The WindFloat Project

February 2010
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
- Large ocean areas available
- Less restrictions for offshore deployments and reduced visual impacts
- Huge potential around the world: PT, Spain, UK, France, Norway, Italy, USA, Canada …
Why Offshore Wind?

**Technology Development**

**Short Term**
- Onshore wind continues with high growth rate
- Shallow Offshore wind increases significantly its growth rate
- Deep offshore wind with first commercial deployments

**Medium Term**
- Onshore wind reaches the limit of its potential.
- Shallow Offshore wind reduces its growth rate
- Deep offshore wind with high growth rate

**Long Term**
- Onshore wind reaches the limit of its potential.
- Shallow Offshore wind reduces its growth rate
- Deep offshore wind with high growth rate

**Milestones Short/Medium Term**
- First results of the demonstration stage
- First successful demonstration projects and technology cost reduction

**Milestones Medium/Long Term**
- Technology consolidation and cost reduction in deep offshore wind
- Large scale deep offshore commercial deployments

**Technical solution**
- Wind Energy conversion stabilized and well known
- Technological challenges:
  - Wind turbine and maritime environment
  - Adapt wind turbine to platform motion
  - O&M operations

**Time to market**
- 5 – 10 years

**Players in the market**
- Market Leaders are involved:
  - Statoil Hydro
  - Siemens
  - ...
- Two floating platforms already installed

**Deep offshore is the only Wind Energy Source with growth capacity in medium/long term**
Why Floating Offshore Wind?

**Monopiles**
- Basic extension of turbine tower w/ transition piece
- Economically feasible in shallow water depths (10-30m)

**Jackets**
- Economically feasible in transitional water depths (30-50m)
- Derivatives from Oil & Gas technology
- Beatrice successfully deployed (2 jackets x RePower 5M)

**Floating**
- Economically feasible in deep water (50-900m)
- Two prototypes have been deployed (Hywind and Blue H)

Source: NREL
Market Potential

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 Coastal Line suitable to be explored
- Energy Potential in PT >40 TWh (~12 GW)
- Energy Potential in SP >290 TWh (~97 GW)

<table>
<thead>
<tr>
<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 Renovable (2007)
• Onshore wind energy limited to ~12 TWh
• Wind energy penetration will reduce to 17% by 2020\(^{(1)}\)
  - If new renewable energies are not introduced to energy mix production
• The deployment of commercial Offshore Wind farms in transitional waters (>40m, < 60m) will:
  • Enable Portugal to keep the leading position in renewable energy
  • Maintain the wind energy penetration of 20% by 2020 and 2030
• If floating offshore wind is deployed the wind energy penetration will increase significantly

\(^{(1)}\)Considering a grow rate of ~3% in energy consumption
Market Potential – Portugal Offshore Wind Potential

- Onshore wind energy limited to ~12 TWh
- Wind energy penetration will reduce to 17% by 2020\(^{(1)}\)
  - If new renewable energies are not introduced to energy mix production

- The deployment of commercial Offshore Wind farms in transitional waters (>40m, < 60m) will:
  - Enable Portugal to keep the leading position in renewable energy
  - Maintain the wind energy penetration of 20% by 2020 and 2030

- If floating offshore wind is deployed the wind energy penetration will increase significantly

\(^{(1)}\) Considering a grow rate of ~3% in energy consumption
Market Potential – Value Creation in Portugal

**Components development and fabrication**
- **Turbine**
- **Tower**
- **Support structures**
  - Transitional depth (30-50m)
  - Deep waters (>50m)

**Production of ancillary equipments (e.g., substations, connections)**

**Engineering work focusing on installation**

**Installation and maintenance**

**Exploration (promotor)**

---

**Significant opportunity for PT in offshore wind support structures**

- **National Competences**
  - **Degree**
  - **Already existing**
  - **Development Potential**
  - **Stronger Difficulties**
- **Ambition**

- **Attract to Portugal activities in the areas of research, development and demonstration in key offshore areas such as offshore turbines and support structures**
- **Lead in installed capacity of offshore ancillary equipments**
- **Become world experts in engineering for offshore energy installations**
- **Adapt ports and shipyards to service the offshore energy projects**
- **Diversify RE portfolio by gradually integrating offshore energy projects alongside with mature technologies**

- **Experienced Renewable Energy promoters**
- **Civil engineering companies with strong experience in construction of maritime infrastructure**
- **Good network of ports and shipyards, to be leveraged with service providing to these equipments**
- **Technology transfer from O&G sector. Incentive would stimulate O&G companies interests to pursue RE tech.**
- **Technical transfer from O&G sector.**
- **Technology based in civil engineering achievable given Portuguese background**
- **Presence of National tower producers**

---

**WINDPLUS S.A.**
Enormous potential for value creation

- Wind energy resource available
  - Limited potential for water depths <40m
  - Total potential **almost unlimited** for floating wind turbines (water depths >40m)
- Business in the range of 1Bi+ € in 2025* (80% exports)
- Jobs in excess of 7,000*
- Leveraging on existing know-how, attracting more knowledge in a R&D intensive area
- Develop a national cluster
  - Opportunities in fabrication, engineering and O&M and environmental studies
- Taking advantage of existing infrastructure (ports and docks)
- New opportunities for the distressed maritime sector

* Preliminary estimation based on a study for the Wave Energy Sector
The WindFloat Technology – Key Features

Turbine Agnostic
- Conventional (3-blade, upwind)
- No major redesign
  - Control system – software
  - Tower – structural interface

High Stability Performance
- Static Stability - Water Ballast
  - \( \approx \frac{1}{2} \) of hull displacement
- Dynamic Stability - Heave Plates
  - 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
- No specialized vessels required, conventional tugs
- Industry standard mooring equipment
WINDPLUS S.A. Structure

Phase 1 – 2 MW Prototype
- 2MW Prototype in Portugal
- ~5 km of the coast in 40-50m water depths
- 12 months monitoring period
- Validation criteria for acceptance

Phase 2 – Pre-Commercial
- Controlled roll-out with the deployment of 3 to 5 full scale devices (5 MW each)
- Deployment off Portuguese west coast, grid connected

Phase 3 – Commercial
- Up to 150 MW deployment
- Grid connected with 5MW OWTG
- Location TBD
Summary

- Offshore wind provides Portugal with an ability to meet and maintain RE generation capacity > 20%
- The WindFloat project offers multiple benefits:
  - Technology Know-How
  - Infrastructure shift to RE
  - Jobs creation
- This is a project of National significance
Thank You – Obrigado!