



Energy @ Sea

An opportunity to create
sustainable value

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Jornadas de Engenharia do Ambiente

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Content

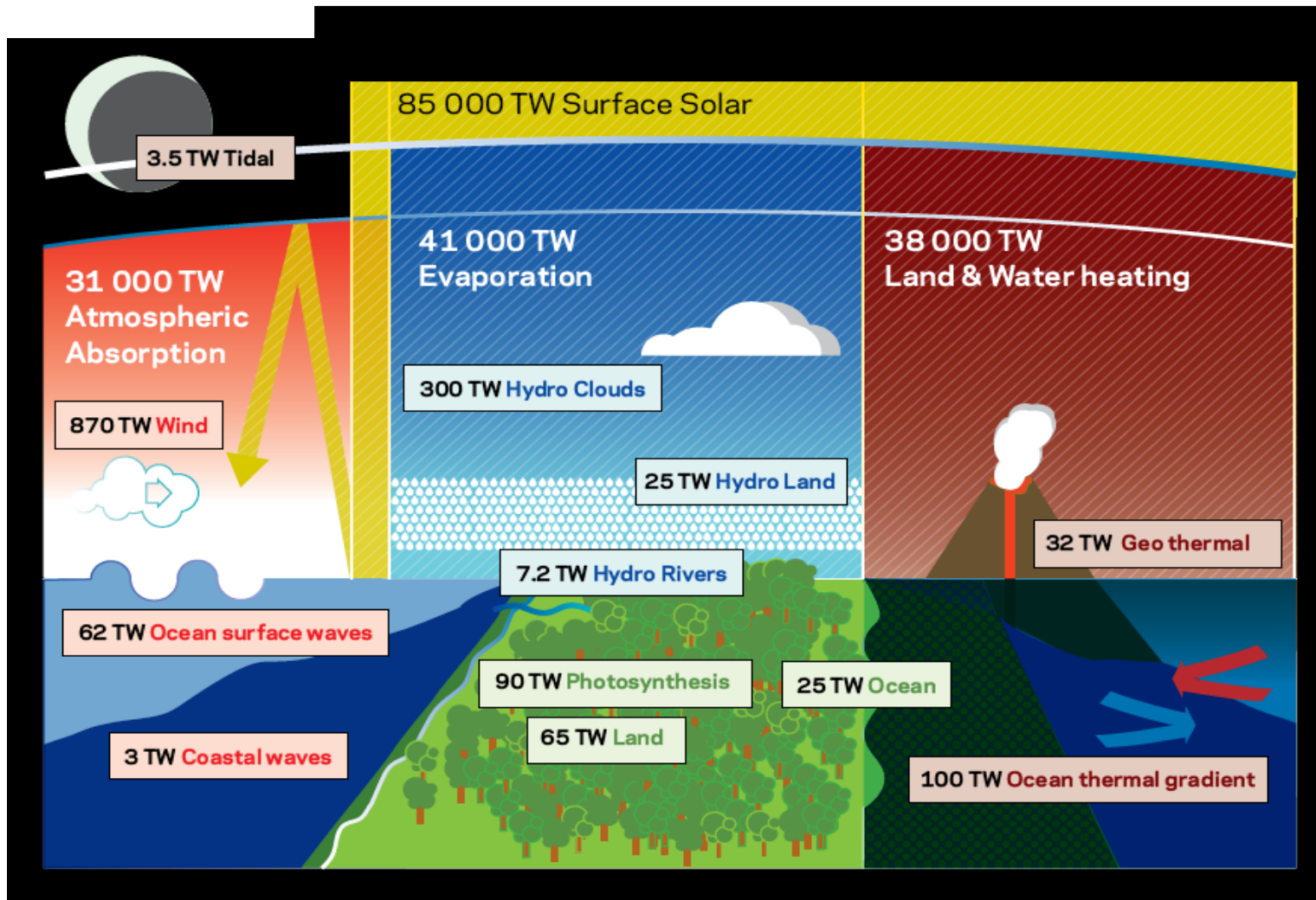
- **Energy @ sea (opening remarks)**
- Wave energy
- (Deep) offshore wind energy
- EDP's vision
- Possible path for Portugal (closing remarks)



Oceans represent 72% of the surface of the earth

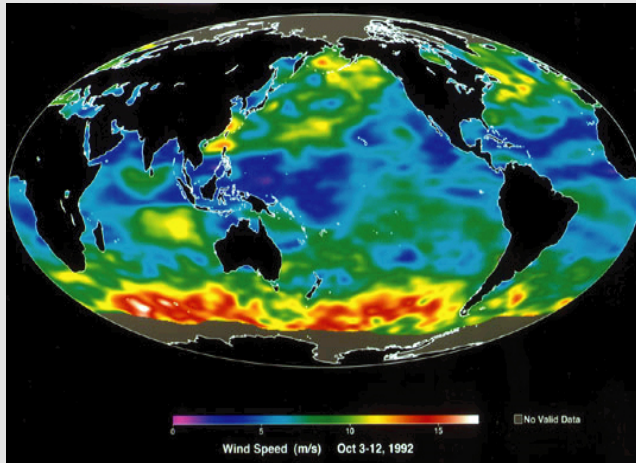


Renewable Energy potential is huge and the Sea is one of the areas one should proactively address to solve world's energy challenges

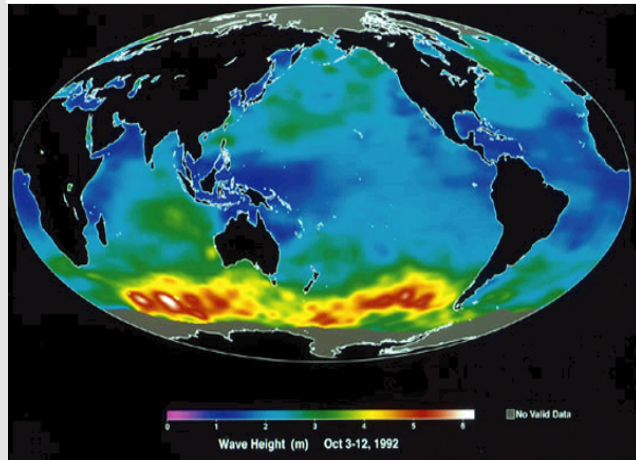


There are significant synergies between wave and wind potential at sea and they can be explored

