INSTITUTO SUPERIOR TÉCNICO

WaveEnergy Centre
Centro de Energia das Ondas

- Wave Energy Centre
- Why Ocean Energy
- Status of the technology
- Economic and financial aspects
- Route to success
- Conclusions

Ocean Energy

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Wave Energy Centre: Members

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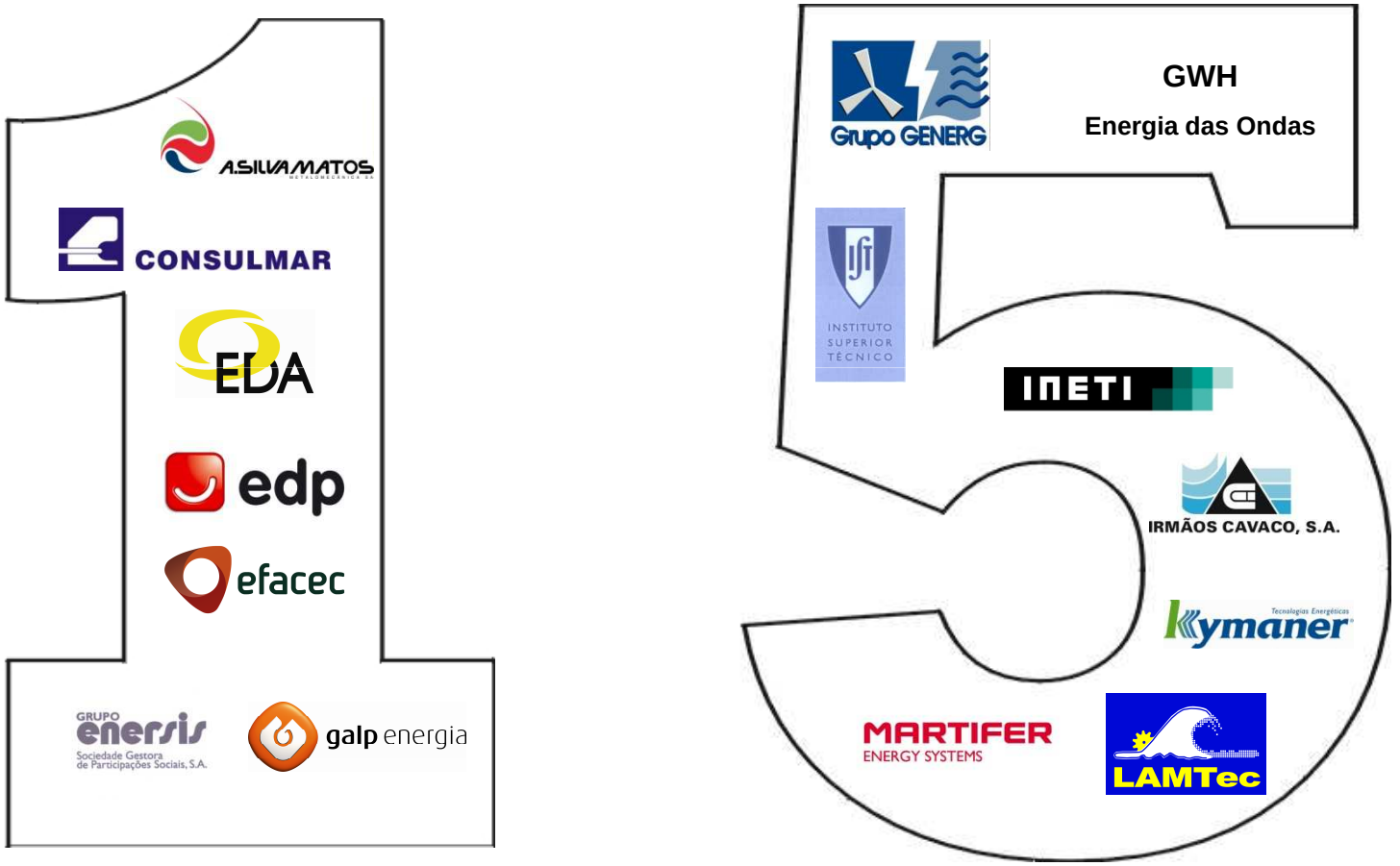

R&D and Services at WavEC (+ IST & ...

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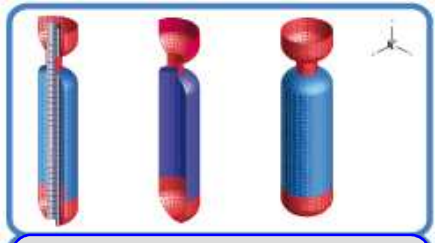
Plant operation & monitoring

Due Diligences & Strategic An.



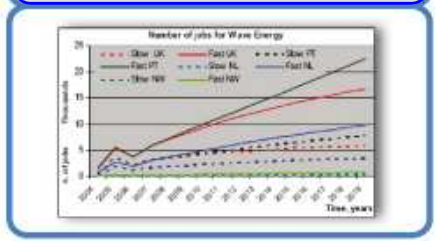
Experimental & Numerical mod.

Waves, floating offshore wind and algae

Dissemination & training

Environment & site selection

Public Policies



Forms of Ocean Energy

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- Tides
  - Dam and reservoir (La Rance) – 300 TWh/y
  - Tidal currents
- Ocean currents

} 2,200 TWh/y

- Ocean Salinity Gradients – 20,000 TWh/y
- Ocean Thermal Gradients – 33,000 TWh/y
- Waves – 45,000 TWh/y

