PECC Hawaii Seminar

MARINE RENEWABLE RESOURCES

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The marine renewable energy innovation policies

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The marine renewable energy Innovation policies

A projected timetable to promote new marine technologies

from research and development to industrial implementation :

A cost-efficiency approach

Many Questions ??

For a better and wider use of the new sources of energy from the oceans (thermal, wave, tidal, wind, etc.);

What are the Available technologies and the new technologies and industries to be developed ?

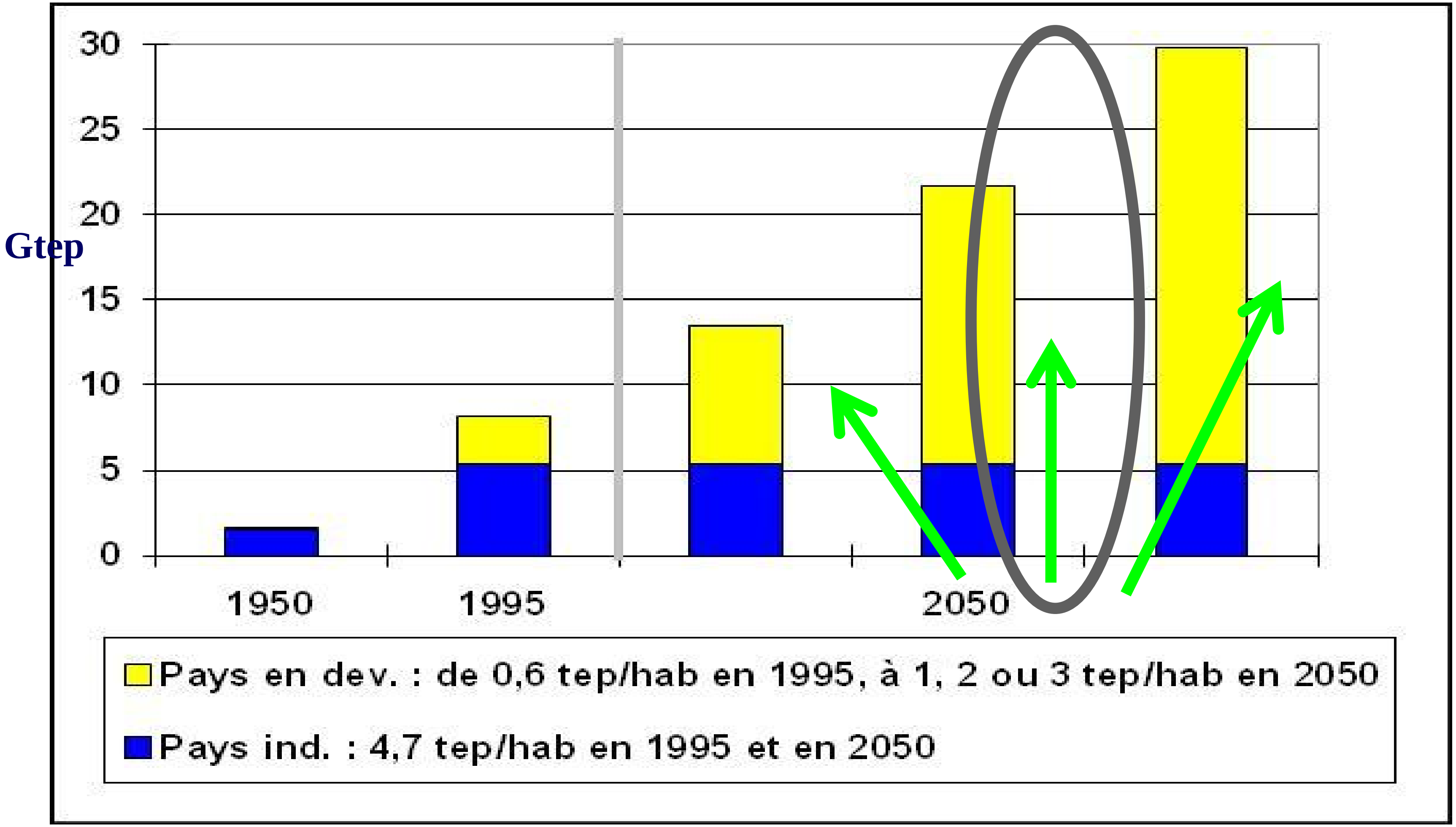
Which ways to increase the use of energy from marine sources (research, incentives, etc.);

Role of marine energy, cost, and financing of necessary infrastructures.