Correlation between Wind and Waves

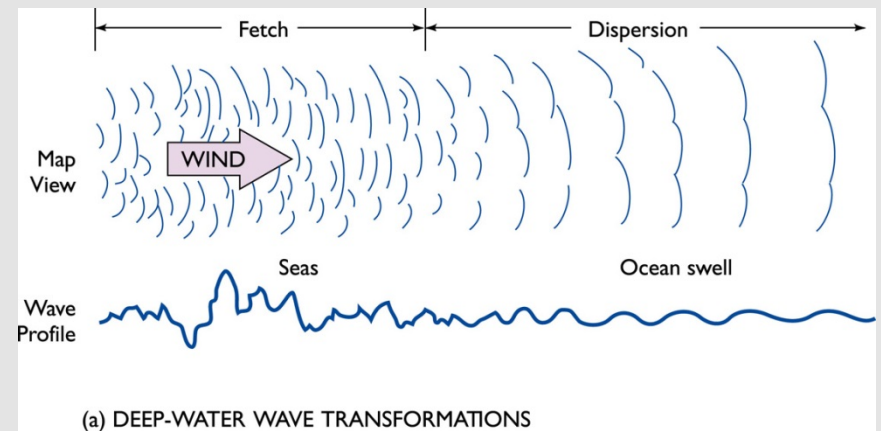


TOPEX/Poseidon Prime Mission Results

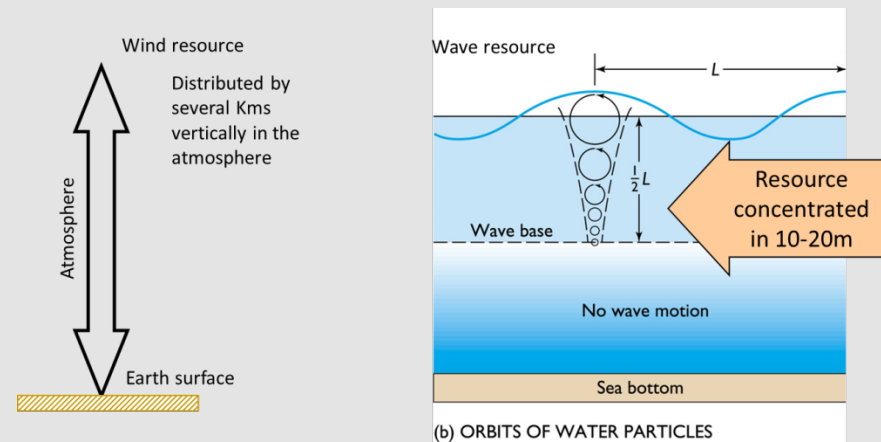


TOPEX/Poseidon Prime Mission Results

Potential, power density and predictability



(a) DEEP-WATER WAVE TRANSFORMATIONS



(b) ORBITS OF WATER PARTICLES



Despite significant potential both in wind and waves, Portugal has failed to create (so far!) an adequate development framework

+ need to
differentiate PT

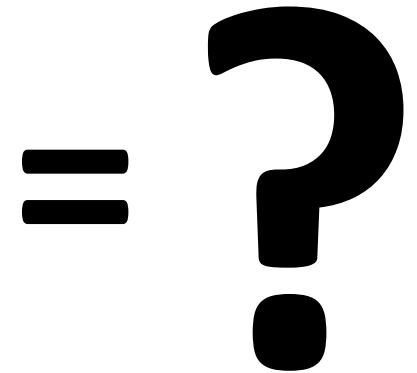
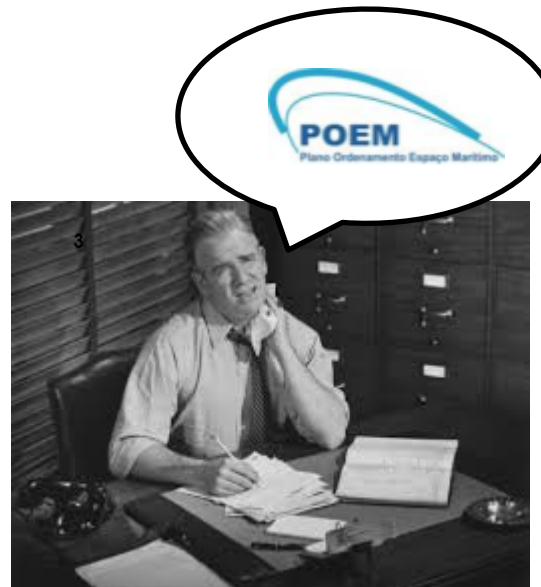
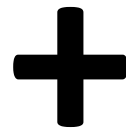
+ existing
infrastructures

Offshore Wind

3 to 4 GW of explorable
potential

Waves

3 to 4 GW of explorable
potential



+ willingness to
invest

+ ...

