Pelastar TLP Floating Wind Turbine Foundation

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PRESENTED AT *TEN YEARS OF INNOVATION*

**THE ETI AND THE PELASTAR TLP FLOATING WIND TURBINE FOUNDATION**
ETI Focus Area: Deep Water Wind

The Tension Leg Platform
- Less mature technology
- Potential for Lowest Cost of Energy
- Technical Challenges that need solutions

ETI Push for Ambitious Goal
- Take Concept through Front-End Engineering Design (FEED) for a FULL SCALE Demonstration (6MW) Project Offshore

Engineers working with Engineers
DEEP WATER FOUNDATION OPTIONS

Spar:
• Hywind (Statoil)

Semi-submersible:
• WindFloat (PPI)

TLP:
• Not demonstrated

<table>
<thead>
<tr>
<th>Cost Drivers</th>
<th>Jacket</th>
<th>HyWind</th>
<th>WindFloat</th>
<th>TLP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onshore Assembly</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Lightweight Structure</td>
<td>-</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Turbine Performance</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Siting Flexibility</td>
<td>✗- 45m max</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Serial Production</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tbody>
</table>
#4 above is the Magnolia TLP, considered the world's tallest structure at 1,432 meters from seabed to top of platform.

- Worlds tallest skyscraper is 828m tall.
- A PelaStar is 285m tall from seabed to blade tip. (with 6MW – 150m blade diameter turbine in 100 meters of water)

#5 - The SeaStar TLP, the oil and gas precedent for PelaStar
Developed by engineers seeking the best deep-water turbine foundation solution at the lowest cost.
OUR ETI PARTNERSHIP ADVANCED TLP TECHNOLOGY

An Engineered Technology Development Driven by a Focus on Lowering CoE

- Advanced TLP Technology to Technical Readiness Level (TRL) 5
- Established a design, analysis and regulatory framework
  - Participation in DNV JIP contributed to floating foundation regulatory rules development
  - DNV GL approved Basis of Design and reviewed the FEED-level design
- 1:50 scale model tests performed
  - with software validation reviewed and studied by DNV GL with results co-published
ADVANCED TLP CONFIGURATION TO 5 ARMS

• Provided Redundancy and Reliability not found in 3 or 4-Arm Designs

Design Patents awarded in EU, US and Japan
ADVANCED TENDON TECHNOLOGY

Synthetic Cable Tendons solve many of the traditional TLP mooring and installation challenges

• Enable simultaneous tendon and platform installation
• Minimize need to adjust tendon tensions to balance uneven loads at installation  
  *Patent Pending*
• Tolerate slack-line events in extreme conditions
## TENDONS VS. CHAIN - 6MW FLOATING FOUNDATIONS

<table>
<thead>
<tr>
<th></th>
<th>PelaStar</th>
<th>Hywind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mooring System</td>
<td>5 Vertical Synthetic Tendons, 7.5” dia, totaling 420 meters and 10 tons</td>
<td>3 Catenary Chains, 6” dia, totaling 2,400 meters and 1,200 tons.</td>
</tr>
</tbody>
</table>

Credit: Statoil

![Image of PelaStar mooring system](image1.png)

![Image of Hywind mooring system](image2.png)

Hywind Pilot Park Scotland 253 m (175+78 m)

Credit: Statoil
ADVANCED TLP INSTALLATION TECHNOLOGY

• Design of installation vessel

Patents awarded in UK and US

Long-term utility-scale installation and deployment method utilizes a dedicated installation barge
The GE/Alstom 6MW turbine is the first turbine to be integrated with the PelaStar foundation.
DEVELOPED FIRST FULLY-VETTED, TRANSPARENT COST DEFINITION TO INDUSTRY

• Demonstrated that the TLP at commercial scale will have the lowest LCOE among all FOWT concepts
  • has the lowest primary steel cost (lowest weight and simple to build),
  • Recent steep reductions in bottom-fixed costs, due to competition and learning curves, will lower floating wind baseline cost estimates

This is a 2015 forecast – timeline needs to move out to reflect current industry progress and wind farm development timescales.
TODAY: NEW OPTIONS FOR DEMO INSTALLATION

- DEME / GeoSea’s ORION – 2019 delivery – 3,000t lift at 50m reach
  - Enables Transport and Installation of PelaStar in Deep Water
  - Vessel Dynamic Positioning and Heave Compensation on the Hoist
OUR PARTNERSHIP ADVANCED TLP TECHNOLOGY

• Established the TLP as a viable foundation option for deep water offshore wind
• Generated worldwide interest in the TLP for deep water offshore wind turbine foundations
  • competing concepts emerging

Today – we continue to pursue a demonstration project and commercialization of PelaStar….
  • ….with confidence that the ETI vision and trust in engineering to optimize lowest-cost solutions will be realized.
Our ETI Partnership was Extremely Beneficial for Industry, and Highly Rewarding for the Participants

Thank you.

“Scientists discover the world that exists; Engineers create the world that never was.”
—Theodore von Karman