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An Horizon 2020

Coordination and Support Action Project

Can Combining with Other Blue Sectors Further Reduce Offshore Wind's LCOE?

Mike Blanch, BVG Associates, Associate Director / Operations Director / lead on Financial Modelling and offshore wind

and …

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…other Maribe partners

- Gordon Dalton and Eoin Moynihan, University College Cork
- Ian Masters and Dimitris Pletsas, Swansea University
- Sander Vandenburg, Stichting Dienst Landbouwkundig Onderzoek (DLO)
- Kate Johnson, Heriot Watt University (ICIT)
- Pedro Diaz, Universidad de Cantabria
- Roland Wijnen, Business Models Inc.

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- A Horizon 2020 Coordination and Support Action Project (Societal Challenges BG 5: Preparing for the future innovative offshore economy)
- So scope has been varied to reflect what EU Commission needs to inform its thinking
- Findings are being used to inform future EU Commission funding calls beyond current H2020
- Project ends August 2016.

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Why?

- EU wants to intensify, diversify and expand further offshore economic activities in Europe‘s seas – blue growth
- Helping develop larger scale activities offshore by overcoming technological and non-technological challenges and using the most promising and sustainable business models

- Combining different activities at the same location
  - Multi-use of space (MUS) – share infrastructure / services
  - Multi-use platform (MUP) – share platform.

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Leading combinations with wind

- Fixed bottom offshore wind
  - Multiple-use of space (MUS): enabling mussel farming – Dutch mussel yields are dropping significantly and multiple-use of space was requested in the recent windpark Borssele tender.
  - Multi-use platform (MUP): JJ Campbell's wind and wave Platform - CúNaMara Floating Multiple-use Energy Harvesting Platform
- Floating offshore wind
  - MUP: Floating Power Plant's floating wind and wave platform – Poseidon
  - MUP: EcoWindWater's floating wind and desalination platform
  - MUS: Cobra and Besmar's floating wind and aquaculture

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11 partners

HERIOT WATT UNIVERSITY

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

BVGassociates

BUSINESS MODELSINC

eCOAST
MARINE RESEARCH

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

Swansea University
Prifysgol Abertawe

FAO
FIAT PANIS

AQUABIOTECH GROUP

WAGENINGEN UR
For quality of life

PrimeUCC
PROJECT RESEARCH AND INNOVATION MANAGEMENT ENTERPRISE

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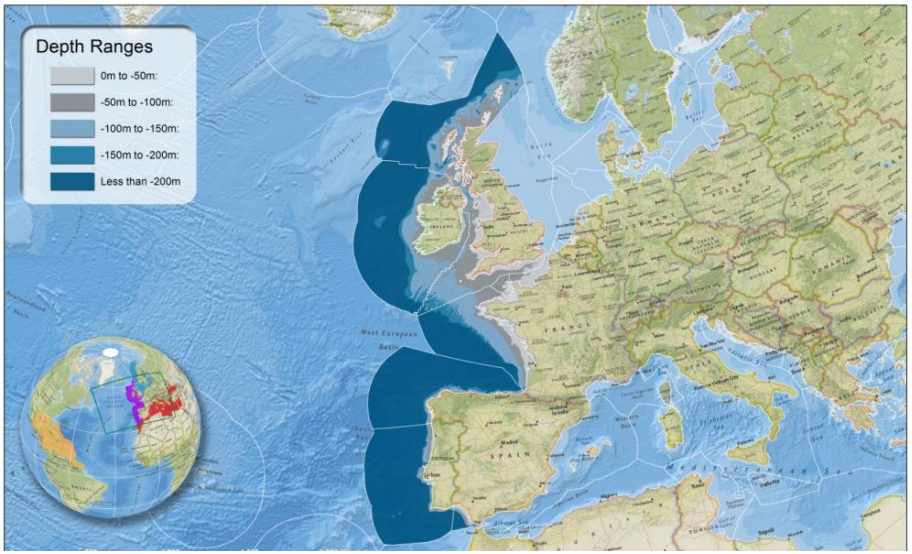
Basins considered

