EDP Innovation involvement in offshore energy

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EDP’s Business Portfolio

**EDP Brasil**

- 12% of EBITDA
- Listed subsidiary: EDP Brasil (EDP has 51%)
- Presence since 1996
- Power generation: 2.6 GW
- 2 electricity distribution concessions

**Wind & Solar Power**

- 32% of EBITDA
- (10% North America; 6% Spain; 4% Portugal; 5% Other)
- Listed subsidiary: EDP Renováveis (EDP has 77.5%)
- IPO in Jun-08
- Wind & Solar Power: 9.7 GW
- A worldwide renewable market leader

**Portugal**

- 43% of EBITDA
- Privatization in 1997 (IPO)
- Single electricity distributor
- Power generation: 10.0 GW

**Spain**

- 13% of EBITDA
- Presence since 2001
- Power generation 6.0 GW
- #2 in gas distribution

Note: Data as of Mar-16
EDPR is a market leader with 9.7 GW of wind energy installed capacity worldwide...
EDP covers a big spectrum of Clean Tech generation technologies in different stages of development...

- **Eólica Offshore (fixo)**: Mature
- **Solar CPV**
- **Eólica offshore flutuante**
- **HAWE\(^{(1)}\)**
- **Energia Ondas**: Early stage

\(^{(1)}\) High Altitude Wind Energy
Current fix Offshore projects to support growth options and capture a new wave of industry development and R&D leadership

UNITED KINGDOM

Moray Firth

1.1 GW in consenting
750 MW in development

Consent granted for offshore wind development; Partnership with CTG (up to 30%)

Next step: CfD allocation
Auction: pending date

FRANCE

Le Tréport

500 MW + 500 MW

Iles d’Yeu et de Noirmoutier

Partnership with Engie allows de-risking and complementary skills

Selected in May-14 for the development, construction and operation

Notes: (1) CfD – Contract for Difference
Floating wind also has been a strategic bet from EDP with direct involvement in the development of the WindFloat technology since 2008.

1. Strategic investment
- Shareholder of PPI with ~25% of the capital
- Provides a sustainable growth opportunity
- Diversification of generation portfolio

2. Anticipate market trend
- Leader in floating offshore wind
- Support the development of the floating offshore market

3. Controlled Risk
- Develop technology in incremental steps (Prototype, Pre-commercial, Commercial)
- Acquire know-how at an early stage of the technology
A successful implementation of a technology is supported in three pillars: Technology, LCOE and Bankability.

- **LCOE**: Bringing the technology to be cost competitive with other Renewable Energy Sources.
- **Bankability**: Reduce the risk to ensure the finance ability of the commercial projects.
- **Technology**: Develop a reliable and full scale tested solution.
The WindFloat Technology offer a significant number of advantages when compared with conventional and state of the art technology.

The WindFloat...

... requires **NO PILLING**

...is structurally **decoupled from seadbed**

...is **independent from depth**

...is assembled and commissioned quayside

...**does NOT require high lift capacity vessels**

**Reduced Risk and Cost**
The main characteristics of the WindFloat leads 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
The involvement of EDP in the development of the WindFloat technology allows to take a relevant position in key markets.

Global net market potential of > 2,000 GW
The WF1 was the first prototype and completed successfully the demonstration plan

### Project Description

- **Site**
  - Aguçadoura, Portugal.
  - 43 m water depth
  - Hs: 7m: 1 year return, 12m: 50 year return

- **Project**
  - 1st presentation to EDP, June 2008
  - FID: mid 2010
  - Load out, September 2011
  - First electron, Christmas 2011

- **Operation**
  - ~17 GWh produced in 5 years
  - Operated in Hs of 7 m
  - Survived 17 m waves
  - Reliable O&M and inspection program

- **Decommissioning**
  - July 2016
  - Reversible operation
  - Sole use of local tugs (No AHV)
  - Removal of the turbine at quay side (hull floating)
  - Life extension of the platform possible

### Prototype Objectives

- Demonstrate the ability to: Fabricate, commission at quayside and install fully-assembled WindFloat
- Produce power up to the one-year storm
- Survive large winter storms
- Withstand wave- and wind-induced fatigue
- Perform O&M activities on the platform
- Operate the Active Ballast System and other systems and equipment
- Predict the important responses of the system with numerical tools
- Decommissioned safely with minimal budget and negligible impact to the environment
The WindFloat Atlantic is the next stage of development and intends to demonstrate the pre-commercial phase of the technology.

- **Total capacity**: 25MW capacity, (3 units equipped with MHI-Vestas V164)
- **Total investment**: ~125M€ (partly funded by the EC)
- **Location**: 20 km off the coast of Viana do Castelo, in water depth of 85-100m, in an area of sand and sediments, suitable for mooring
- **Interconnection**: to be constructed by REN
- **Construction**: several shipyards options available close to final location. **Turbine installation quayside**
- **Floating structure certification**: designed for 25 years, certified throughout design, construction and installation by **ABS**, an independent party
- **Key Dates**:
  - FID: Q2-2017
  - Start Fabrication: Q3 2017
A competitive LCOE is already being achieved by scaling effects and by incorporating technical innovations in the concept.