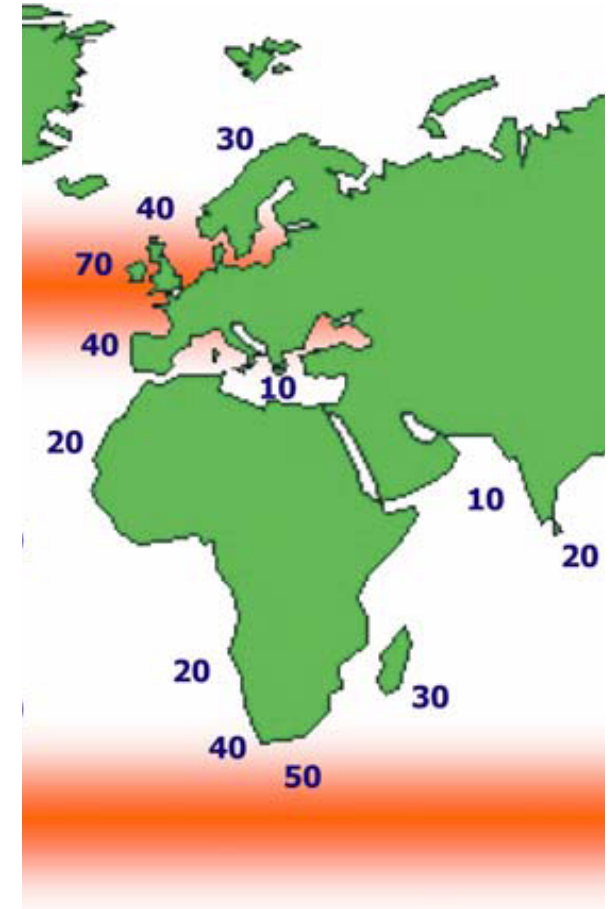
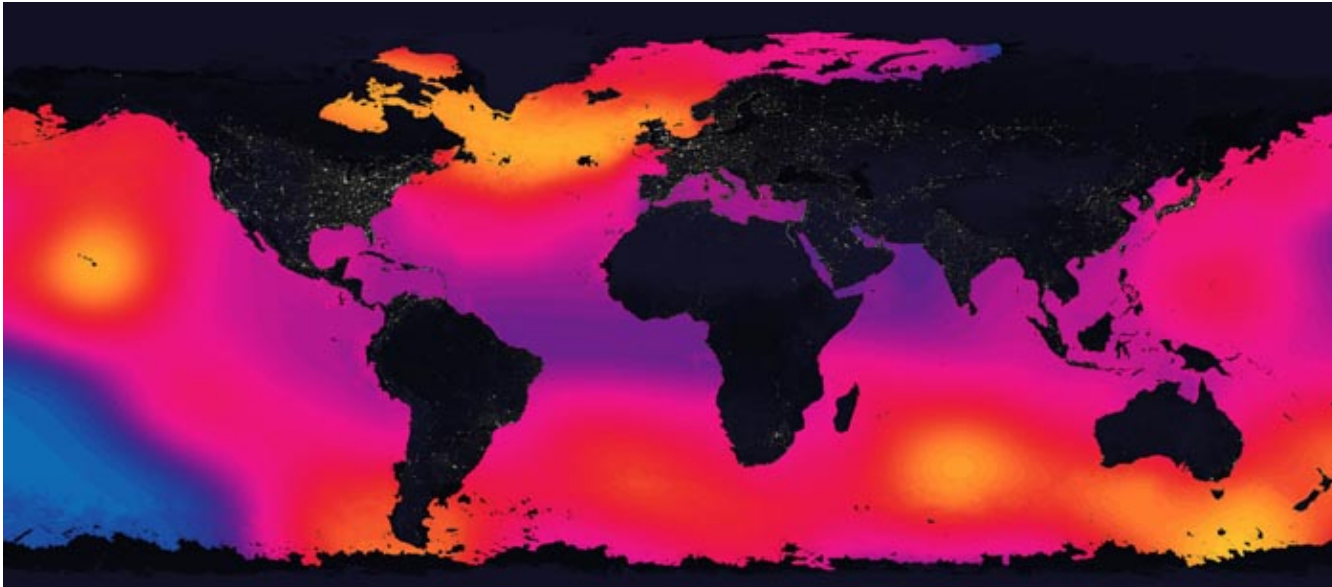
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Resource and market potential is huge

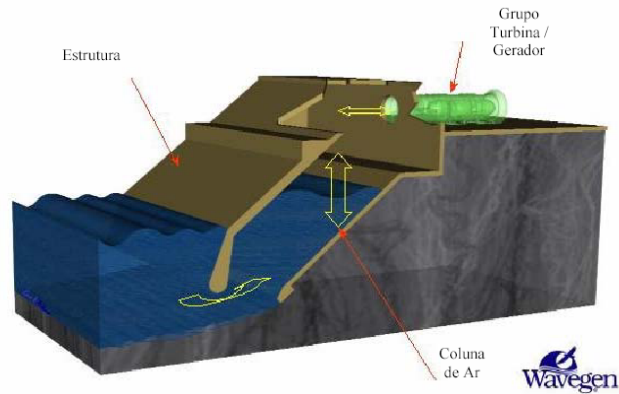
Wave energy's worldwide potential is vast. In particular the west coast of Europe is very suitable for wave energy development



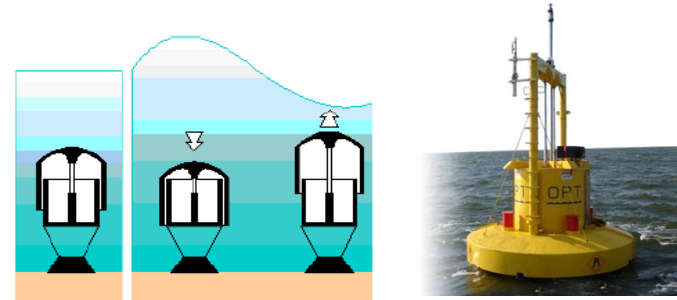
- Worldwide wave resource ranges 2 TW (15% in Europe)
- **200 GW of world installed capacity (feasible) until 2050**

There are 4 main types of technologies / energy conversion principles and more than 100 tech. companies worldwide

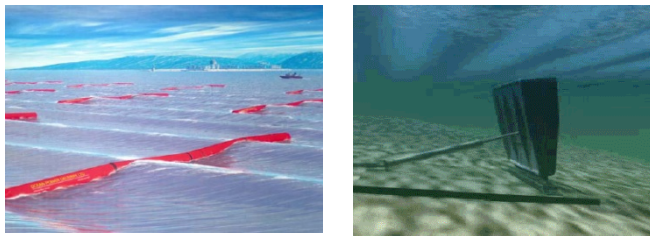
Oscillating Water Column (onshore, nearshore or offshore)