Values represent technical exploitable resources

Benefits of world leading EU O.E. Industry

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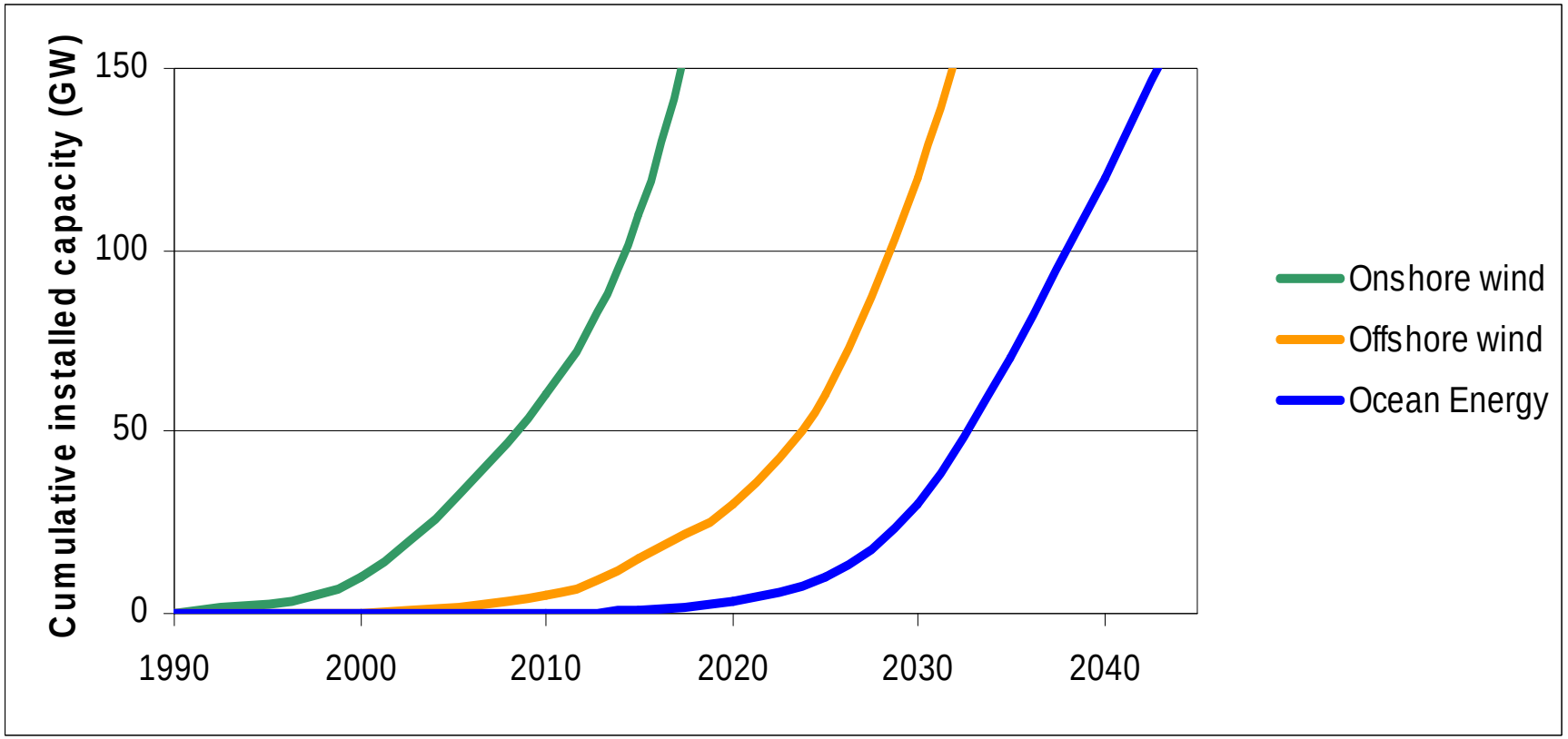
Installed Capacity in EU / GW	Direct Jobs	Total Jobs	CO_2 avoided Mt / Year	Investment €m
3.6 (in 2020)	26.000	40.000	2,61	8,544
188 (in 2050)	314.213	471.320	136,3	451,104

Source: Oceans of Energy – European Ocean Energy Roadmap 2010 – 2050, European Ocean Energy Association (EU-OEA), May 2010.

Projected O.E. installed capacity in EU



Source: Oceans of Energy – European Ocean Energy Roadmap 2010 – 2050, European Ocean Energy Association (EU-OEA), May 2010.

Characteristics of O.E.

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- Salinity and Thermal gradients are steady and 8760 hr/y available.
- Waves, Tidal & Ocean currents
  - Unsteady, but
    - Tides & Ocean Currents are known with years in advance;
    - Waves are predicted 6 days in advance and a very stable resource.

Wave Energy Resource

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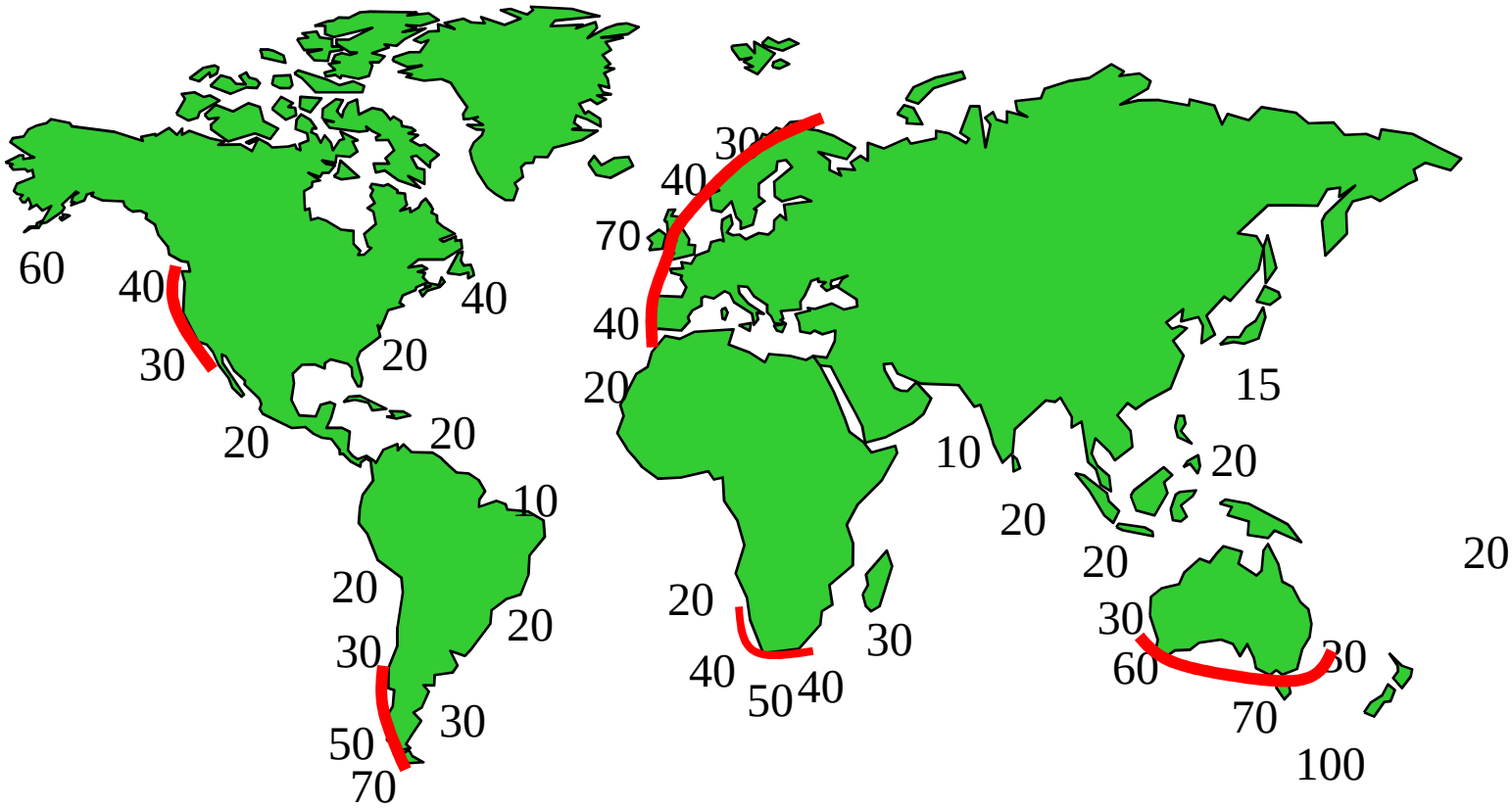
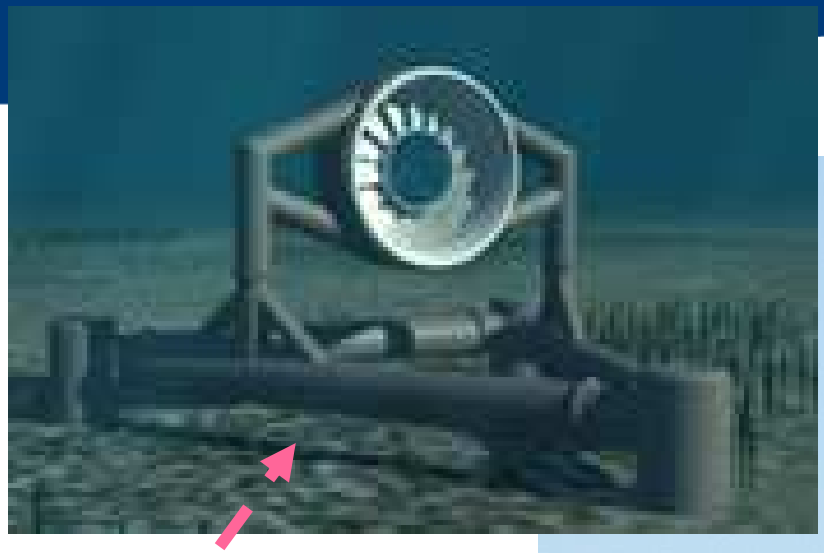