- larger turbines (x3-4)
- design life extension (x5)
- global sizing – “smaller” platform
- structural optimizations
- equipment improvement
- accessibility
- mooring improvements
- installation improvements

- Capacity: x4
- Production: X4.5
- Unit cost: x1.75
The technology roadmap allows for visibility on the LCOE reduction and it is expected to be achieved < 100€/MWh post 2020.

- **WF1 (2 MW)**: Current design LCOE @ EUR 110-120 / MWh for large WF.
- **Pre-Commercial Demos (20-50 MW)**: 180-220 €/MWh.
- **Commercial Projects (>100 MW)**: <100 €/MWh.

UK Cost Reduction Goal: 135€/MWh (GBP 100).

Path to Commercialization: Competitive with industry targets.
Bankability has been addressed very seriously and it has been demonstrated that floating offers several competitive advantages.

<table>
<thead>
<tr>
<th>Description</th>
<th>Implications</th>
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<tbody>
<tr>
<td><strong>Fabrication</strong></td>
<td></td>
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<tr>
<td>• Fully conducted onshore</td>
<td>• Lower design risk</td>
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<tr>
<td>• All structures are alike</td>
<td>• Lower execution risk</td>
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<tr>
<td>• Certification: strict guidelines from oil &amp; gas industry</td>
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| **Sea bed** |  |
| • Anchoring technology with >60 year experience | • Lower geotechnical costs and risk |
| • Big flexibility on soil conditions |  |
| • Lower need of geotechnical studies |  |

| **Installation** |  |
| • Shorter weather windows required | • Lower execution costs and risk |
| • Fewer and simpler operations | • Lower weather risk |
| • No use of special installation vessels |  |

| **Large correctives** |  |
| • Shorter weather windows required | • Lower execution costs and risks |
| • Fewer and simpler operations to be conducted offshore | • Lower weather risk |
| • No use of special O&M vessels |  |

| **Decommissioning** |  |
| • Simple operation | • Lower execution risk |
| • No impact whatsoever on the site | • Lower third party risk |
| • All works done onshore |  |
The WindFloat Atlantic was able to capture experienced and strong partners for the development of the project:

<table>
<thead>
<tr>
<th>Partner</th>
<th>Country</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>EDPR</td>
<td>Portugal</td>
<td>19.4%</td>
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<tr>
<td>Repsol</td>
<td>Spain</td>
<td>19.4%</td>
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<tr>
<td>Trust Energy (Engie + Marubeni)</td>
<td>Japan + France</td>
<td>20%</td>
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<tr>
<td>DGE (Mitsubishi Corporation)</td>
<td>Japan</td>
<td>20%</td>
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<tr>
<td>CGE (Chiyoda Corporation)</td>
<td>Japan</td>
<td>20%</td>
</tr>
<tr>
<td>Principle Power</td>
<td>Portugal + USA</td>
<td>1.2%</td>
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<td>WindPlus</td>
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...and is already in advanced conversations with financing entities

First floating wind farm ever financed with non-recourse debt!

Commercial Bank 1

Commercial Bank 2

Consortium approved, pending due diligence
WFA will have a strong impact in Portugal

- It will have a GVA of €63m employing 1400 people.

- A floating wind industry will add 1% to national GDP and will generate 46,000 new employments.

- It will strongly revitalize important segments of our industry.

PWC
EDP is also supporting other innovative offshore solutions to cover a wider water depths range and overcome constraints in offshore logistics.
Wave Energy also presents a great opportunity in terms of resource but the technology is still at an earlier stage of development. EDP is actively looking for promising technologies.

**Wave energy**

- 29 500 TWh/yr theoretical potential worldwide;
- >500 GW worldwide;
- >30kW/m required for commercial exploitation;
- **Atlantic European Coast**, West Coast US, South America, Australia.

Global offshore annual wave power level distribution (Cornett, 2008).
Floating solar PV plants
A new growing market...

- **Floating PV plants** is a new growing market with potential in places around the world where the available land for PV installations is scarce and its cost is much higher than the cost of water surface.

- Today, there is already a demand for floating PV in countries such as Brazil, USA, Japan, Korea, Australia, etc.

- **Advantages** of floating PV:
  - Closeness to grid connection point;
  - Reduction of water evaporation;
  - Water cooling effect on the PV modules;

- EDP Produção developed a **Floating PV pilot plant in Alto do Rabagão**.

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**Alto do Rabagão**

*Installation: October'16*

*Power capacity: 200 kWp*

*Cost: 2 €/Wp*

*Expected energy: 290 MWh/year*
THANK YOU!