COLLABORATION OPPORTUNITIES BETWEEN SPAIN AND JAPAN IN THE OFFSHORE TECHNOLOGY

December 15, 2016

Alberto Ceña
OFFSHORE WIND MARKET IN SPAIN
**Spain has a strong position in onshore wind sector as well as in the shipping and boats production**

**Evolución anual y acumulada de la potencia instalada en España**

<table>
<thead>
<tr>
<th>Record</th>
<th>Valor</th>
<th>Fecha</th>
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<tbody>
<tr>
<td>Potencia instantánea:</td>
<td>17.553 MW</td>
<td>29/01/2015 19:27h</td>
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<tr>
<td></td>
<td>45.9% cobertura de la demanda</td>
<td></td>
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<tr>
<td></td>
<td>78% de potencia instalada</td>
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<tr>
<td>Producción diaria</td>
<td>367 GWh</td>
<td>12/02/2016</td>
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<tr>
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<td>47.7% cobertura de la demanda</td>
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<td>Producción Mensual</td>
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<td>01/2014</td>
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<td>29.6% cobertura de la demanda</td>
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<td>Cobertura Instántanea de demanda</td>
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<td>Cobertura de demanda diaria</td>
<td>52.3% 343.000 MWh</td>
<td>21/11/2015</td>
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<tr>
<td>Cobertura de demanda mensual</td>
<td>30.2% 6.091 GWh</td>
<td>02/2016</td>
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**Capacidad de intercambio comercial (MW) del 28/05/2016 al 10/06/2016**

**Spain has a strong position in onshore wind sector as well as in the shipping and boats production**
A SOLID INDUSTRIAL NETWORK TO ATTEND THE DOMESTIC AND INTERNATIONAL MARKETS

More than 700 companies, involved in the wind sector from manufacturers to financial services.

Spanish wind power sector industrial centres
NEVERTHELESS OFFSHORE MARKET HAS NOT YET STARTED

1. Remuneration was approved in 2007 using a pool+premium scheme that it was never applied.

2. Projects were neither approved even if a strategical environmental plan was defined and in spite of the goals of power of the different RE plans.

3. Several R&D initiatives were launched to resolve the main challenges: lack of continental platform, reduction of costs, higher reliability, grid integration, ..

4. Spanish Companies, as Iberdrola and EPDR are among the main promoters of off-shore wind farms.

5. Manufacturers are also supplying WTGs and specific components.
EVOLUTION OF THE THEORETICAL FORECASTED CAPACITY TO BE INSTALLED IN THE 2020 HORIZON

ZURBANO
5,000 MW

Draft NREAP
3,000 MW

NREAP (UE)
3,000 MW

Proposal for state agreement: 500 MW

Renewable Energy Plan 2011/2020
750 MW

5 GOOD WIND SPOTS BUT A TOO DEPTH SEABED NEARSHORE.
OFFSHORE PROJECTS WITH INITIATED PERMITTING PROCEDURE

Around 40 potential projects for around 14 GW.

28 projects are in the licensing phase, representing 9.540 MW.
MARKET HAS NOT YET TAKEN OFF, BUT SPANISH COMPANIES ARE SUPPLIERS FOR EU WIND FARMS

• ADWEN a GAMESA affiliated company has installed a total of 630 MW in the North Sea area.

• NAVANTIA has manufactured the jackets for the Wikinger Wind Farm.

• ORMAZABAL has supplied many MT switchgear boxes.