Atlantic Region



Mediterranean Region

Baltic Region

Caribbean Region

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Approach

- Opportunities
  - Considered potential combinations for multi-use of space or multi-use platforms including EU funded projects such as those under Oceans of Tomorrow and MERMAID
- Challenges
  - Examined the socio-economic context and the key technical and non-technical challenges facing these projects based in part on lifecycle learning

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Approach

- Companies
  - Identified those with most promise who wish to work with us. Developed summary, financial model, business plan, risk assessment
- Advising and testing
  - Use the consortium's network to introduce project stakeholders to key advisors and potential investors. Advisory sessions held in Brussels

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Work

- Unlock the potential of multi-use of space in the offshore economy
  - Socio-economic context WP 4
  - Technical and non-technical barriers WP 5
  - Investment WP 6
  - Business models WP 7

  - Cooperation opportunities WP 8-10

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Exploration

- WP 8-10 focus on the exploration of cooperation opportunities
- Identified 22 combinations
  - Rated based on technological, environmental, socio-economic, financial, commercial viability criteria
  - Shortlisted to 9 combinations with input from EC and willingness of companies to be involved
  - Those 13 not shortlisted outlined their strategic plan and roadmap in strategic reports. Includes some good combinations like powering enhanced oil recovery from floating wind turbines

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Deliverables for shortlisted combinations

- For shortlisted combinations developed for specific projects
  - Technical brief
  - Financial models (commercial after 2 successful commercial projects, pilot)
  - Business plan
  - Risk assessment
  - Implementation plan.

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Advisory sessions 15 and 16 June 2016

- Brussels event where companies pitched their project concepts to an advisory panel made up of:
  - OES International Energy Agency
  - European Aquaculture Society
  - 1-Tech
  - DP Energy
  - Offshore Renewable Energy Catapult
  - Federation of European Aquaculture Producers
  - DNB Norway
  - Scottish Investment Bank
  - World Ocean Council
  - Ernst & Young
  - Black & Veatch
  - INNOSEA
  - The Crown Estate
  - Maribe partners

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Advisory sessions 15 and 16 June 2016

- Also a shorter 3 minute pitch was given to all companies and Marie Donnelly (Director - Renewables, Research and Innovation, Energy Efficiency - DG ENER)
- B2B's between companies and with advisory panel.

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Next steps

- Digest feedback actively sought and collated on the Advisory Sessions from companies, advisory panel members and Maribe partners
- Sharpen documents / financial model especially for pilots based on feedback by 18 July
- Compile final report with recommendations to commission end August
- Closing meeting at end August

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9 shortlisted projects

- Atlantic:

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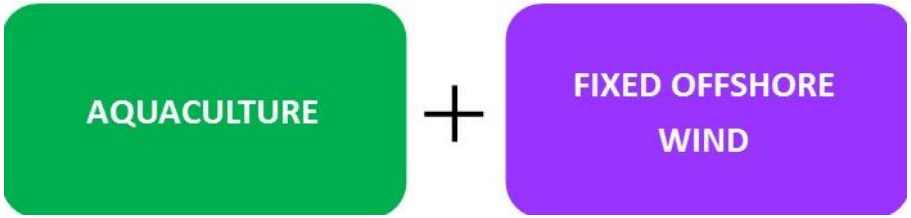
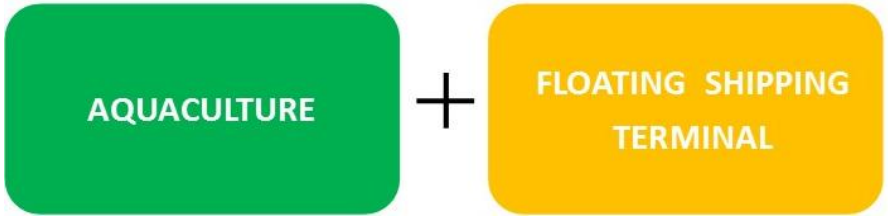
9 potential projects

- Mediterranean and Black Sea:

- Baltic and North Sea: Caribbean



- Caribbean – French Guiana



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9 potential projects

- All 9 include energy generation
- 2 include fixed foundation wind
- 3 include floating foundation wind
- 5 include wave
- 1 merely includes provision for Ocean Thermal Energy Conversion (OTEC) once it is proven

