EERA DeepWind 2016

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Experimental validation of the W2Power Hybrid Floating Platform

Paper presented at EERA DeepWind 2016,
13th Deep Sea Offshore Wind R&D Conference, Trondheim (Norway), January 20th – 22nd 2016

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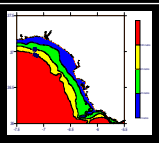
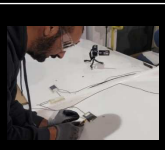
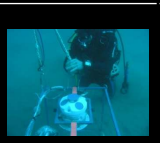
Outline

- EnerOcean introduction
- Future of offshore wind
- W2Power Technology Development:
  - MARINET Testing
  - W2Power Technology Development: Achieved TRL 3 and 4 in 2012-14 Validated TRL 5 at FloWave 2015
  - Video impressions from tank tests
- W2Power Advantages
- Ongoing developments

- Lean R&D SME
- Specialised in Marine Energy Engineering
- Business scope:
  - from resource & feasibility studies to commercial exploitation
- Winner of numerous awards, tenders and funded projects
- Developer of W2Power hybrid offshore solution, together with Pelagic Power AS





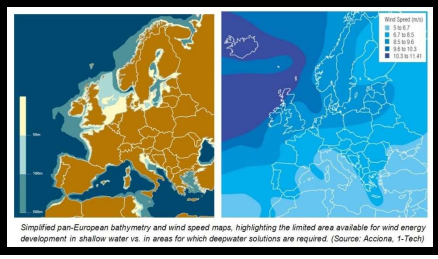


Competences:

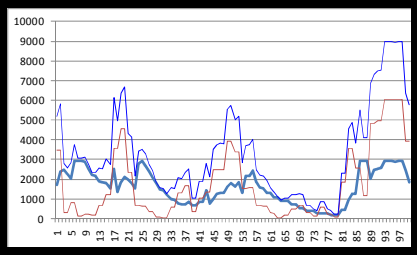
- Offshore wind, wave and tidal energy
- Floating platform design
- Structural health/Condition monitoring
- Techno-economic modelling and financial viability assessment
- Integration into grid of offshore renewable energy and energy storage solutions
- Commercialisation of innovative solutions

Future of offshore wind

- Offshore wind will move to deep waters and worldwide deployment
- Floaters are the logical solution, as the oil & gas industry discovered
- Combined utilisation of wind & wave energy is an attractive prospect <u>if done properly</u>:
  - Large wave resource in many ocean areas
  - More hours of renewable energy production and better price (wind and wave are not always simultaneous, swell)
  - Better use of marine space (MSP)



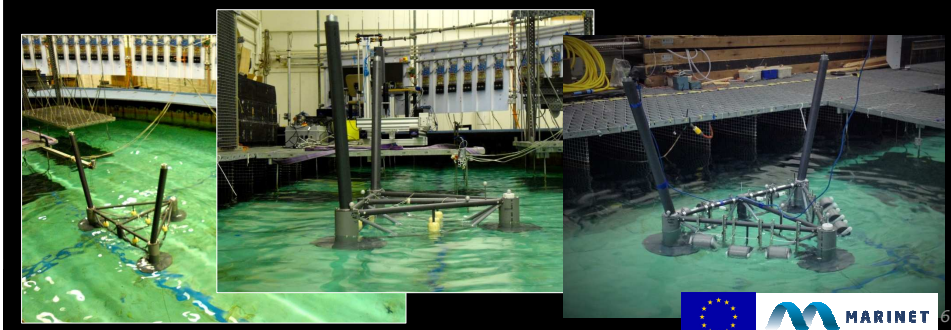
Simplified pan-European bathymetry and wind speed maps, highlighting the limited area available for wind energy development in shallow water vs. in areas for which deepwater solutions are required. (Source: Acciona, 1-Tech)