South hemisphere much more stable

Present status of ocean energy



- Tidal currents:
  - Prototypes
    - Hammerfest Strøm 300 kW turbine (2004 to 2008)
    - Open Hydro 1000 kW operational since 2009
    - SeaGen 1200 kW operational 2009
  - First farms expected by 2012
    - Scottish Power Renewable
    - EDF

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Present status of ocean energy

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- OTEC (thermal gradient):
  - DCNS plans to built 4 MW plant in La Reunion
- Salinity gradient / Osmotic power:
  - Statkraft built small demo plant in 2009 in Norway (4 kW, 1 W per m^2 of osmotic membrane, € 15 M)
  - Expected to deliver first commercial plant in 2015.

Waves: 5 basic technologies

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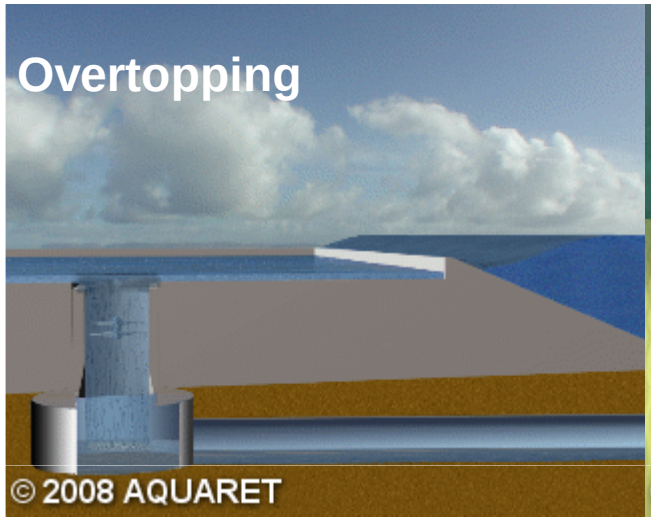