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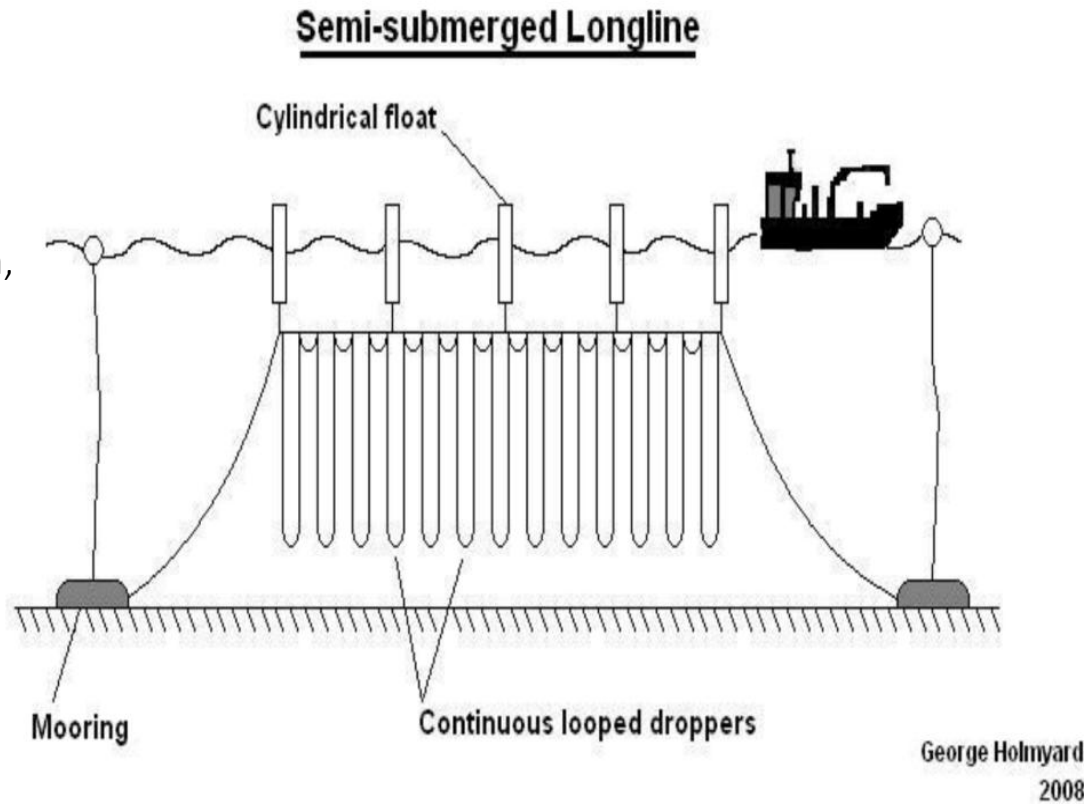
AQUACULTURE + FIXED OFFSHORE WIND

1. Mussel farming and offshore wind

- Multi-use of space – structures are separate allowing turbine access
- Considered feasibility for Dutch Borssele wind farm
  - Development of wind farm is a given, with fixed structures
  - Water depth between 15m and 35m
- Double long lines (continuous) attached to anchors
- Annual production target for mussels: 5.5 million kg of mussel seed



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AQUACULTURE + FIXED OFFSHORE WIND

- Recently closed tender for Borssele wind farm had option for multi-use of space. Likely to be more common requirement in the future.
- Adding mussel aquaculture is likely to increased returns despite the small CAPEX compared with the wind farm
- Conventional mussel farming has declined in yields – potential reinvigorated by this action to farm mussels. Proven technology for mussel seed collection. Mussels are responsible for much biofouling in area.
- Mussel longlines will act to damp sea – may give improved access to (some) turbines
- Additional risks are expected to be limited making it more likely that wind farm developers will be willing to accommodate such multi-use

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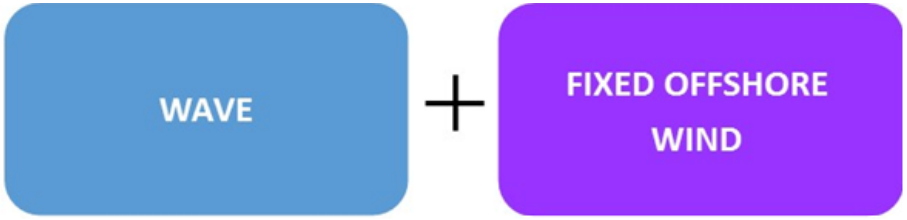

