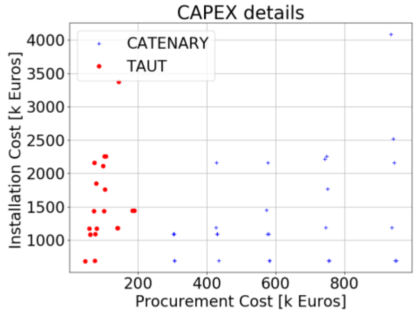


Figure 2 : Installation cost versus Procurement Cost for Taut and catenary mooring configurations.

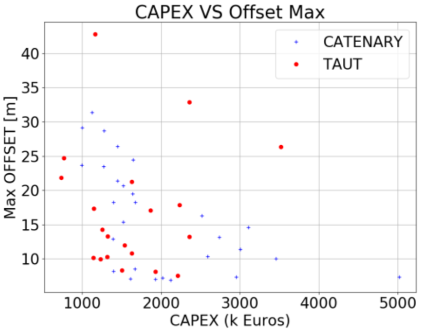
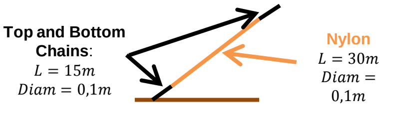


Figure 3 : CAPEX versus station keeping performance

Taut mooring configurations



Catenary mooring chains

Chain
$L = 15m$
$Diam = 0{,}1m$

CONCLUSIONS

The main outcomes can be summarized by:

a) Different wave directions could significantly change loads in the mooring lines

b) A synthetic methodology with Key Performance Indicators has been defined

c) When taking into account not only CAPEX but also Environmental impact and Station keeping performance, Taut mooring configurarions appear efficients.

d) Actual uncertainties on Marine Growth properties on site lead to a certain level of risk and unadapted mooring system.

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