The WindFloat Project

Deep Offshore Wind – an opportunity for Europe

Conference Atlantic Forum

Brest, 30th of October, 2012
Are we creating sustainable value from our oceans? How can we do it? Energy as a sustainable value creation driver @ sea

“Ocean Energies... can contribute to the development of a “blue economy” in Europe... provide jobs and spur economic growth. Innovation and technology will drive this new economy.”

ENERGY  SEA
TECHNOLOGY AND INNOVATION
VALUE CREATION  JOBS
OPPORTUNITY FOR EUROPE
Agenda

- EDP and its renewable energy positioning
- Deep offshore wind rationale
- WindFloat Project
- Deep offshore wind - an opportunity for Europe
#3 wind energy player in the world with 7,500 MW of installed capacity in 11 countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Installed MW</th>
<th>FY2011 EBITDA</th>
<th>ENEOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>3,422</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>215</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>58</td>
<td>1,448</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>43</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>306</td>
<td>1,614</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>618</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>939</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Romania</td>
<td>579</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>Poland</td>
<td>830</td>
<td>285</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>2,201</td>
<td>390</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>3,850</td>
<td>1,365</td>
<td></td>
</tr>
<tr>
<td>FY2011 EBITDA + ENEOP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installed MW</td>
<td>7,483</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under construction</td>
<td>375</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipeline</td>
<td>21,028</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
EDP is partnering with Repsol for the development of Offshore Wind Projects in the UK

### UK Offshore Wind Partnership

EDPR is leading the development of up to 2.4 GW of wind offshore projects with a 60% stake.

- Partnering with Repsol, 1\textsuperscript{st} class company in Energy Sector with strong commitment to wind offshore capacity development.
- Sites to be developed in “transitional waters” (30-60m of depth), 15-25 km shore distance.
- Upon getting key consents, construction and operation could begin between 2015 and 2020.
Why Offshore Wind and Why Floating Offshore Wind

Why Offshore Wind?

• Higher wind resource and less turbulence
• Large ocean areas available
• Best spots in wind onshore are becoming scarce
• Offshore wind, including deep offshore, has the capacity to deliver high quantities of energy

Why Floating Offshore Wind?

• Limited spots with shallow waters (mostly in the North Sea)
• Most of the resource is in deep waters
• Huge scale ocean areas available
• Less restrictions for offshore deployments and reduced visual impacts
• Enormous potential around the world: PT, Spain, UK, France, Norway, Italy, USA, Canada ...
Deep offshore wind potential goes in line with the quality of the resource and the availability of areas to explore

**EU15 Potential**

- Good offshore wind resource (load factor > 3.000h)
- Offshore wind potential is mostly in transitional and deep waters\(^{(1)}\) (~65 %)
- Energy Potential >700 TWh (~220 GW)
- Ports and docks available along European coast

\(^{(1)}\)Analysis limited to 100m water depths

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Offshore potential EU15</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 30</td>
<td>40 – 200 +</td>
</tr>
<tr>
<td>77 GW</td>
<td>&gt;140 GW</td>
</tr>
</tbody>
</table>

Source: Greenpeace & Garrad Hassan 2004; IEA; Global insight;

**Portuguese & Spanish Potential**

- Continental shelf ends near the coast
- Grid connection available near the coast
- Limited Potential for water depths < 40m
- 250 km of PT Costal Line suitable to be explored
- Energy Potential in PT >40 TWh (~12 GW)
- Energy Potential in SP >290 TWh (~98 GW)

<table>
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<th>Depth (m)</th>
<th>Offshore potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 30</td>
<td>40 – 200 +</td>
</tr>
<tr>
<td>PT</td>
<td>2 GW</td>
</tr>
<tr>
<td>SP</td>
<td>18 GW</td>
</tr>
<tr>
<td></td>
<td>&gt;10 GW</td>
</tr>
<tr>
<td></td>
<td>&gt;80 GW</td>
</tr>
</tbody>
</table>