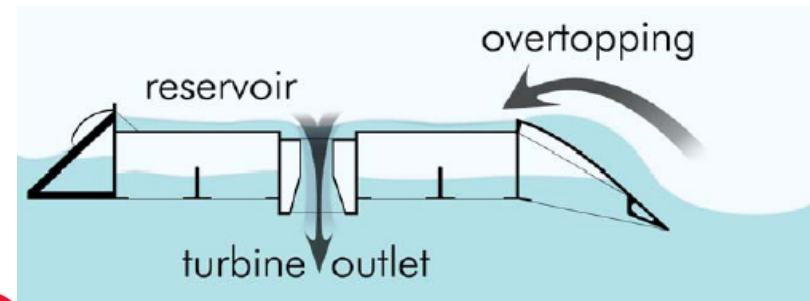
Point Absorbers – Floating or submerged, usually hydraulic PTO



Articulated



Overtopping (onshore, nearshore or offshore)



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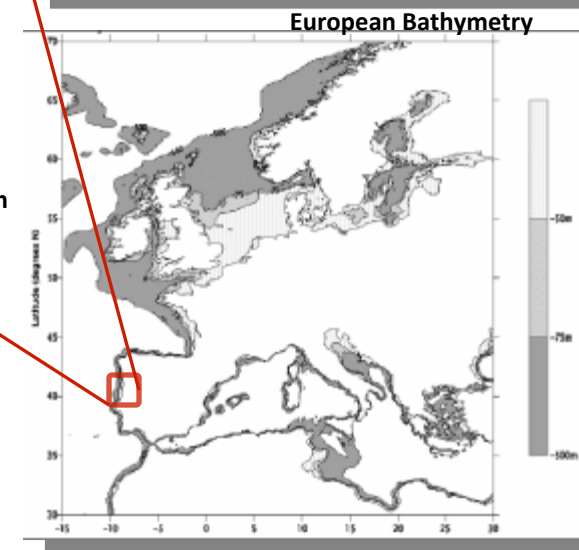
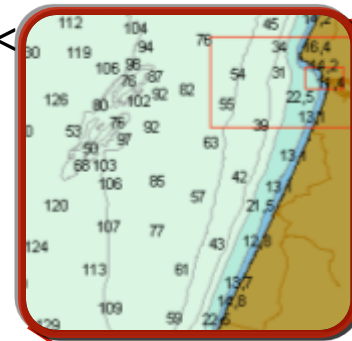
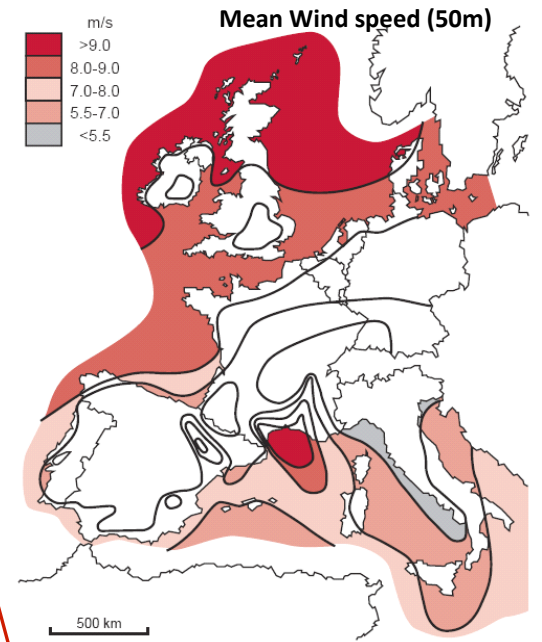
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Resource and market potential is huge namely in deeper waters

EU15 Potential

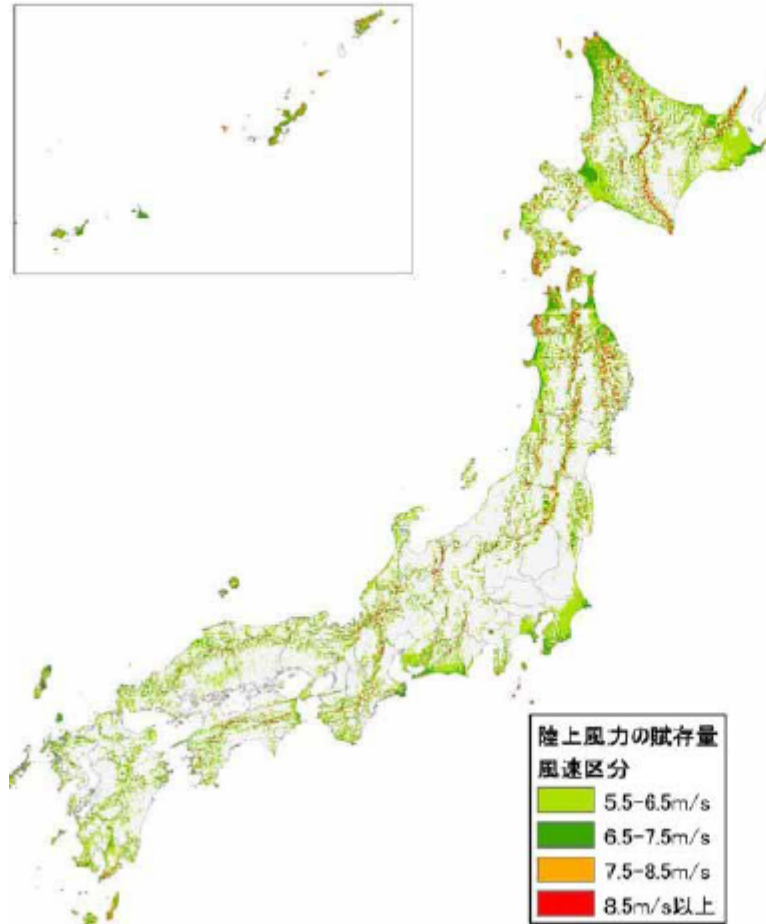
- Good offshore wind resource (load factor > 3.000h)
- Offshore wind potential is mostly in transitional and deep waters (~65 %)
- Ports and docks available along European coast
- Continental shelf ends near the coast in many countries (Limited Potential for water depths < 40m)
- Grid connection available near the coast