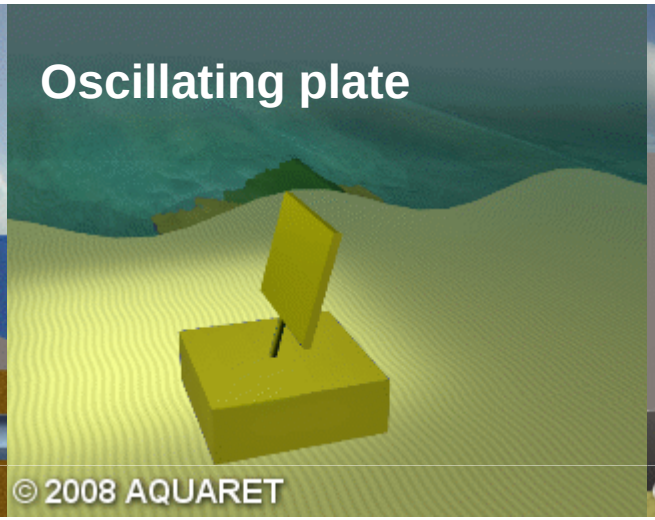

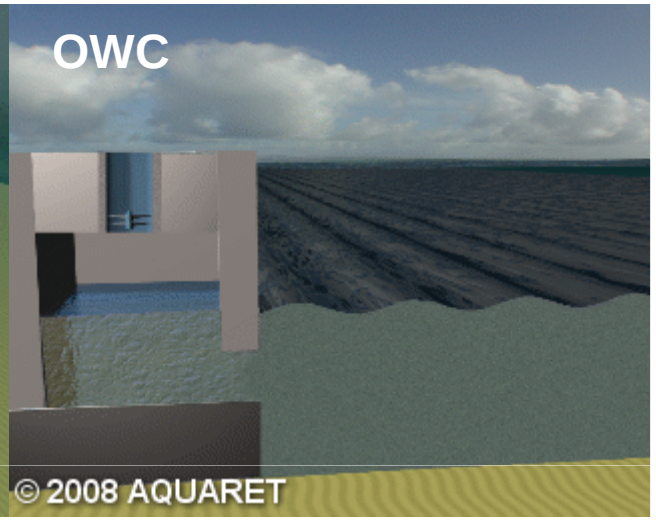

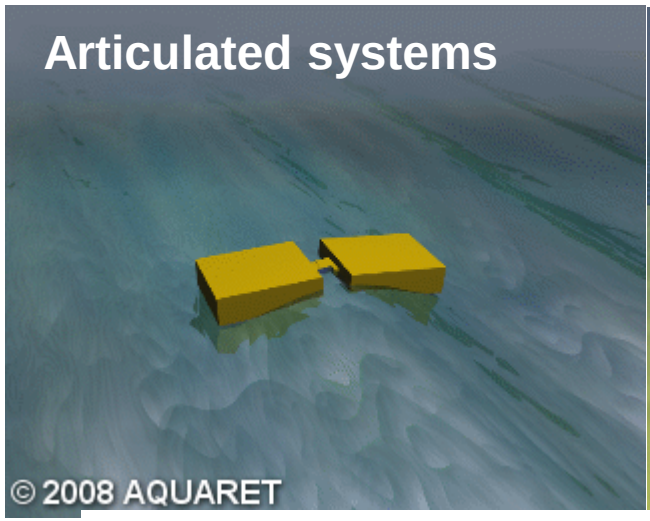

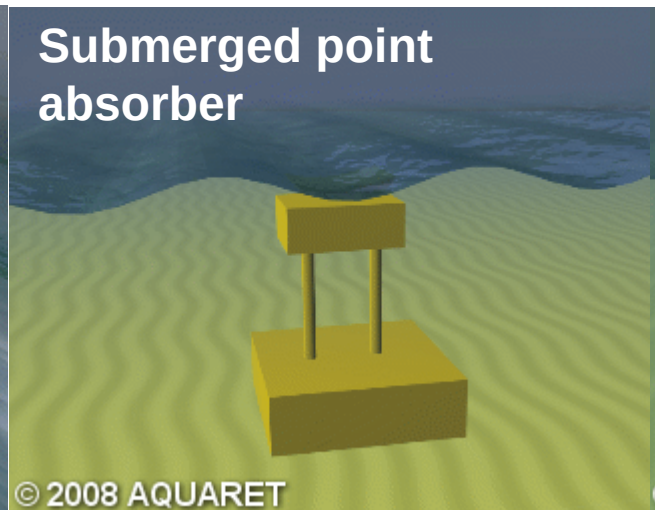

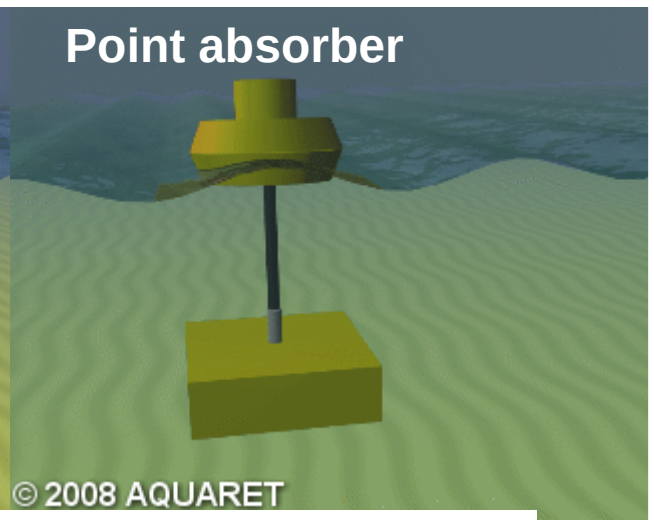

- Significant progress in the last 5 years, in spite of the small investment done (€ 300M / 10 years) **but need to deliver in 5 years**

Pico (Azores) wave energy plant

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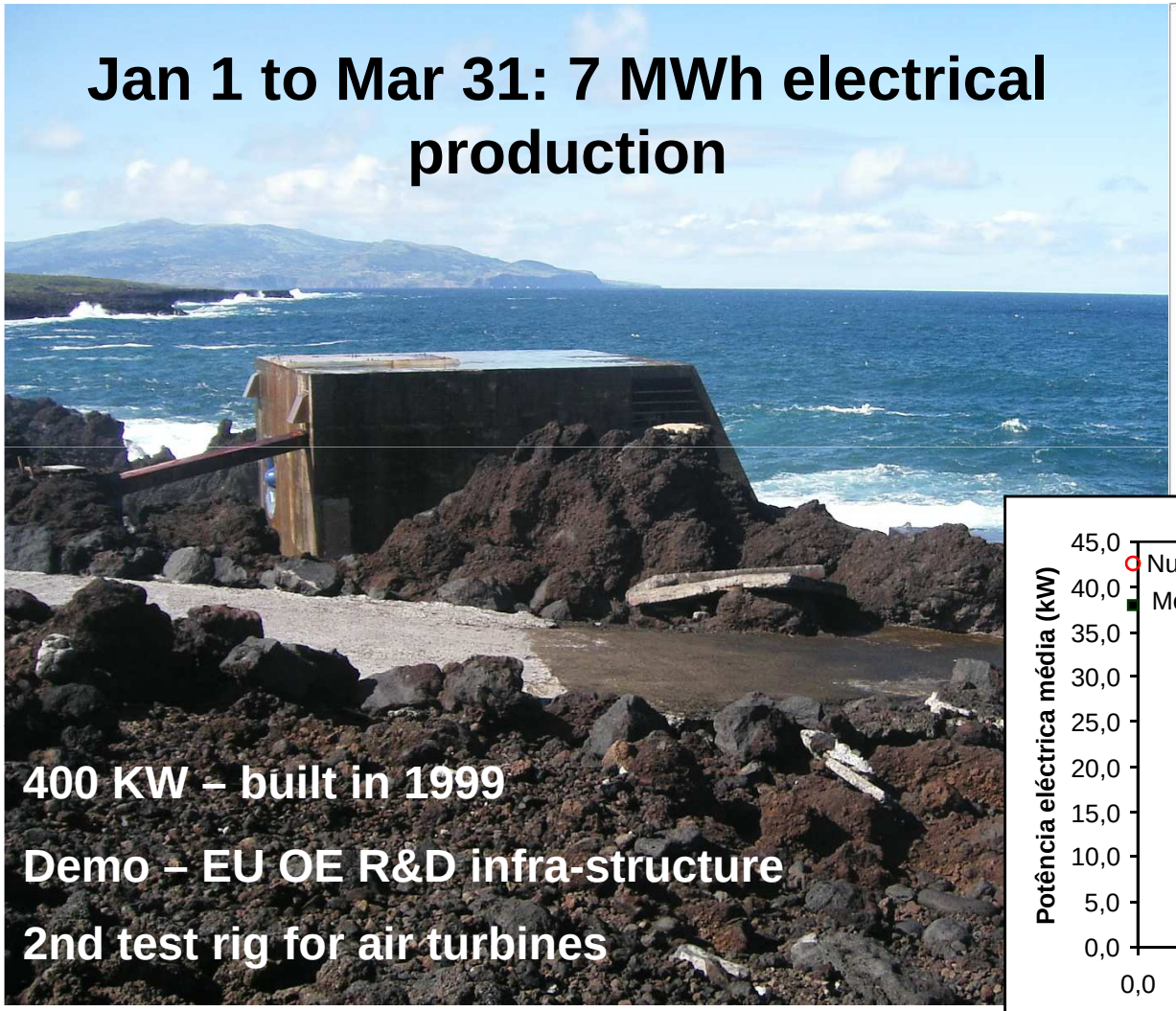