W2Power Technology development:
Sequential progress to TRL 3, 2012 – 2013

<u>FP7 MARINET testing project: "W2P Sea States Tests 1 and 2",</u>

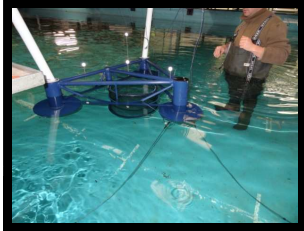
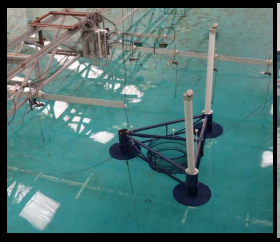
- Facility: University of Edinburgh. Curved wave tank
- Tank testing in multi-directional sea states for design verification at 1:100 scale
- WEC's characterization and global behavior in operational and survival modes
- From TRL 2 ("Stage 1") to TRL 3 ("Stage 2") upon completion of all tests



W2Power Technology: to TRL 4

FP7 Marinet testing project "W2P Mooring and wind" (2014)

- Facility: UCC-Beaufort (HMRC) – Cork, Ireland
- Tank testing in multi-directional sea states for performance validation at 1:100 scale with scaled-down full design of the mooring and wind force simulation.
- Compatibility with other economic activities on the platform (aquaculture).
- Specific test campaign on the validation of the WEC's (wave energy converters) and a new innovative control system developed, validated at 1:30 scale.
- TRL 4 achieved after validation of the main components individually


W2Power Technology: to TRL 5

FP7 Marinet project: "W2P TRL5 Validation" (2015)

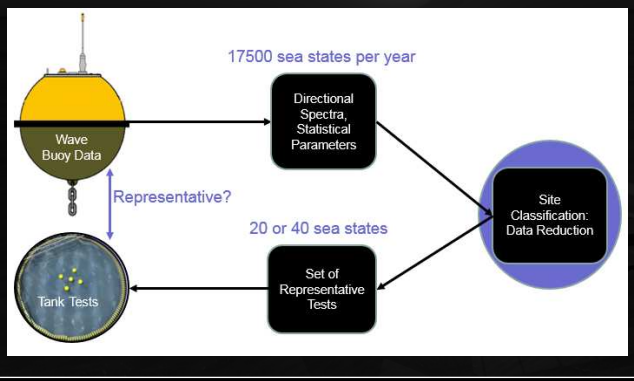
Facility: Univ. Edinburgh - FloWave TT: Current and Wave Test Tank

- 25 m diameter, 2 m deep. Allows testing W2Power at full 1:40 scale
- 168 force feedback wave makers, 28 reversible flow drive units
- 360º wave and current generation capability

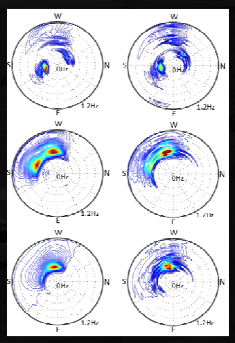
W2Power Technology: to TRL 5

- Flowave allows acurate reproduction of sea states, e.g. from EMEC site

Reproduction of sea states in the Tank



Desired Measured



RESULTS

W2Power Technology: to TRL 5

Test programme Objectives:

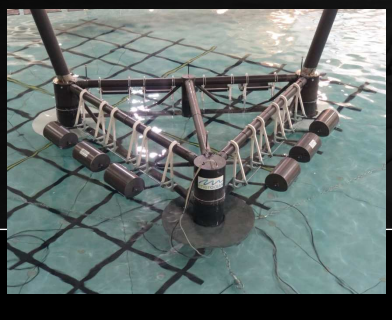
- Fully achieve a Technology Readiness Level (TRL) of 5 for the W2Power platform
- Validation at 1:40 scale the full scale design, mooring and wind force simulation (thrust and gyroscopic effects). Corresponds to 80 m depth.
- Regular and irregular waves (based on real-sea data for Cabo Silleiro off NW Spain), currents (low-speed tidal, to 1 m/s) and wave spreading.
- Specific test campaign on the validation of wave converters' influence on the platform in the worst conditions, operational and survival modes limits.