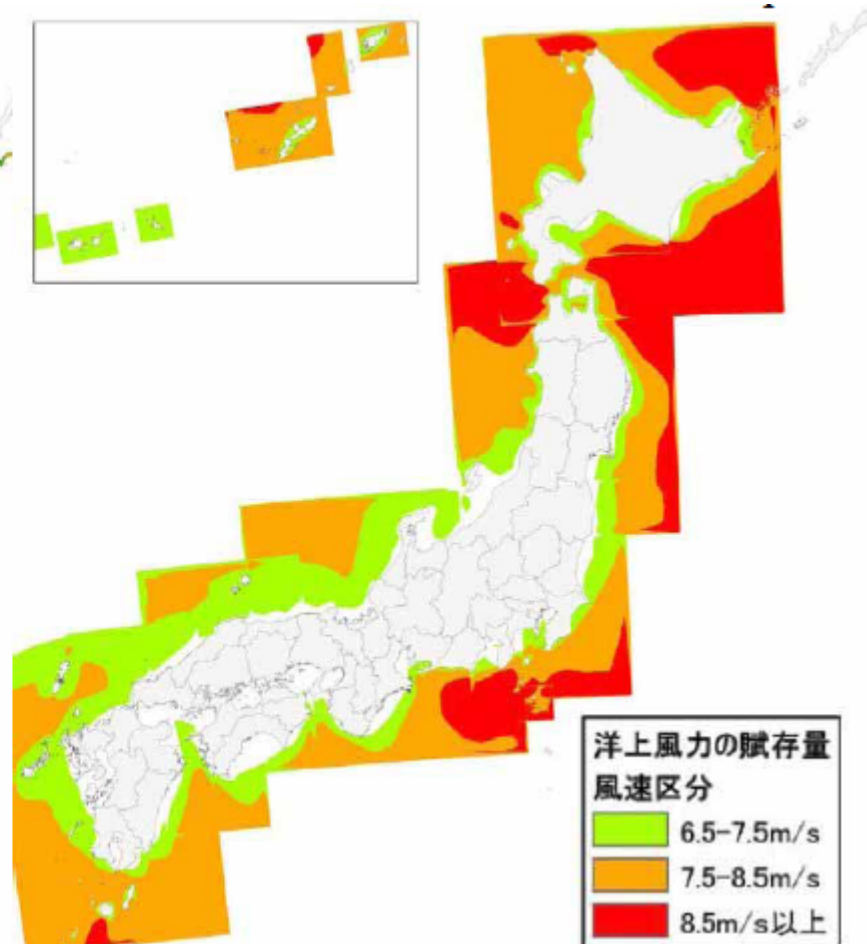
Depth (m)		0 - 40	40 - 200 +
Offshore potential	FR	80 GW	122 GW
	PT	2 GW	>10 GW
	SP	18 GW	>80 GW

For example Japan has ambitious plans to replace nuclear by floating offshore wind