Source: Univ.de Zaragoza – Evaluación Potencial Energías Renovables (2007)
Deep offshore wind carries the potential to deliver sustained long term growth to the Wind Energy industry

Deep Offshore Wind Technology development milestones

**Short to Medium Term**
- First outputs of demonstration projects
- First successful demonstration projects

**Medium to Long Term**
- Technology consolidation
- Cost reduction
- First large scale commercial deployments

Onshore Wind
Shallow-water Offshore
Deep-water Offshore

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High growth rates mid 2000s reaching close to 200 GW in 2010
First commercial projects, reaching around 3GW in 2010
First demonstration projects

High growth continues driven by emerging markets

High growth period focused on North Sea and a few other smaller shallow other areas
Several demonstration and pre-commercial projects First commercial projects

~2012

~2020

Adequate new sites become scarce in most markets Focus on repowering
Adequate new sites become very scarce
High growth stage (potentially sustainable for a very long period of time)
WindFloat Project
The WindFloat technology – its main characteristics lead to High Stability even in rough seas

Turbine Agnostic
- Conventional turbine (3-blade, upwind)
- Changes required in control system of the turbine

High Stability Performance
- Static Stability - Water Ballast
- Dynamic Stability - Heave Plates and active ballast system
  - Move platform natural response above the wave excitation (entrained water)
  - Viscous damping reduces platform motions
- Efficiency – Closed-loop Active Ballast System

Depth Flexibility (>40m)

Assembly & Installation
- Port assembly – Reduced risk and cost
- No specialized vessels required, conventional tugs
- Industry standard mooring equipment
We are still developing the 1st phase (demonstration phase) of a potentially larger project. Next step – Pre-commercial phase

**Phase 1 – Demonstration**
- **Capacity:** 2MW WindFloat prototype
- **Location:** Aguçadoura, grid connected
  - ~6 km of coast, 40 - 50 m water depth
- **Turbine:** 2MW offshore wind turbine
- **Test period:** 24+ months

**Phase 2 - Pre-commercial**
- **Capacity:** ~27MW (~5 WindFloat units)
- **Location:** Portuguese Pilot Zone
- **Turbine:** Likely Vestas and other, Multi MW

**Phase 3 - Commercial**
- **Capacity:** 150MW, gradual build-out
- **Location:** TBD
- **Turbine:** TBD
The WindFloat project was structured as a Joint Venture, WindPlus

The Project is being developed by...

...in a joint venture...

WindPlus*

...with the support from...

* WindPlus shareholders are edp, repsol, inovcapital, principle power and a. silva matos
Workshop Fabrication of main components

A. Silva Matos was the responsible for the fabrication of the WindFloat.
Pre-assembly of the columns outside the Dry-dock in Setúbal
Columns moved to Dry-dock
Mooring Pre-Lay in parallel with the fabrication
Turbine Installation in the Dry Dock using the shipyard’s gantry crane
WindFloat being loaded out of the dock
WindFloat at the Sado Estuary, just outside the shipyard
Tow from Setúbal to Aguçadoura (~400 km) using the same vessel that was used for the mooring installation.
Hook-up at final location
In Operation since December 2011!
The WindFloat is monitored 24 hours a day remotely
Survivability and performance proved in normal and extreme conditions

22 Oct 2011
Installation complete

01 Nov 2011
15 meters wave

20 Dec 2011
First Electron produced

03 Jan 2012
Operation in Hs=6m and Hmax=12.6m
WindFloat is commissioned and producing at full power (when there is enough wind!). 3 GWh and counting!
WindFloat is behaving well in line with the models and turbine is following its original power curve – no losses due to motions.
WindFloat technology can lead to 70 to 110 €/MWh

Main Drivers of Improvement:

1. Increase the Power of the turbine as:
   - The size of the platform is mostly driven by the metocean conditions (1)
   - Turbines of 7 MW – 15 MW are currently in development (Vestas 7MW announced) and in final testing phases