• VICINAY: chains and fixing components.
ADWEN, BRIEF PRESENTATION

Born a leader in offshore wind

Overview

- Joint-venture merging parent companies’ offshore wind businesses
- 700 people
- 630 MW installed capacity at sea
- 2.5GW installed capacity by 2021
- Fully operational industrial base (Germany)
- Renowned offshore R&D & technological know-how: Engineering centers in Germany, Spain and France
- Access to best-in-class wind know-how in cost optimization, component supply platform and long-standing operation & maintenance expertise

Shareholding

50/50

Product portfolio

| Adwen 5MW | Adwen 8MW |

Note that AREVA and Gamesa have reached agreement pursuant to which Gamesa would acquire AREVA’s 50% shareholding in Adwen, subject to authorization by the German competition authority. Closing is expected in January 2017.
Invaluable experience

18.2% market share in Europe 2015

120 5 MW turbines commissioned at two flagship projects during the summer of 2015

Global Tech I
Customer: Global Tech I Offshore Wind GmbH
Turbine: AD 5-116
Installed capacity: 400 MW
Electricity supply: 445,000 households

Trianel Windpark Borkum
Customer: Trianel Windkraft Borkum GmbH
Turbine: AD 5-116
Installed capacity: 200 MW
Electricity supply: 200,000 households
Recognition of proven technology and experience

2.5 GW installed capacity by 2021

- **2009**
  - alpha ventus
    - 6 WTG
    - 30 MW

- **2015**
  - Global Tech I
    - 80 WTG
    - 400 MW
  - Trianel Borkum
    - 40 WTG
    - 200 MW

- **2017**
  - Wikinger
    - 70 WTG
    - 350 MW
  - Bremerhaven
    - 25 MW

- **2020**
  - Saint Brieuc
    - 62 WTG – 8 MW
    - 496 MW

- **2021**
  - Le Tréport
    - 62 WTG – 8 MW
    - 496 MW
  - Yeu Noirmoutier
    - 62 WTG – 8 MW
    - 496 MW

- **2013**
  - Gran Canaria
    - 5 MW

630 MW operating at sea
Selected for 1,838 MW at 4 projects

Adwen
AN AREVA GAMESA COMPANY
ADWEN: THE RIGHT OEM TECHNOLOGICAL PARTNER

**TECHNOLOGY**
A versatile and comprehensive products portfolio suitable for specific projects requirements

**PIPELINE**
Pole position in an attractive market as recognition of our proven technology and experience

**PEOPLE**
700 experienced and talented people working under the highest standards of health and safety

**OPERATIONAL EXCELLENCE**
From manufacturing to operations and maintenance
RESEARCH AND DEVELOPMENT ACTIVITIES
OFFSHORE FOUNDATIONS

1. **Company: NAUTILUS Floating Solutions S.L**
   - **Project Title:** Development of cost competitive **semisubmersible platforms for 5 to 10 MW** floating offshore wind applications, easy to be built in conventional shipyards, easy to be assembled in conventional ports and easy to be towed by conventional ships to the operation site.

2. **Company: ESTEYCO Energía S. L.**
   - **Project title:** Experimental demonstration and certification of offshore technology foundation with self-erecting telescope tower.
   - **Project Title:** Cost reduction for Offshore wind. (ReCoEFF)

3. **Company: IBERDROLA Ingeniería y Construcción S.A.**
   - **Project title:** Development of optimum technical solutions for tensioned mooring systems for TLP platforms applicable to offshore wind.

4. **Company: DRAGADOS S.A.**
   - **Project Title:** Floating platform of concrete for deep waters wind power exploitation. (MENHIR Project)

5. **Company: ENEROCEAN S.L.**
   - **Project Title:** Wind integrated platform for 10+ MW power per foundation.
   - **Project Title:** MD500 WIND - Robotic Submarine Geotechnical Site Investigation for Offshore Wind Project. Wind integrated platform for 10+ MW power per foundation.
R&D IN OTHER AREAS OF ACTIVITY

- And gaining experience in several others areas:
  - O&M in offshore wind farms.
  - Floating foundations.
  - Multi-purpose platforms: wind power and marine renewable energies.
  - Resource assessment through floating met towers (Idermar).