On-shore wind resources in Japan

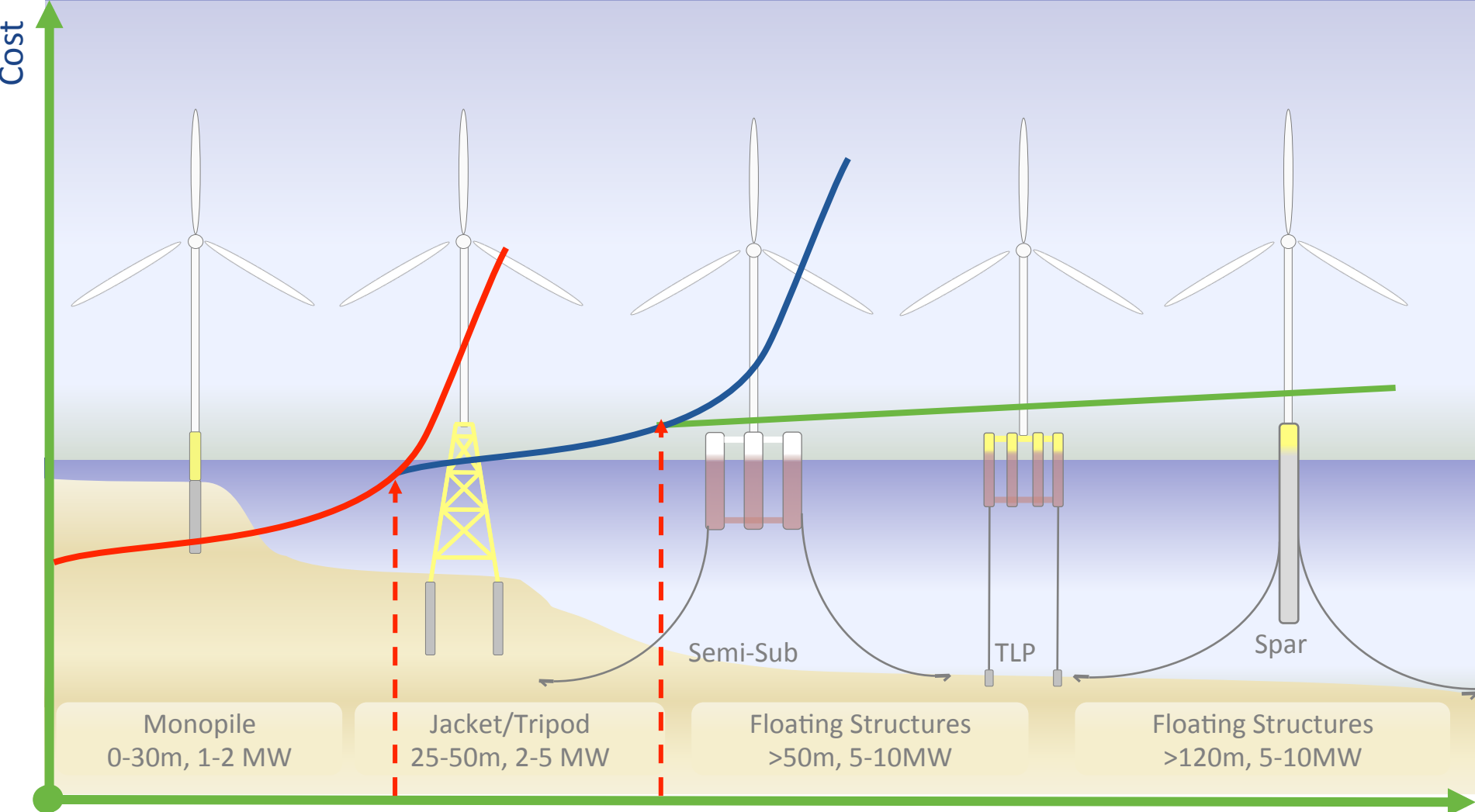


Off-shore wind resources in Japan



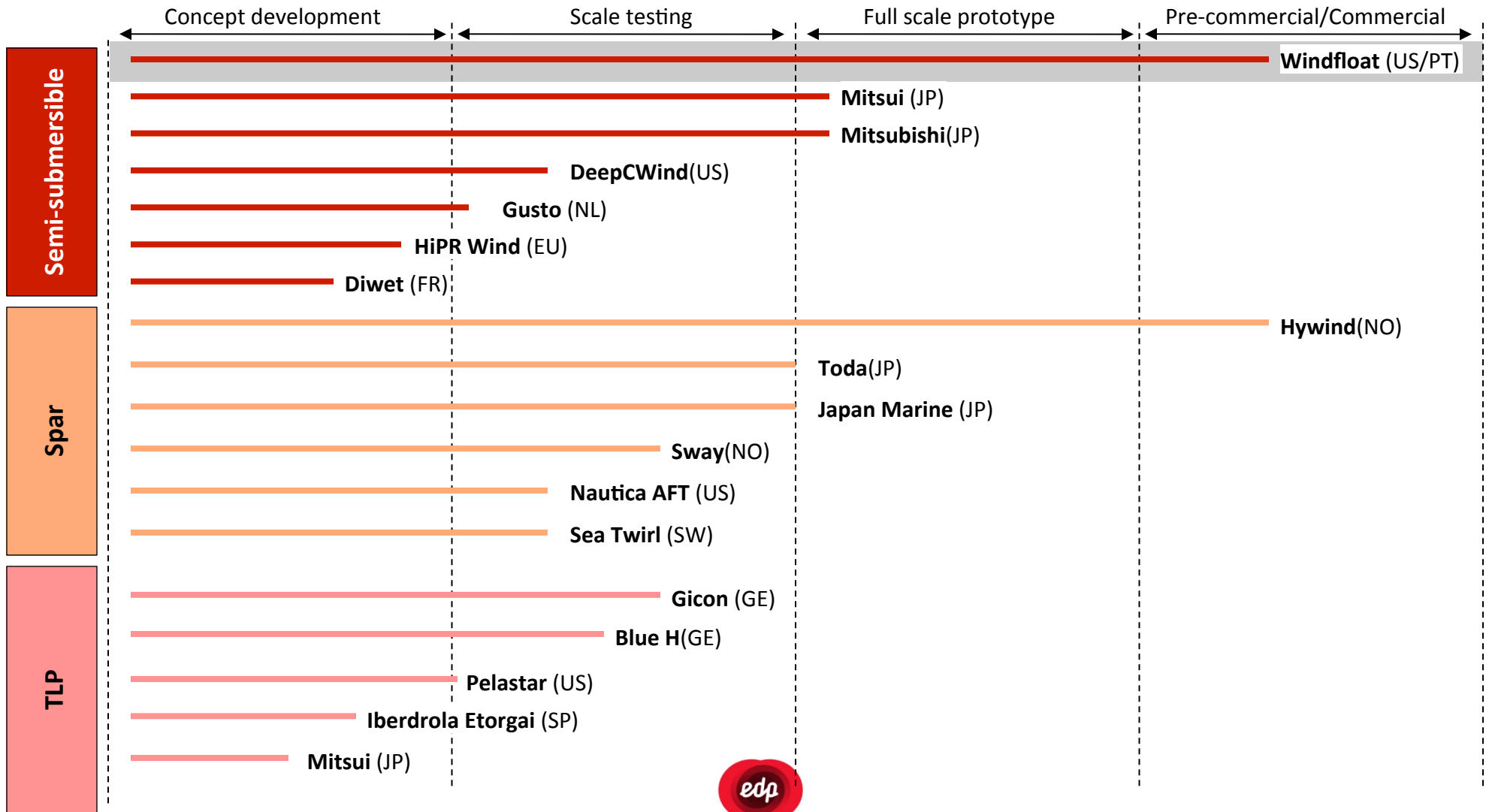
Economic potential: 141GW (almost all floating)
Total potential: 1600GW

There are different technologies that target (and are more competitive in) different water depths



Portugal via the semi-submersible technology WindFloat is a pioneer in deep / floating offshore wind technology

State of development of selected floating turbine concepts



WindFloat has demonstrated its survivability and performance in normal and extreme conditions. >8.3 GWh produced

22 Oct 2011
Installation complete

20 Dec 2011
First Electron produced

Dec 2010
Windplus is created

01 Nov 2011
15 meters wave

10 April 2012
Operation in Hs=6m and
Hmax=12,6m



edp

PORTUGAL VENTURES

PRINCIPLE
renewable energy delivered

ASILVAMATOS GROUP

REPSOL
(Joins in June 2012)