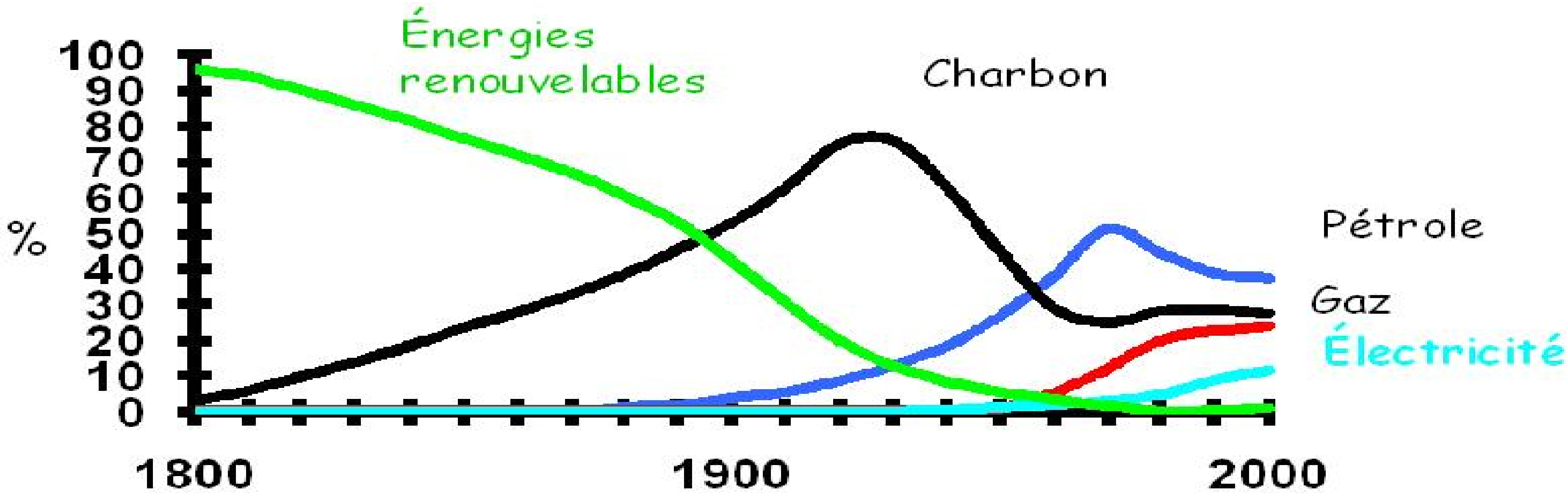
World Energy Consumption by 2050

(P. Boisson, ENERGIE 2010-2020, CGP 1998)

Developing Countries population from 4.6 billions in en 1995 to 8.1 in 2050
Industrialized Countries : from 1.15 to 1.14 Billion