2. JJ Campbell & Associates CúNaMara wind and wave platform

- The CúNaMara platform combines wind and wave energy generation technologies, comprising 8 MW of wind and 16 MW of wave
- Further potential uses include photovoltaic power, aquaculture and others
- Preferred location off West coast of Europe in depths of up to 100 metres
- At a typical site, the platform will produce 77.5 GWh per annum, equivalent to the electrical consumption of 21,000 typical homes

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WAVE + FIXED OFFSHORE WIND

CúNaMara wind and wave platform

- Oscillating Wave Colum (OWC) technology is a proven method of converting wave energy to electricity
- Floating platform allows electricity generation in greater water depths
- The modular nature of the platform allows the platform hull to be constructed onshore
- Concrete hull construction used as more cost effective compared to steel construction
- Having two renewable energy technologies on one platform allows for aggregation of wind and wave resources to provide smoother power delivery to grid

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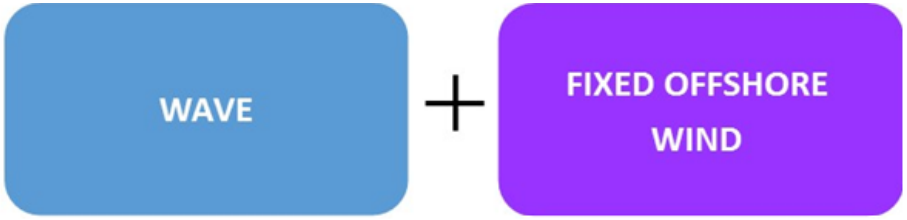

CúNaMara wind and wave platform

- Next stage 1:4 scale sea trials
- Third Phase Commercial farm rated at 480 MW farm and comprising 20 MUPs
- Levelised cost of energy for third phase commercial farm currently predicted to be 178 €/MWh assuming WACC 8.9%. Recognise LCOE needs to be much lower.

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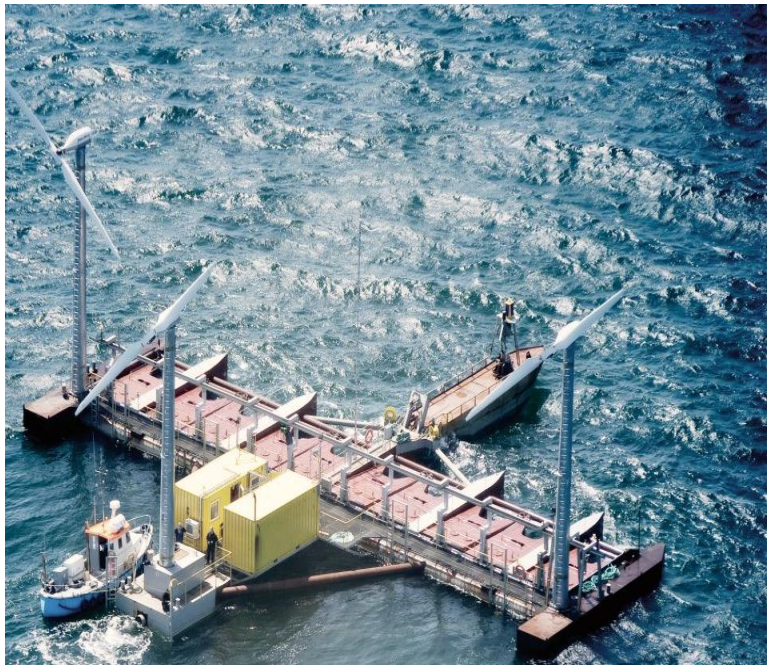
FLOATING OFFSHORE WIND + WAVE

3. Floating Power Plant A/S

- FPP is the only company in the world that has supplied power to the grid from a combined floating wind and wave device. 4 offshore tests have collected two years of offshore data for a ½ scale prototype