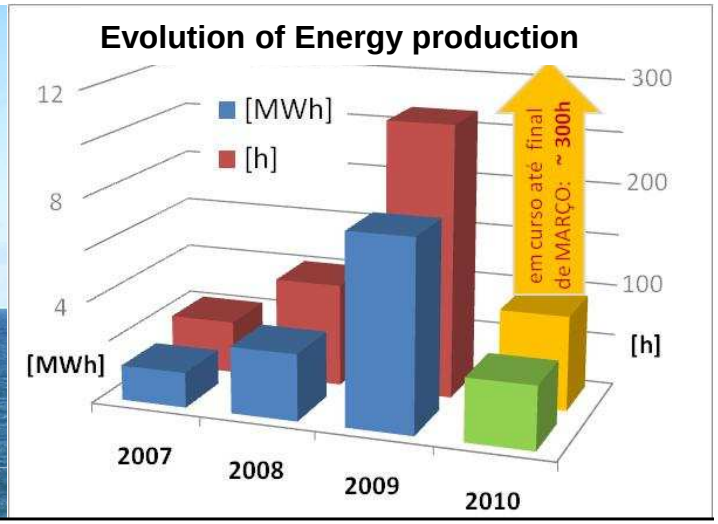

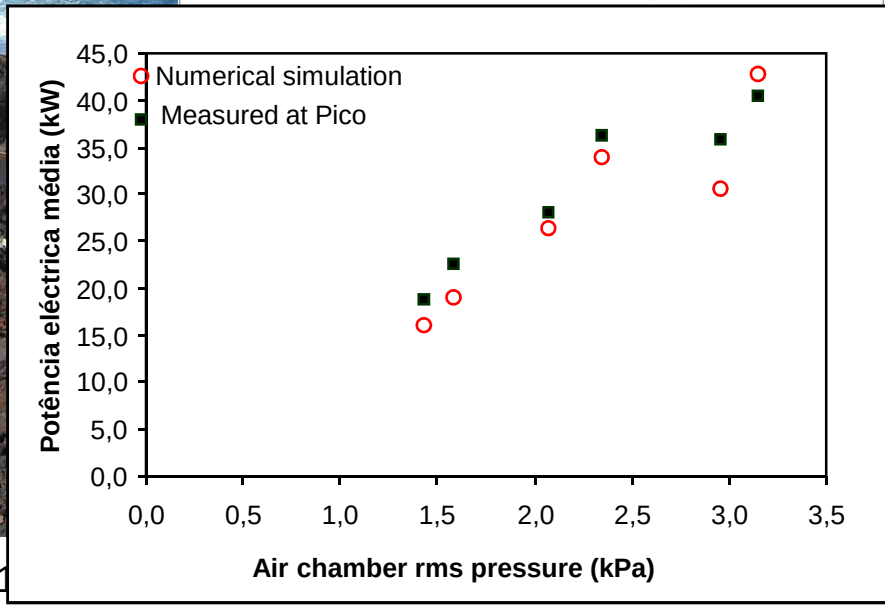

Combined offshore wind & wave energy

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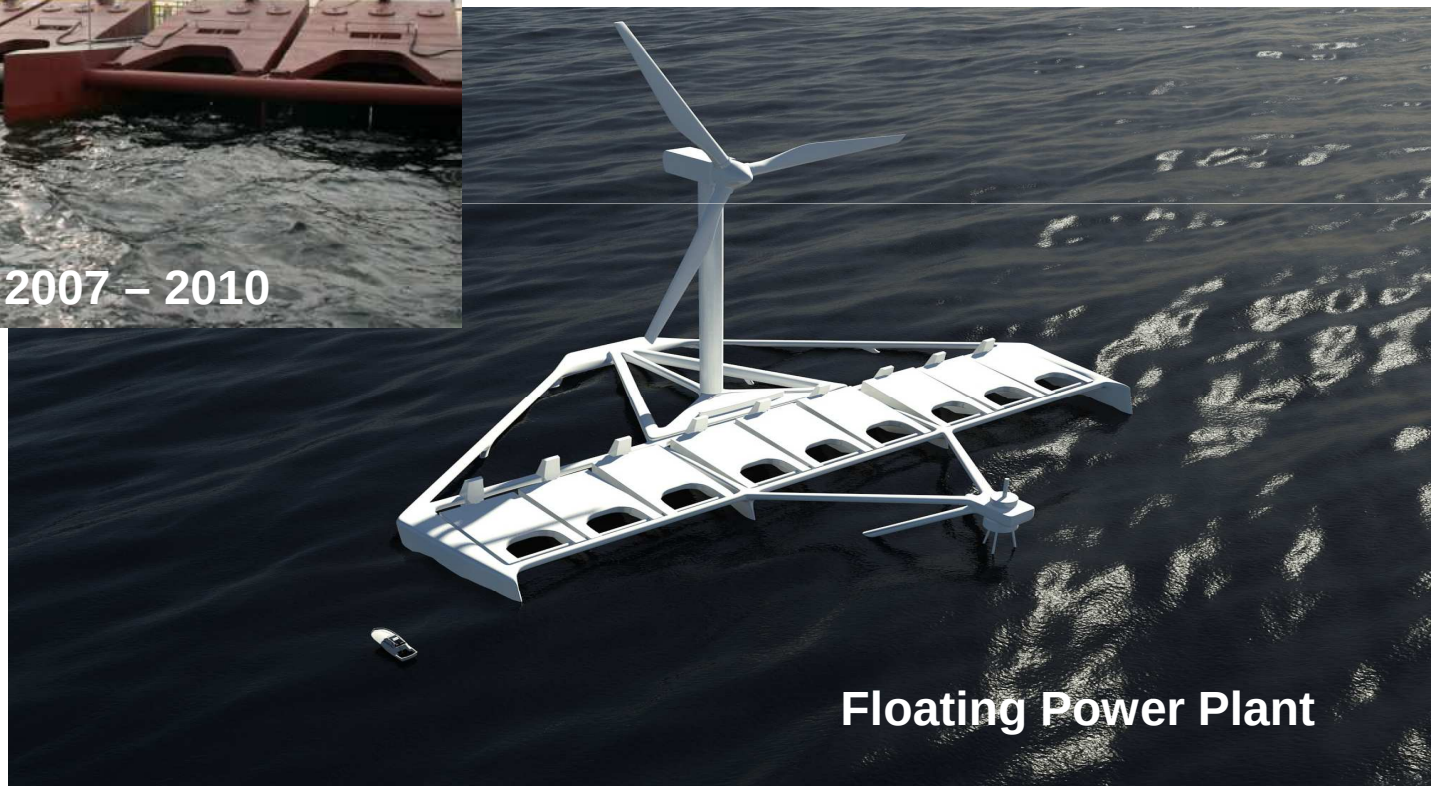

Present status of wave energy

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- 2000: 2 near-shore wave energy plants
- 2004-07: 15 prototypes tested at sea
- 2008: First “commercial” 3 Pelamis farm (Portugal) + Mutriku (Basque C.) and Santoña (Cantabria)