Renewables energies dominated the story of humanity until XXth century



in percentage

before19ème siècle :wood, watermills, windmills, slaves and horses,

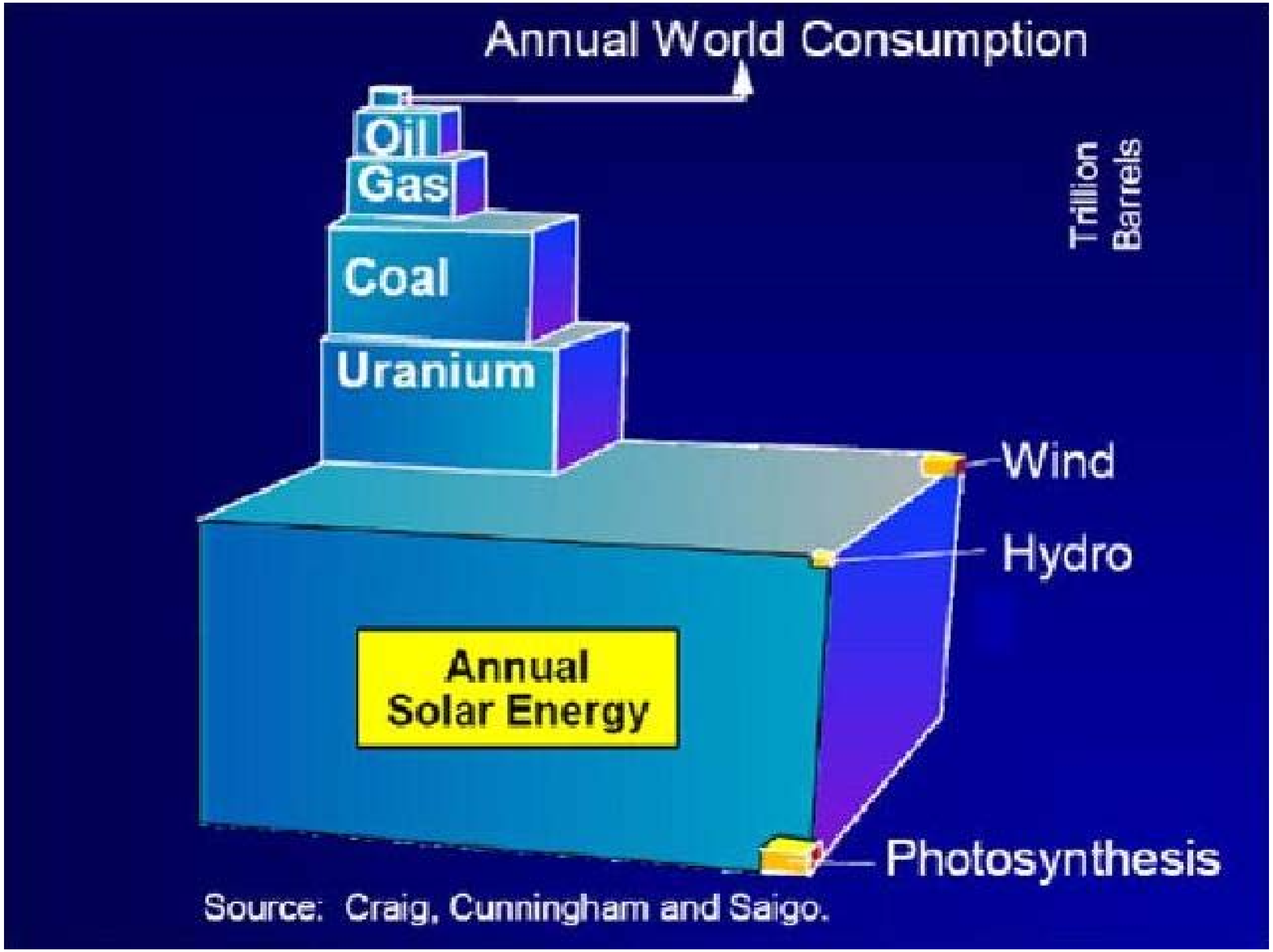
19th century : coal, steam engine

20th century Oil, gas, nuclear

Can we come back to renewables ?

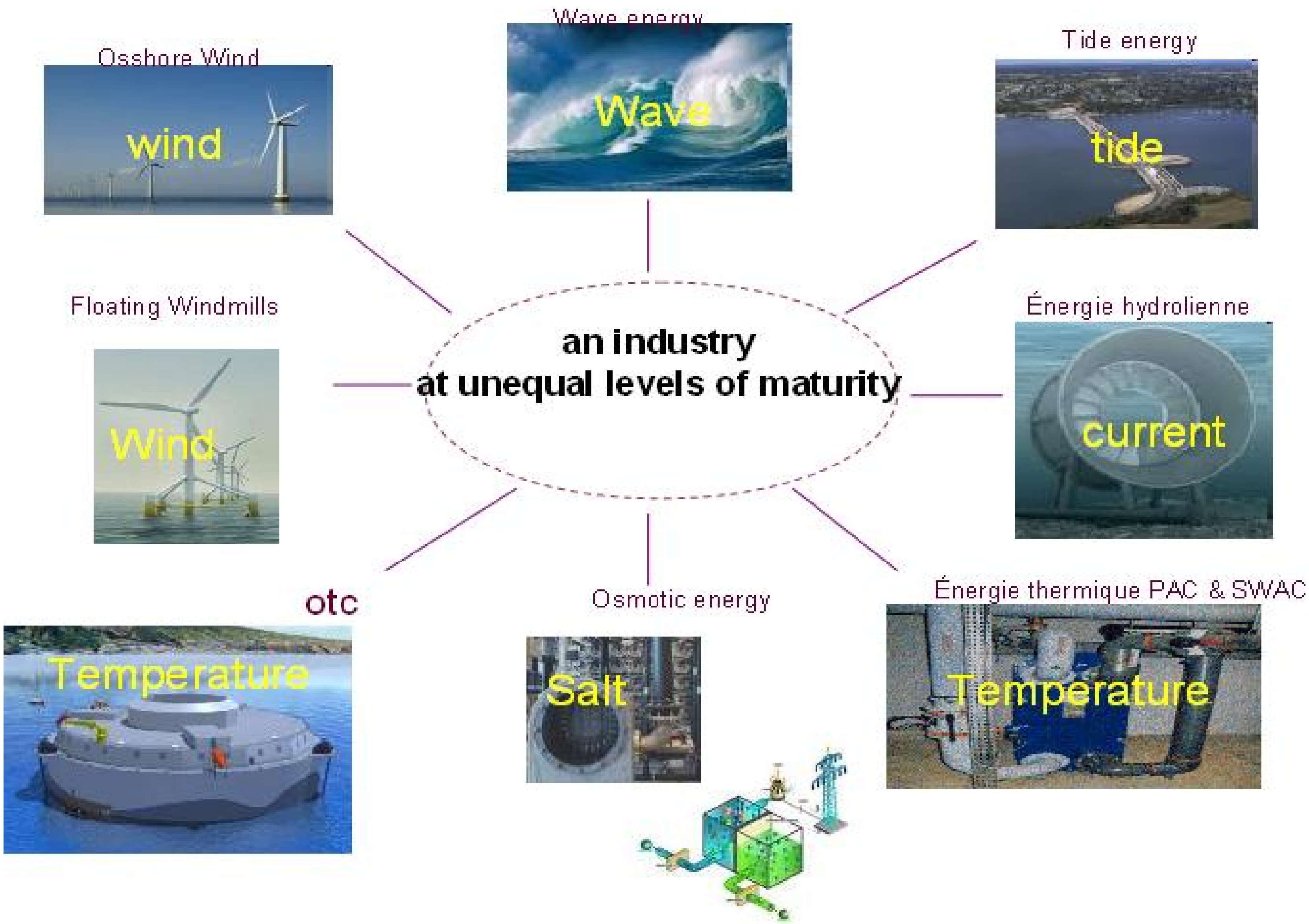
Having Energy when you need it, not only when available…