NOW NEED FOR A DEMONSTRATION PLANT TO TEST COMERCIAL PRODUCTS
TEST FACILITIES

Field Test:
1. BIMEP BISCAY Marine Energy Platform S.A.
2. PLOCAN Plataforma Oceánica de Canarias.

Physical Model test:
1. IHCantabria Instituto de Hidráulica Ambiental de la Universidad de Cantabria.
2. INTA-CEHIPAR Canal de Experiencias Hidrodinámicas del Pardo.

Large Wind Turbine Component’s Test:
1. CENER
What is MARINET?

INITIATIVE TO COORDINATE EUROPE’S MARINE RENEWABLE ENERGY TEST INFRASTRUCTURE.

AIM IS TO ACCELERATE THE COMMERCIALISATION OF MARINE RENEWABLE ENERGY.

- Network of world-class marine renewables testing facilities at all scales
- Funded by the EC (FP7) to:
  - Offer periods of **free access** to all
  - Coordinate **research**
  - **Standardise** testing
  - Organise **industry networking**
  - Provide **training** in testing techniques
The Necessity:
Lack of infrastructures, on real offshore condition, for testing active components or stand-alone systems.

The Answer: HARSH LAB.
• Floating platform permanently moored at an offshore location.
• Versatility to support the widest possible range of testing and experimentation.
• Electric power and data communication supply.
A four-columns semi-submersible platform for Floating Offshore Wind

Reducing LCoE in Floating Offshore Wind Energy

80% of the offshore wind resource in Europe is located in Deep Waters > than 60 m

Floating solutions are required to harvest the wind resource

NAUTILUS:
A simple concept featuring a well proven hydrodynamic behaviour and a simple manufacture process that will allow LCoE reductions

NAUTILUS Roadmap

Concepts Definition Concept Evaluation Conceptual Design Validation Tank tests Detailed Engineering

IP protection Certification

Q4-2016

5MW Prototype Deployment

This information is confidential and belongs to NAUTILUS Floating Solutions, S.L. No copy or transmission is allowed without a written approval.
H2020 – LCE2: EERA Wind LIFES 50+ Project

Qualification of innovative floating substructures for 10MW wind turbines and water depths greater than 50m

Grant Agreement: H2020-LCE-2014-1-640741

OBJECTIVES:
• Optimize and qualify to a TRL 5, of two innovative substructure designs for 10MW turbines
• Develop a streamlined KPI-based methodology for the evaluation and qualification process of floating substructures

FOCUS:
• Floating wind turbines installed in water depths from 50m to 200m
• Offshore wind farms of large wind turbines (10MW) – identified to be the most effective way of reducing cost of energy in short term

BUDGET:
• 7.3 MM€
40 months duration starting June 1, 2015

Project leader MARINTEK, Partners:

www.lifes50plus.eu
GENERAL DESCRIPTION

Cost effective and groundbreaking, the solution uses a gravity-based foundation configured to act as a buoyant platform which integrates an auto-lift telescopic tower together with the complete wind turbine. Each complete unit can be fully assembled onshore, conventionally towed to the site and completely installed with no need for costly and scarce heavy-lift vessels.

The telescopic configuration of the tower brings down the center of gravity during the towed self-floating transport, allowing the bottom foundation platform to temporarily act as a self-stable floating barge over which the complete system can be preassembled inshore, key to a highly industrialized manufacturing process with fast production rates and improved risk control.

Once ballasted to rest on the seabed, the tower can be lifted to its final position by means of cables and conventional heavy-lift strand jacks which are reused to lift one tower level after the other. The recoverable jacks that lift each level are supported by the one below, which also guides the hoisted tube as it rises, in a self-installing procedure in which the tower itself is the only supporting structure required. All works are carried out from a single access platform.

Ballasting is assisted by a dedicated low-cost reusable AFS (Auxiliary Floating System) which ensures high stability and allows optimization of each unit for service life, avoiding substructure over-dimensioning linked to this momentary operation. Construction yard requirements are minimized profiling from low draft and low height works, self-floating and wet storage (8-10 Ha suffice for 60 unit/year production rate).