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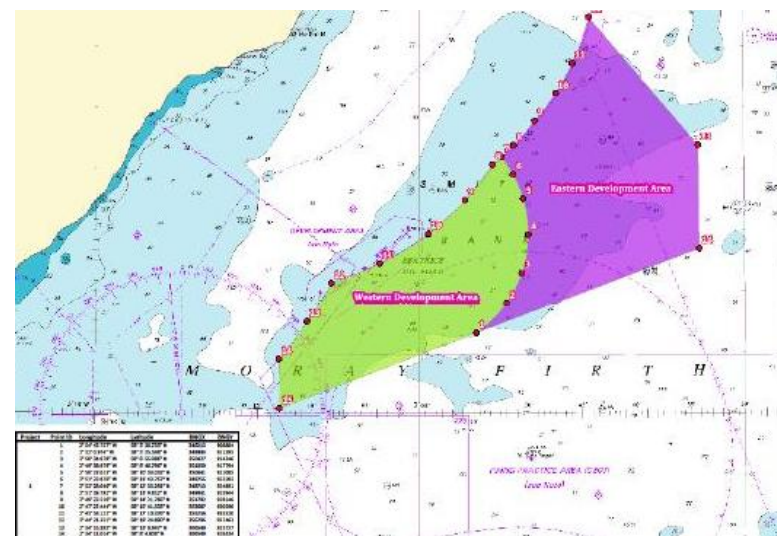


EDP is partnering with Repsol for the development of commercial offshore wind projects in the UK

UK Offshore Wind Partnership

EDPR is leading the development of up to 2.4 GW of wind offshore projects with a 60% stake

- Partnering with Repsol, 1st class company in Energy Sector with strong commitment to wind offshore capacity development
- Sites to be developed in “transitional waters” (30-60m of depth) , 15-25 km shore distance
- Upon getting key consents, construction and operation could begin between 2015 and 2020



During the last 15 years EDP has been consistently assessing and developing opportunities at sea

European Ocean Energy Plant – Azores, 1998



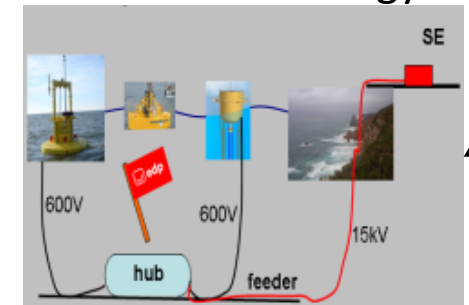
Wave energy technologies evaluation, 2006



Breakwater Project – Oporto, 2007



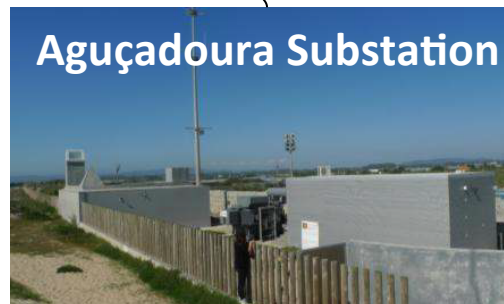
Multi-technology strategy for wave energy



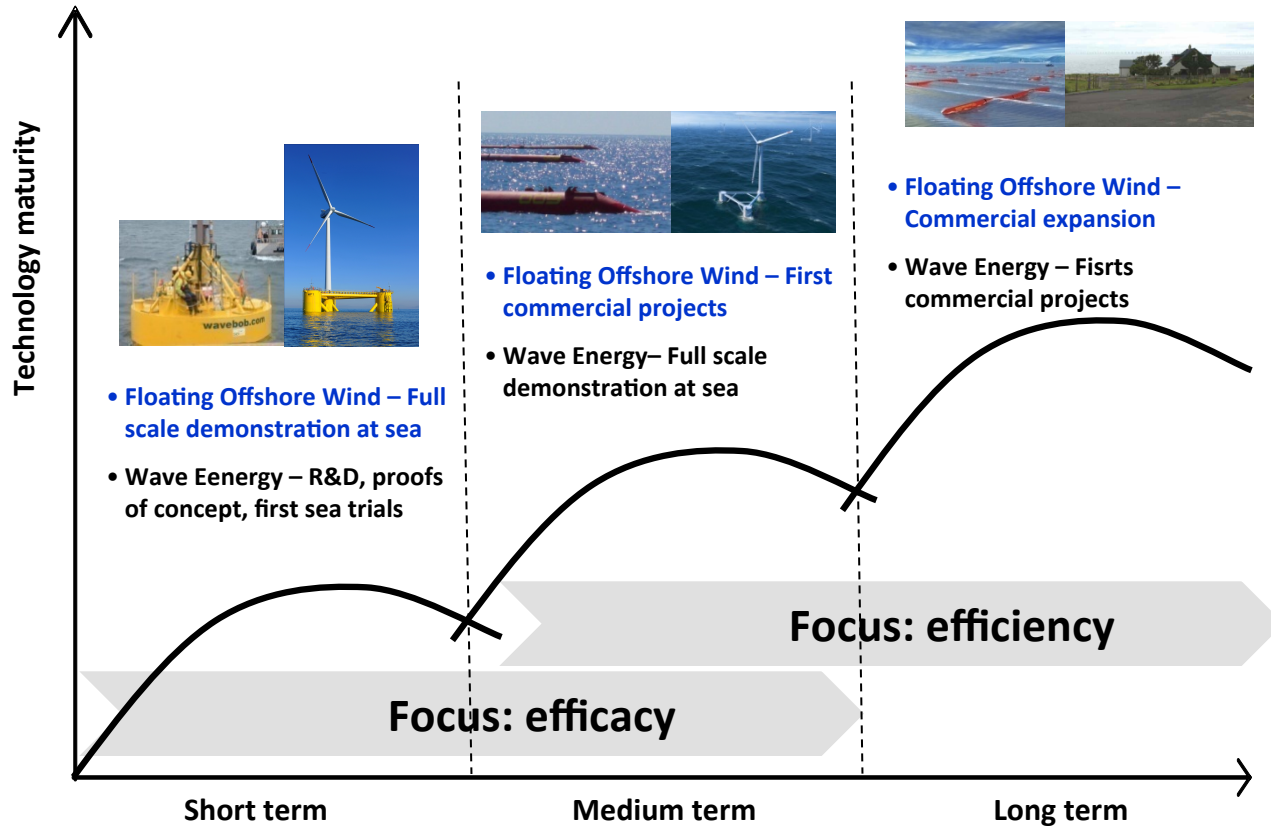
WINDFLOAT Project



Aguçadoura Substation



Given technology maturity offshore wind projects will likely pioneer the exploration of renewable energy resources at sea