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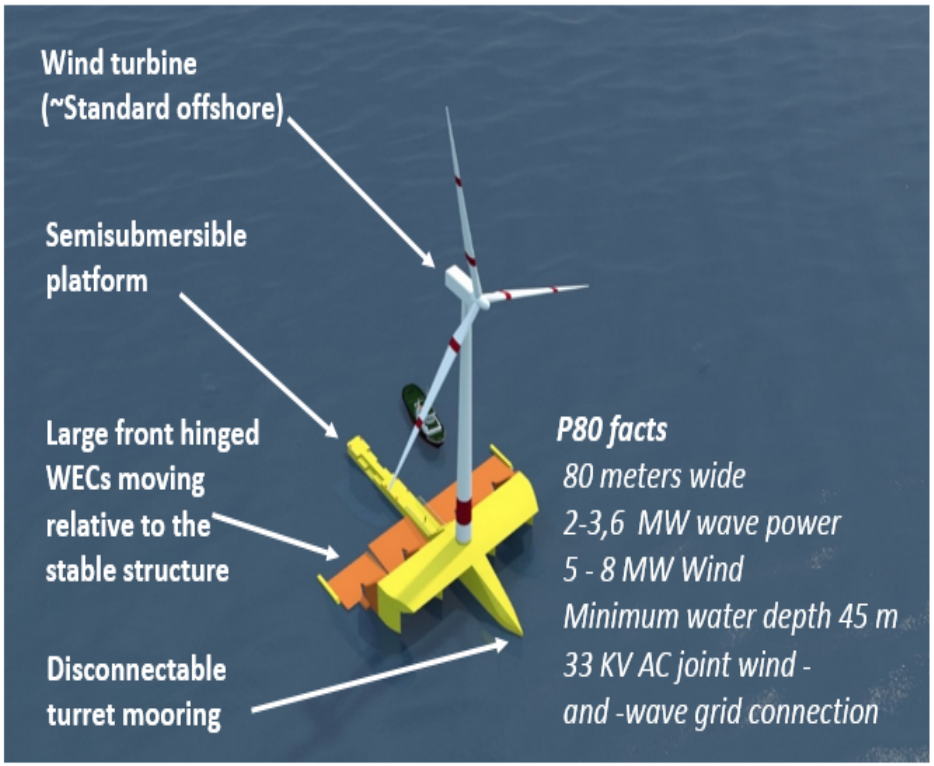
FLOATING OFFSHORE WIND + WAVE



An unique design combination that passively turns into primary wave direction
=> More wave power
=> Safe access zone

Design based on:

- Stable semi submersible platform **- oil & gas component**
- Build via panel line modules – **standard ship principle**
- Mooring / flexible sub-sea cables - **oil & gas components**
- Disconnetable and vaning turret **- oil & gas components**
- Wind turbine – **offshore wind turbine**
- Power export standards – **offshore wind standards**

- Unique wave device and PTO systems placed on a known stable structure
- Integrated on one platform where all components are placed indoors

- For the +45 meter water depth market segment

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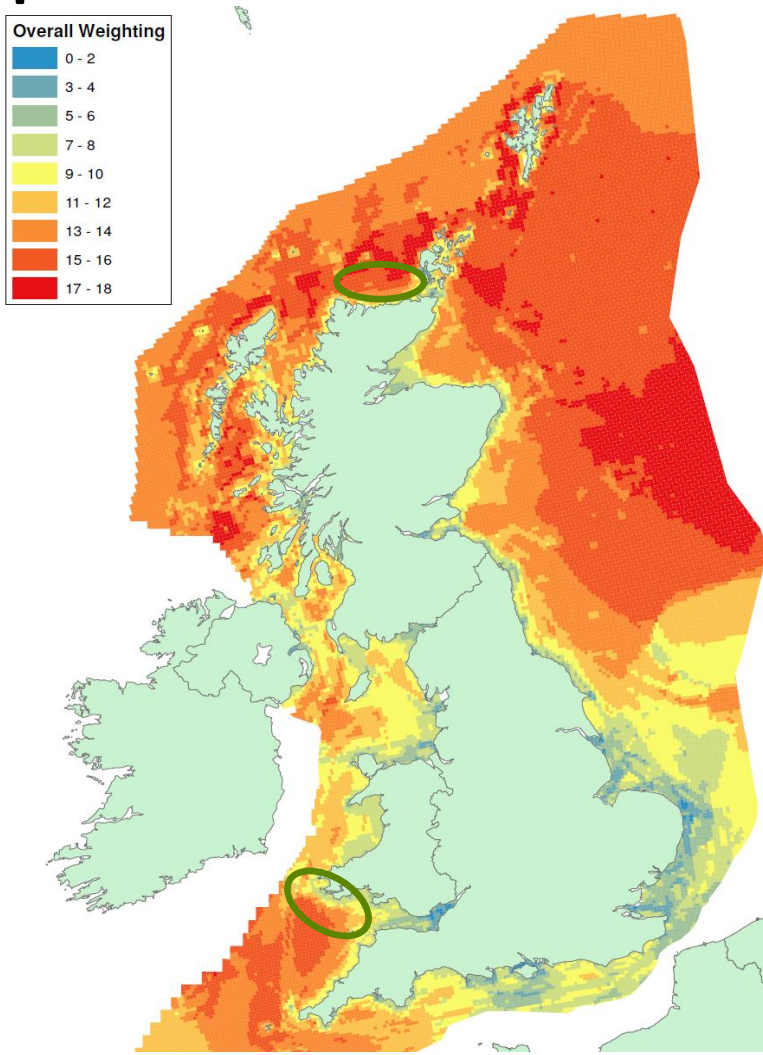
FLOATING OFFSHORE WIND + WAVE