Demonstration phase at sea started

- No technology convergence
- No extended operational experience
- 2008-09 outcomes below expectations, 2010 better

Need to deliver and converge in 5 years

Wave energy costs

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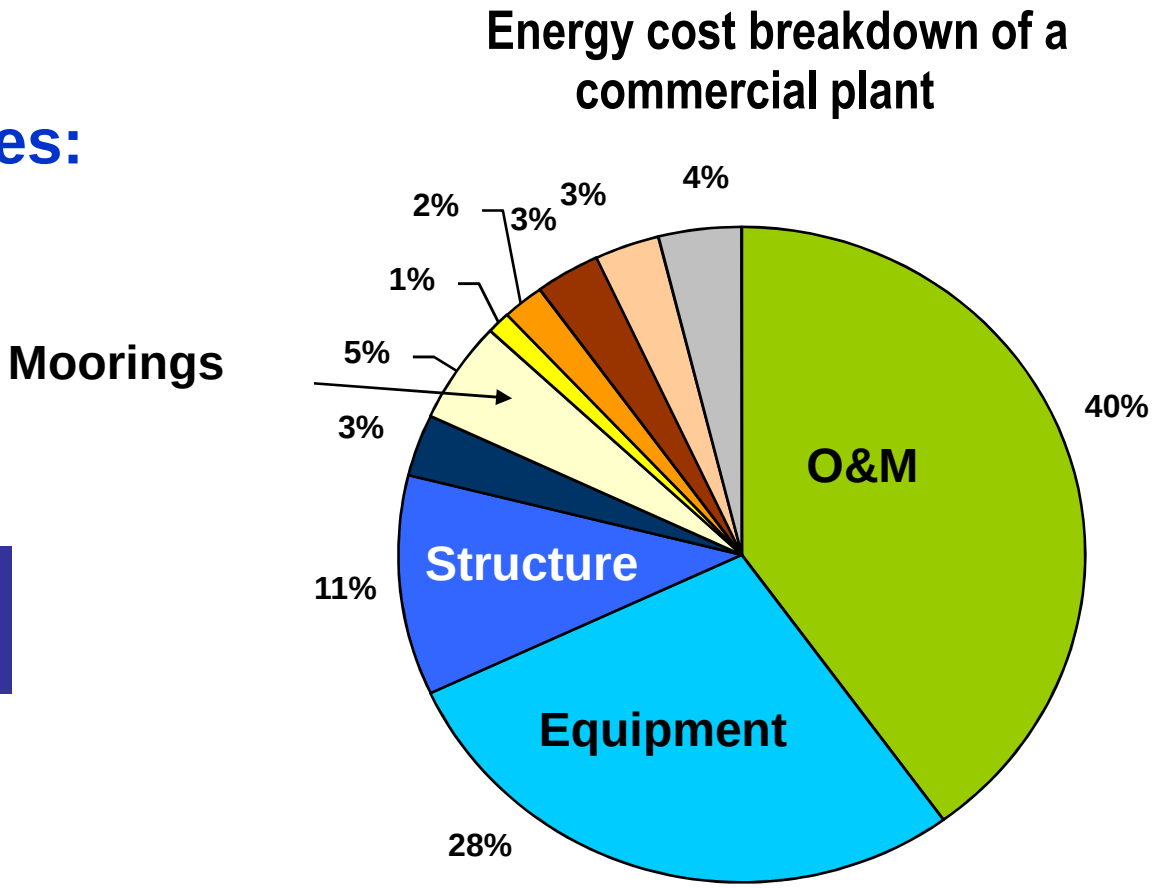
Source: Carbon Trust – 25 January 2006

Present cost estimates:

- **3,5 to 4,5 M€/MW**
- **250 to 350 €/MWh**

Costs must reduce by a factor of 3



Required Financial Resources (Waves)

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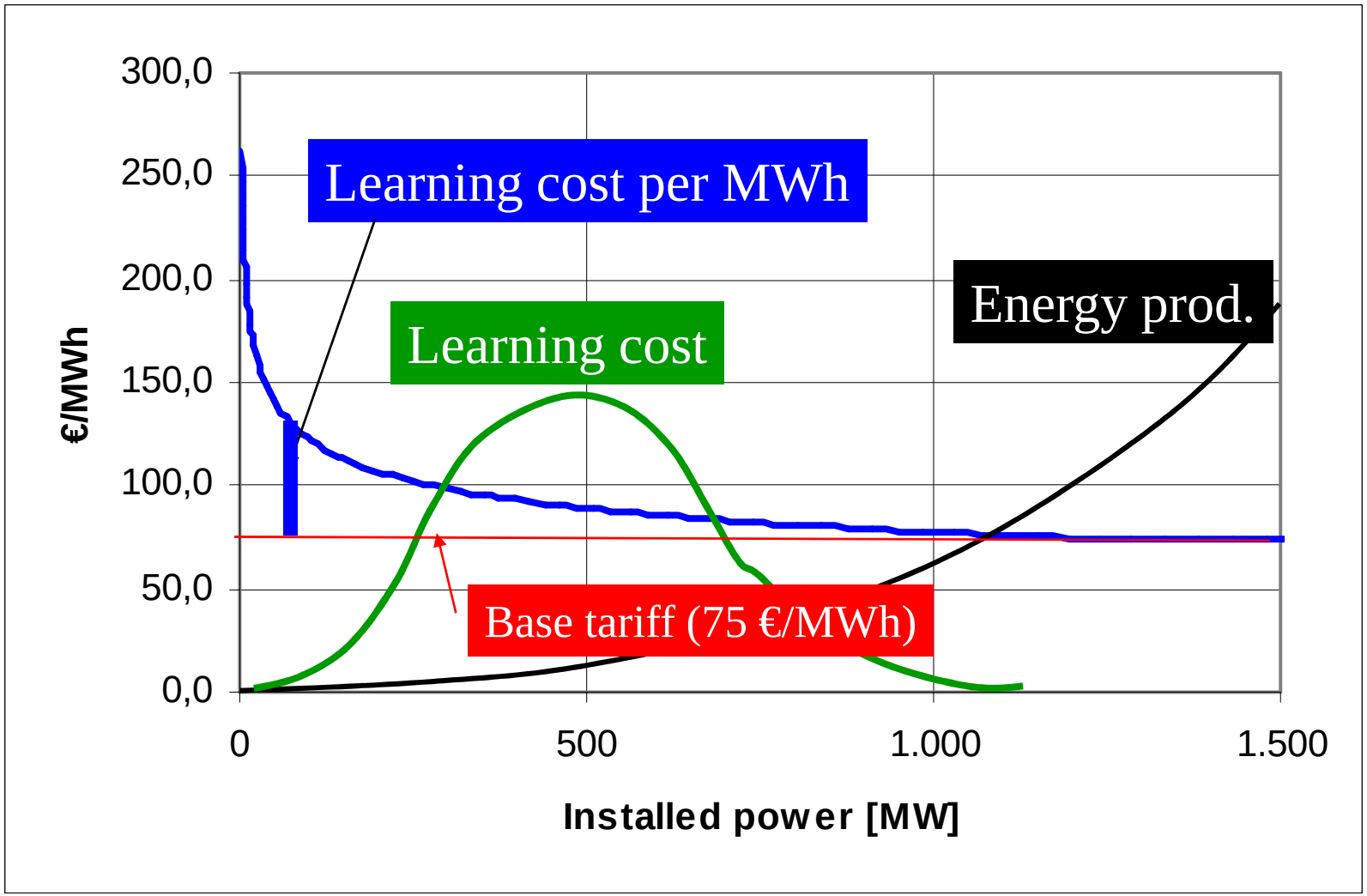
Learning factor of 20%