W2Power Technology: to TRL 5

Configurations:

- Full platform with wind force, without Wave Energy Converters (WEC's)
- Full platform without wind force, without WEC's
- Full platform with max. wind force and WEC arrays in two configurations

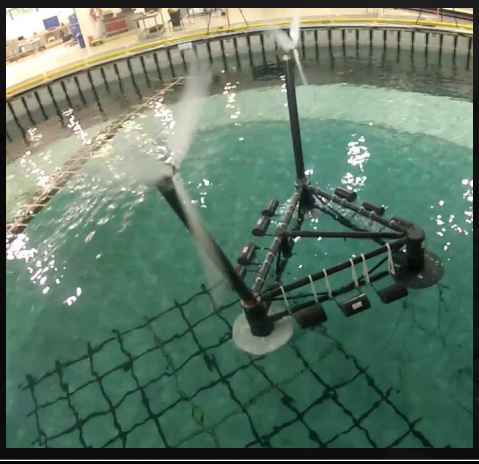
Total 20 hours of test data collection, covering 77 regular wave tests and 36 irregular wave tests (normal and survival modes)

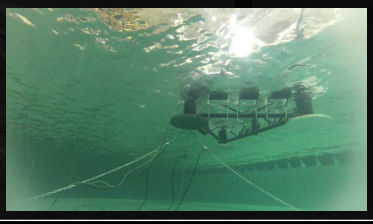


W2Power Technology Development

- EnerOcean introduction
- Future of offshore wind
- W2Power Technology Development:
  - MARINET Testing
  - **W2Power Video: some scenes from the tank**
- W2Power: Advantages
- Next stages

W2Power VIDEO

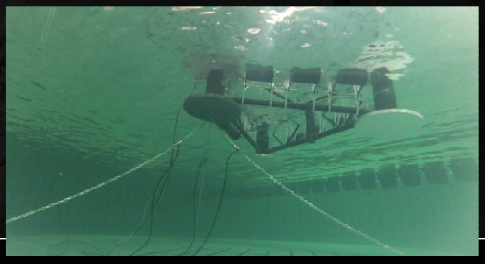




W2Power Technology: to TRL 5

Results (1):

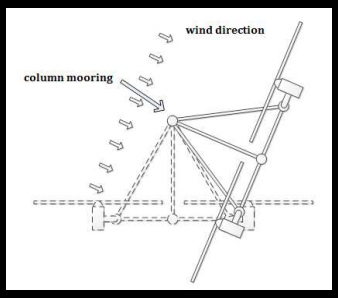
- The mooring design was fully validated w.r.t. stationkeeping and max. load in mooring lines.
- The maximum acceleration measured in normal and survival operations are in line with results of previous testing.
- Limited currents (< 1m/s full scale) don't affect significantly the platform behaviour.

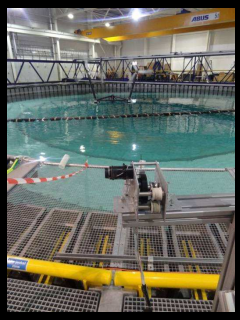


W2Power Technology: to TRL 5

Results (2):

- The tests provided FloWave with an opportunity to test a large scale floating wind turbine model and to investigate wind systems for incorporating wind forces into the tests (motion control using system of lines and pulleys is an effective method).
- When the wind blows in a different direction than the wave angle, this does not significantly affect the wind power production.



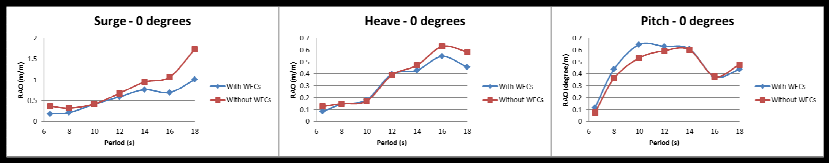


W2Power Technology: to TRL 5

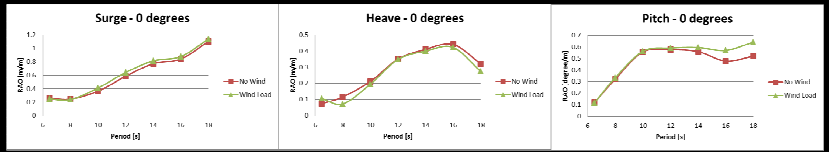
Results (3):

- Measured RAOs are similar to previous test results on the platform at 1:100 scale, when including rotating inertia of wind turbines and wind thrust effects.