2. Improve the installation procedure and O&M strategy

3. Cheaper materials

4. Synergetic commercial activities
The WF technology revives traditional sectors with technological innovation and without significant infrastructure investments

Share of sectors involved in the development of the WindFloat Prototype (%)

- Engineering: 30%
- Electrical Equipment: 18%
- Other: 9%
- Total*: 23 M€

Main sectors of activity directly involved in the project:

1. Engineering Services
2. Maritime Construction - Shipyards
3. Metal-Working
4. Maritime Transport
5. Electrical and Electronic Equipment
6. Offshore Equipment
7. Legal services
8. Financial Services - Insurance
The WindFloat technology requires highly skilled labour in European traditional sectors

FTE’s involved in the WindFloat Prototype (%)

Total*=210

- Unskilled 5%
- Engineer 39%
- Qualified Technician 48%
- Other 5%
- PHD 3%

WindFloat Prototype

- 90% of highly skilled workers
- More than 70% of European Suppliers

WindFloat Pre-Commercial Project

- More than 450 highly skilled workers involved in a three year project
- More than 90% of European Suppliers

* Not including other indirect participants also involved in engineering, investment and management activities from A. Silva Matos, EDP Innovation, EDP Renewables and InovCapital.
EC R&D (and other) support schemes can have a key role in fostering sustainable value creation at sea: Upstream and Downstream
USTREAM – EC funded R&D can have an important role upstream to the development of projects, namely

- Thinking strategically about the sea and its uses
- Studying the ocean in its various dimensions
  - Fauna
  - Flora
  - mineral resources
  - wave, tidal and offshore wind resources
- Studying and characterizing the potential activities to be developed in the ocean and its impacts
  - Fisheries
  - energy exploration
  - mineral exploration
  - Turism
  - logistics and transportation
- Developing criteria (multi-variable / clustering methodologies) to identify what activities should be promoted / favored – Sustainable Value Creation should be the moto
- Partnering with the Authorities and Industry to develop maritime spatial plans to accommodate the activities taking place at sea
- Partnering with the Authorities and Industry to develop simplified licensing processes
DOWNSTREAM – Potential for value creation and significant opportunities for collaboration between Industry and Academia

Potential to explore / fund:

• Deep Offshore wind project development methodologies (site and resource characterization, environmental evaluation...)

• Adaptation of Multi MW offshore wind turbines (control systems, mechanical interface...)

• Offshore wind structures / foundations design

• Offshore wind structures / foundations and integrated systems certification

• Offshore wind structures construction and assembly (industrial planning, industrial engineering, manufacturing optimization...)

edp
• Ports and shipyards reconfiguration and adaptation towards offshore wind systems construction and assembly
  • Docks
  • Cranes
• Offshore wind structures / foundations and integrated systems transportation and installation
  • Methodologies / best practices / consultancy
  • Vessels
  • Skilled labor (training)
• Offshore wind integrated systems commissioning, testing, monitoring and life cycle assessment
  • Instrumentation and monitoring of the systems
  • Data analysis
  • Life cycle assessment
DOWNSTREAM – Potential for value creation and significant opportunities for collaboration between Industry and Academia (cont)

• Offshore wind systems operation and maintenance
  • Methodologies / best practices / consultancy
  • Vessels
  • Access systems
  • Skilled labor (training)

• Offshore wind systems decommissioning

• ...
Final remarks

• WindFloat Project and deep offshore wind represent a significant industrial opportunity for Europe - highly skilled labor and value adding activities in traditionally strong European sectors
• The fabrication and assembly were successfully completed. Being able to construct the unit in Portugal (no offshore experience) indicates that it is possible to adapt naval infrastructures successfully and without major investments
• Offshore installation strategy successful. Supply chain breakthrough?
• The technical results of the first 6-9 months of operation of the WindFloat are very promising. Need to evaluate long term performance and impacts
• Pre-commercial phase is the next meaningful step to bridge the gap between demonstration and market
Thank You

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