Required Financial Resources (Waves)

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- **Economic competitiveness attained when:**

- **Total learning cost: €** 1.3 billion (along 20.5 years)
- **Total energy produced by waves:** 278 TWh (along 20.5 years)
- **Average learning cost per MWh produced by waves:** 4.6 €

- **Compare with the estimated world market of € 700 billion (0.19%) and the base tariff of 75 €/MWh (6%)**

Possible but Challenging

How to progress

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- Increase demonstration at sea

  (Only real sea operation will allow to identify the best solutions - reliability and costs)
- Improve materials, components and power take-off equipment

  (Failures to date are related to components and not the basic concept)
- Improve design, monitoring and control methods and tools for single devices and farms

  (Demonstration at sea is very expensive and risky)
- Improve fabrication, deployment, O&M methods and tools, including support vessels

  (Cost reductions by a factor of 3 are to be attained)

European Infrastructures for O.E.

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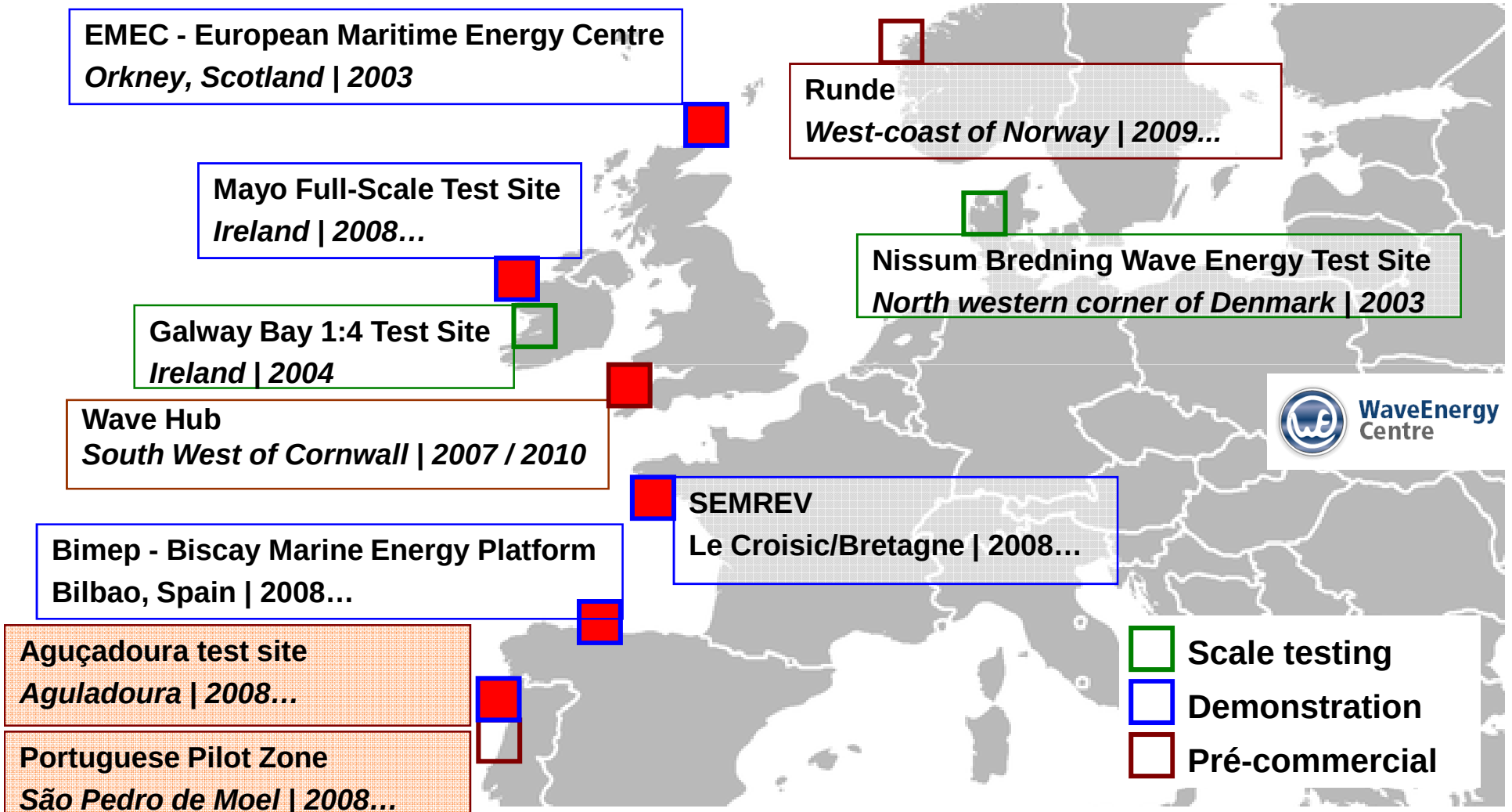