Commercial projects in pipeline

- Step up approach in process
  - Phase 1: Pilot 7 MW (5 MW wind + 2 MW wave)
  - Phase 2: build out to 35 MW (+4 devices)
  - Phase3: build out to 196 MW (+23 device)
- 24 km (15 miles) off the coast of Wales
- Water depth: 60m
- Mean wind speed: 10.3 m/s
- Mean wave resource: 23 kW/m



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FLOATING OFFSHORE WIND + DESALINATION

4. EcoWind Waters' Floating Wind-Desalination MUP

- 35 kW prototype
- Potable water and energy

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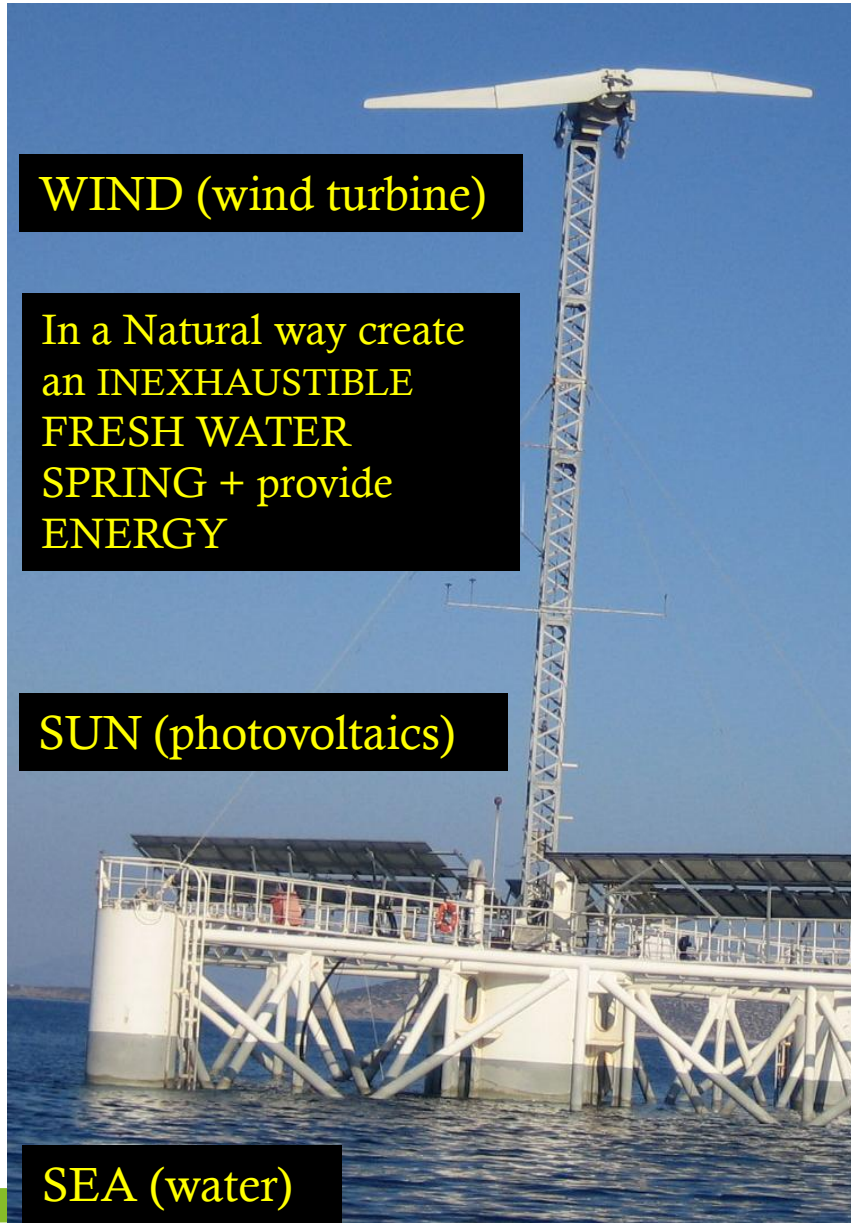
FLOATING OFFSHORE WIND + DESALINATION

