Concrete Floating Platform for Wind Turbines

Dr. Climent Molins
What is Windcrete?
**Integrated concept** of an offshore wind floating platform plus tower for supporting the wind turbine, without any joint

Made of reinforced and prestressed **concrete**

**Spar** type platform (ballast stabilized)
The philosophy

20th Century

HYDRO POWER

- Large passive structures
- Minimum OPEX costs

OPEX MAINLY FOCUSED ON THE TURBINE SYSTEM
21st Century

OFFSHORE WIND?

- Active or passive structure
- Robustness
- Foundation OPEX costs

The philosophy
Avoiding joints between the tower and the floater

Problems in the connection between monopiles and tower, i.e. Princess Amalia Wind Farm
Spar buoy

Monolithic concrete platform (buoy + tower) without joints

Variable Draft (80 m – 130 m)

Operational depth (100 m to >1000 m)

Adaptative design, able to support wind turbines up to 15 MW

Reduced OPEX

Low cost – reduced CAPEX

Life-span >50 years

Reduced LCOE
02
Proof of Concept
Proof of concept
KIC Innoenergy AFOSP project – Simulations & Experiments

- Free decay tests
  - 1:100 scaled experiments
- Numerical results validated in the CIEM-UPC wave flume
- Wave and wind force experiments, composed in different directions & different wave heights
The scaled model (1:100) Laboratori d’Enginyeria Marítima (CIEM-LIM)

- CIEM wave flume:
  - Length: 100m.
  - Width: 3m.
  - Max. depth: 7m.
  - Max. Wave height: 1.6m.
  - Regular & Irregular wave generation.
Numerical models calibration
Modal Analysis

1st structural eigenfrequency

NREL 5WT WT Campbell’s diagram
Coupled aero-hydro-servo-elastic FAST simulation

![Graph showing maximum tower base moment (N m) for different DLC configurations](image)

IEC61400-3 DLC’s
Structural analysis: ULS

Bending moments and shear forces

Axial force

<table>
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<tr>
<th>Limit State</th>
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<tbody>
<tr>
<td>Ultimate Limit State</td>
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<tr>
<td>Fatigue Limit State</td>
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Structural Analysis: Fatigue assessment

Max. $D \leq 0.4$

50 years cumulated damage ($D$)

Floater - Orange line
Mid tower - Red line
Tower Base - Gray line

Proof of concept
KIC Innoenergy AFOSP project – Simulations & Experiments
03 Installation
Transport & Tug boat
Erection
- Water ballasting - Dynamic control
Wind turbine installation
- Catamaran ship
Emerging
- Aggregate ballasting

Ballast: black slag, a by-product of electrical furnaces, to reduce costs and environmental footprint.

25 kN/m³ specific weight
Cost analysis
Concrete vs. Steel cost comparison

5MW WT SPAR equivalent designs

- Steel SPAR
- Concrete SPAR

<table>
<thead>
<tr>
<th>Component</th>
<th>Concrete</th>
<th>Steels</th>
<th>Ballast</th>
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<td>Ballast</td>
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LCOE WINDCRETE: 14.27 €ct/kwh(1)

Scenario:
Gross Load Factor: 51%
Water depth: 145m
Distance to shore: 20km
Turbine size: 10MW
Including 1.77€ct/kwh of transmission charges without seabed rent

Substructure plus tower CAPEX is 1,498 k€/MW

**Milestones**

1. **2012: Concept UPC patent**
2. **2013-2014:** KIC Innoenergy AFOSP project
   **Proof of Concept**
3. **2016-2018:** Detail engineering for 100 kW prototype
4. **2018-2020:** 100 kW unit and field tests
5. **2021:** Prototype
   **... Industrialization & Commercialization**
Thank you!