The Pilot Zone

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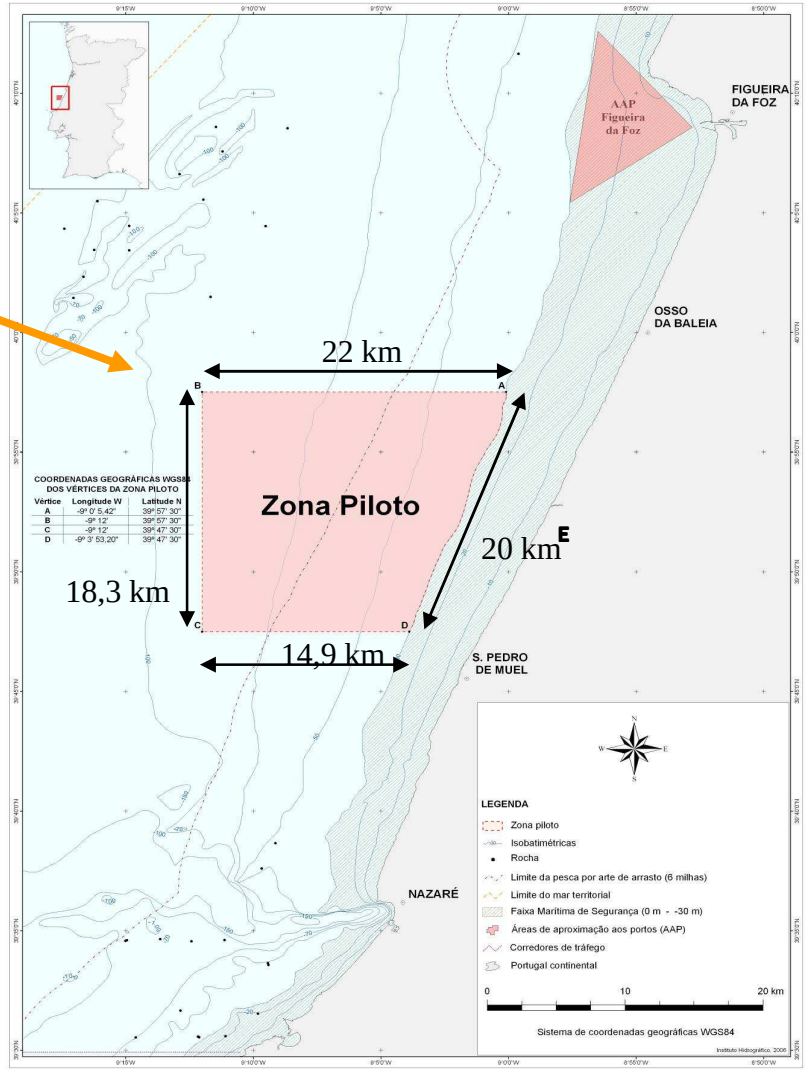

- Pilot Zone
  - 400 km² offshore area (30m to 90 m water depth)
  - Up to 250 MW of electrical connection (18 MW; 80 MW; 250 MW)
  - Simplified licensing
  - Managed by REN (PT TSO)

EFCA - 2010

Route to success – Public Policies in place

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Technology development – funds, tax incentives & R&D+I infrastructures

Licensing procedures – simple, clear, fast and cheap

Concession contracts – fair and competitive

Market development:

- Grid access
- Targets for Ocean Renewable Energy
- Feed-in Tariffs & Tax incentives

Financing:

- Risk sharing mechanism

Wave Energy Feed-in Tariff (Portugal)

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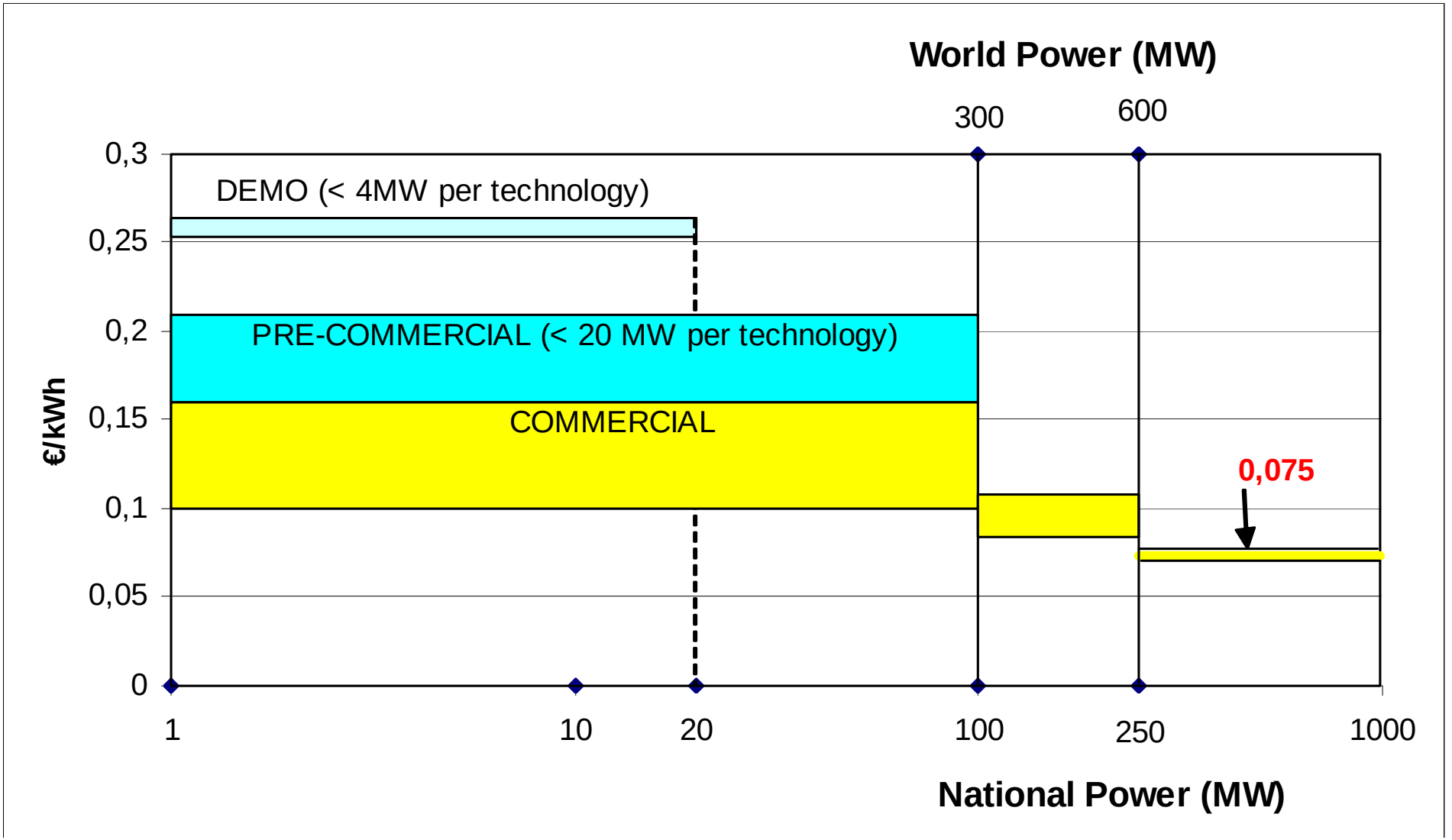

Route to success – EU - OEA

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Become member of the European Association of OE

Develop a European Industrial Initiative with EU-OEA:

Conclusions

- Significant progress in the last 5 years, in spite of the small investment done (€ 300M / 10 years) **but need to deliver in 5 years**
- Learning cost acceptable **but challenging**
- Development is taking **longer**, being **harder** and **more expensive** than anticipated, with the technology possibly stabilizing in 2015.
- A large number of barriers can be identified, most of which may be removed or significantly reduced with proper public policies
- Support EU-OEA and European Industrial Initiative to include OE in the SET-Plan by 2014.