- Ecological
  - No fossil fuels, 100% RES
  - No chemical pre-treatment of sea water
  - Far away from the coast, without any impact on the island
- Scalable
- Autonomous , Unmanned
- Low installation and maintenance costs
- Transportable
- Integrated with any RES device (Wave, tidal energy devices etc..)



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FLOATING OFFSHORE WIND + DESALINATION

EcoWind Water's MUP next steps

- Initially aimed at islands that have potable water delivered, are in danger from salinisation, and limited space especially access to erect medium sized wind turbines
- Next step 0.8 MW pilot
- Then 2MW commercial unit

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AQUACULTURE + FLOATING OFFSHORE WIND

5. FLOCAN5

- Cobra, Besmar Aquaculture S.L. and PLOCAN are working on collocating a pilot floating 5 MW turbine with an existing organic sea bass farm (FLOCAN5) and then expanding both by factor of 5
- The Canaries site chosen for the prototype is ideal for its wind and environmental sea conditions,
  - the organic farm pilot was already located in one of the most “high energy sites” in Europe before its use for wind was considered.
- The goal is to test (at TRL8) if it is possible to have the two industries together and how much benefit is really created by multi-use of space.

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AQUACULTURE + FLOATING OFFSHORE WIND

- Fish farm expected to benefit from:
  - CCTV camera security (less robbery)
  - Sheltered spot to grow small fish (better survival and production security).
  - An increased economic performance of about 10 % from O&M synergies with wind farm.
- Wind farm expected to benefit from:
  - Enabling more local benefits (more local job creation).
  - Image of a more “green” project.
- If the pilot demonstrates that the combination is beneficial, further integration of the combinations will be considered in the proceeding project.

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- Both will share vessels for O&M
- MUS in this project at “simple” share of space and no physical connexion that could potentially jeopardise each sector
- If beneficial, combination could be further integrated in proceeding project.

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Other combinations shortlisted:

- Float Incorporated 's Security Port, composed of the Pneumatically Stabilized Platform (modular, monolithic platform; stable; variable deck load capabilities; mobile, and extensible) which is constructed of pre-stressed reinforced concrete, and incorporates the Rho-Cee Wave Energy Converter as well as an LNG terminal for a base-load power source. This multi-use platform is designed to serve as a shipping and container terminal off the south of Ireland

- Grand Port Maritime de Guyane is developing a floating multi-use terminal for shipping (container transfer hub), oil and gas logistics hub, and aquaculture support. This facility is designed to be located on the maritime cross route between from East to West, Central America and Western Africa, and from South to North, Brazil and Caribbean Islands.

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- Wave Dragon, Seaweed Energy Solutions and BELLONA are working together on a combined wave and aquaculture project in the North Sea.
- Albatern is working with AquaBioTech investigating the potential of wave energy technology providing power to an aquaculture farm in the Mediterranean basin. Primarily this is to reduce and potentially replace diesel generation.

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- On Stand 234 where I will be pleased to talk further
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- Thank you for listening; mjb@bvgassociates.co.uk

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