Surge, Heave, Pitch RAO for 3 m waves, 0 degrees, without wind effects (1:100 scale)



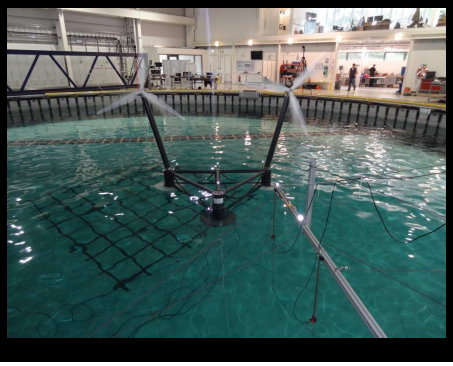
Surge, Heave, Pitch RAO for 3 m waves, 0 degrees, with wind effects (1:40 scale)

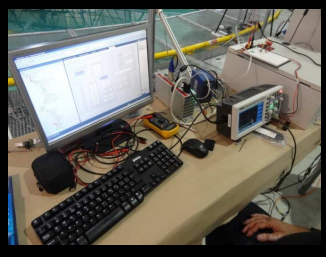


W2Power Technology: to TRL 5

Results (4):

- A custom developed monitoring system to measure accelerations in the platform with industrial sensors and devices has worked as planned.





W2Power Technology Development

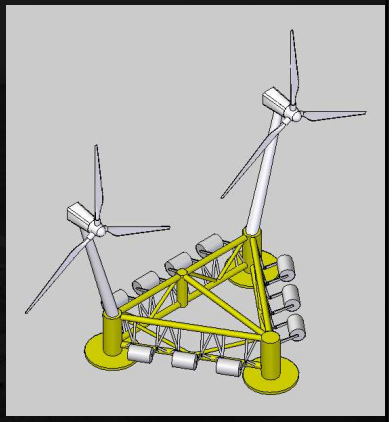
- MARINET Ambassador Users
  - EnerOcean: Winner of Prize Category “Combined / Hybrid Technologies”

W2Power Advantages

W2Power is a patented technology that...

- Uses proven platform technology and today commercially available wind turbines, allows major de-risking of the technology
- Can be built, installed, maintained and repaired world-wide, no depth limits.
- Wind-vanes, eliminates turbine yaw
- Offers the highest power (>12 MW, wind and wave) per foundation:

  Provides more efficient use of foundation, electrical cabling, installation, decommission & maintenance costs than what is achievable by mono-turbine wind floaters or by independent exploitation of the wind & wave resources



A 4.5 GW / year market in 2030, meaning at least €8 billion / year (similar to today's total wind market). Source: Alstom/DCNS

Next Stages: Ongoing work

- *Scale up and test at sea*
- *Prototype in the water by 2017 (WIP10+ Project)*
  - ***Approved for DemoWind Funding (H2020 ERANET Cofund)***
  - *EnerOcean (project leader), Ingeteam, Ghenova (Spain), TTI (UK)*
  - *TRL 6 by functional validation at sea (PLOCAN, Canary Islands)*
- *First Commercial Unit (FCU) to be fully engineered, with costing & certification => Market ready from 2018*
- *"Satellite" projects to study added functionalities (Multi-Use platforms / applications).*
- *Business development: Equity need for 2016-18 clear. EnerOcean is active in Horizon 2020 SME Instrument Phase 3: Investibility coaching, with private investors, possible access to EU risk finance instruments…)*

DemoWind

WIP10+

Project leader enerOCEAN

Spanish partners: Ingeteam SERVICE, GHENOVA ingeniería

UK partners: TTI

CDTI Centro para el Desarrollo Tecnológico Industrial

Department of Energy & Climate Change