EXPERIMENTAL DEVELOPMENT AND DEMONSTRATION

Extensive tank and lab experimental demonstration have already been completed during the development and certification process, which also included a full scale testing prototype of the telescopic tower for the tuning and demonstration of the auto-lift system. All these experimental derisking initiatives shall be culminated with the fully operative 5MW prototype currently under construction in the Canary Islands.
SUPRAPOWER

SUPERCONDUCTIVITY APPLICATION FOR ACHIEVING MORE RELIABLE, LIGHTWEIGHT AND HIGHER POWER RATE GENERATOR FOR THE OFFSHORE MARKET.

TWO MAIN OBJECTIVES:

• TECNO-ECONOMICAL VIABILITY ANALYSIS CONCERNING A NEW POWER SOLUTION BASED ON A LOW COST SUPERCONDUCTOR MATERIAL.

• CONCEPTUAL DESIGN OF A BIG GENERATOR ACCORDING TO THE FOLLOWING REQUIREMENTS:
  • Direct Drive 10MW
  • MgB$_2$ superconducting field coils
  • Cryogen free cooling system

R&D PROYECT, FUNDED FROM THE EU 7Th PROGRAMME.

Patented by TECNALIA (PTC/ES2009/070639)
Beyond the state-of-the-art technologies for re-powering AC corridors & multiterminal HVDC systems

**DEMO 1:** Multiterminal HVDC links in offshore wind farms
**DEMO 2:** Interoperability of Multivendor HVDC converters
**DEMO 3:** Uprating of multiterminal interconnectors
**DEMO 4:** Innovative repowering of corridors
**DEMO 5:** HVDC superconducting cable

**Demo 1.** HVDC links in offshore wind farms and offshore interconnections.

**Aim:** Get deeper practical and operational knowledge related to connection of offshore wind farms through VSC HVDC multiterminal links:
- Development of control algorithms for VSC HVDC multiterminal links.
- Stability and faults analysis.
- AC/DC interactions
- Resonances
- Grid code compliance
- Study of DC collector systems.
CONCLUSIONS
COLLABORATION OPPORTUNITIES

1. Those are mainly concentrated, but not only, in the development of floating solutions and the implementation of demonstration projects.

2. In this sense opportunities appear in different areas, for instance:
   – Wind data collection and permanent metering using floating systems
   – New floating systems in harmful wind conditions
   – Common testing procedures in different sea conditions
   – Coating and painting advanced products
   – Grid integration and HVDC solutions
   – Chains and tie up solutions
   – Corrosion detection and new solutions to replace the anodes protection
   – Advanced condition monitoring systems
   – Lay on the sea bed the connection cables
   – Maintenance shipping and boats
   – ...
BREAKDOWN OF CLAIMS (CONSTRUCTION)

% - share, total number of claims

Deductible:
- Assembly: 9.7%
- Blades: 6.9%
- Lightning: 4.2%
- Fire: 2.8%
- Foundations: 1.4%
- Electrical: 15.3%
- Collision: 12.5%
- Cable claims: 6.9%

% - share, total claims cost

Deductible: 0.8%
- Assembly: 0.8%
- Blades: 0.3%
- Lightning: 0.3%
- Fire: 0.3%
- Foundations: 9.5%
- Electrical: 4.5%
- Collision: 0.6%
- Cable claims: 83.2%

Source:
Lloyd Warwick & Codan
TOP 5 PRIORITIES FOR PROJECT OWNERS

• Focus on the risk instead of the Capex and involve O&M-team in construction

• Keep contractual hierarchy as simple as possible and only use contractors with a strong track record

• Involve a specialist Marine Warranty Surveyor – not a generalist!

• Timeline and Business Continuity Planning strategies are key!

• Involve insurers early