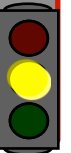
Floating Offshore Wind

- Conversion principle stabilized – incremental innovation
- 5 to 8 years to maturity



Wave Energy

- No technology convergence – disruptive innovation
- 10+ years to maturity



Offshore wind still has a way to go in order to become competitive vis-à-vis conventional generation... Technology takes time to develop

Figure 1: Levelised cost of electricity, Q1 2013 (\$/MWh)



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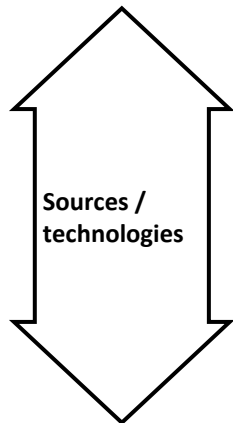
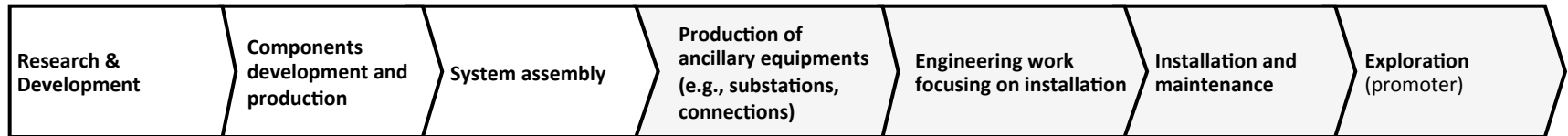
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There are evident synergies between wave and offshore wind businesses and Portugal can have a say

☐ Phases with more significant synergies

Wave Energy



Same needs regarding infra.structure for grid connection

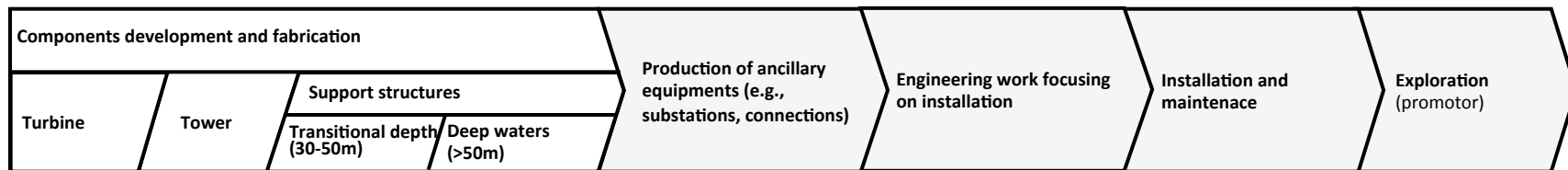
Synergies and knowledge sharing namely in:

- site selection
- Installation and maintenance techniques and innovations
- anchoring

Possibility to develop versatile shipyard facilities and vessels able to accomodate wave and offshore wind works

Lots of synergies in development and risk management

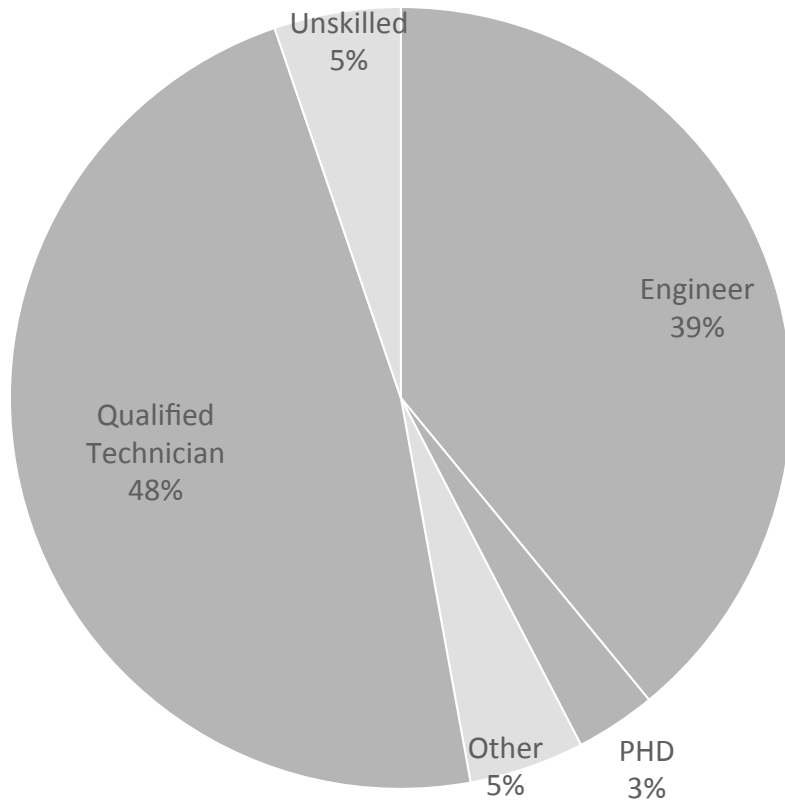
Offshore wind energy



WindFloat, for example, represents an opportunity as it requires highly skilled labour in traditional sectors, such as naval industry

FTE's involved in the WindFloat Prototype (%)

Total*=210



* Not including other indirect participants also involved in engineering, investment and management activities from A. Silva Matos, EDP Innovation, EDP Renewables and InovCapital.

WindFloat Prototype

- 90% of highly skilled workers
- More than 70% of European Suppliers

WindFloat Pre-Com Project (estim.)

- More than 450 highly skilled workers involved in a three year project
- More than 90% of European Suppliers



Closing remarks

- Oceans represent a significant opportunity and enclose a vast energetic potential
- In Portugal, stable and competitive frameworks should be put in place in order to enable necessary investments
- Technology is developing: short to medium term – offshore wind; medium to long term – wave energy
- Portugal is a pioneer in R&D and technology development and can have an important industrial role





Obrigado