Annual Solar Energy



Earth is mostly ocean

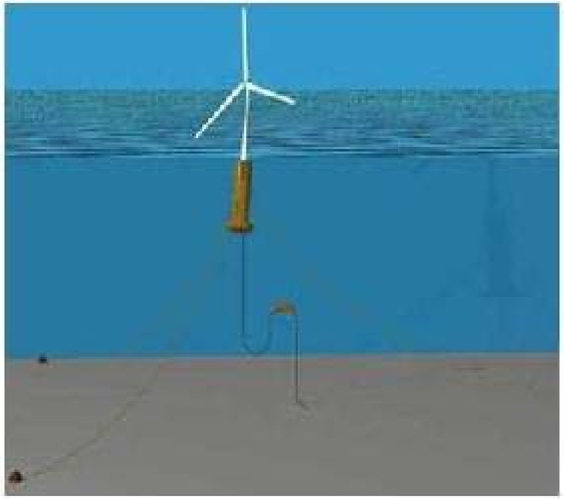
Marine energies
which renewable energy at sea?

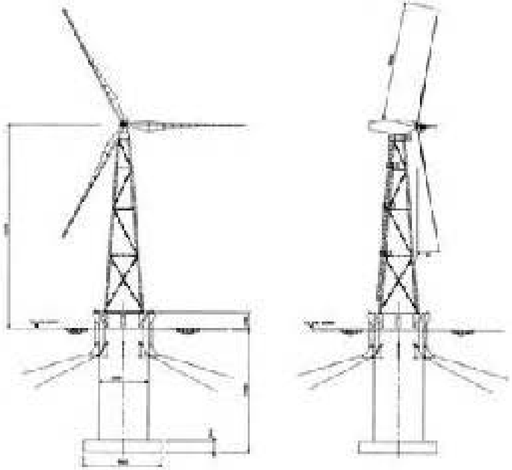


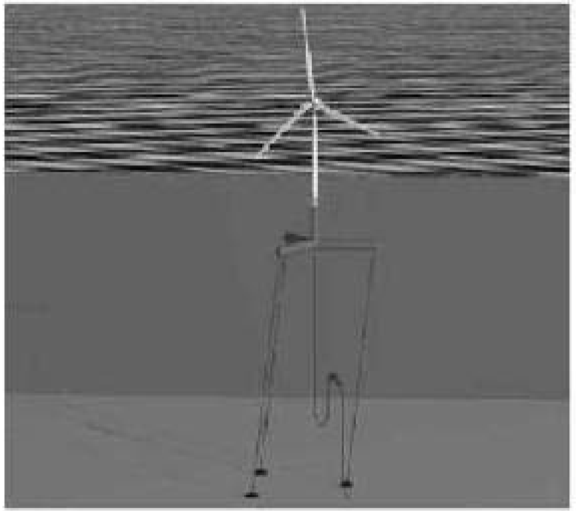
Marine renewable energies
Few mature technologies, a large number of concepts at disparate stages of development

Stade	**Technologie** *(équivalent anglais)*	**Site**	
Recherche amont	Concept *(Concept design)*	-	*Le concept est élaboré, modélisé, amélioré.*
Développement Démonstration	Maquette *(Part-scale)*	Bassin d'essais en laboratoire	*Une maquette est testée dans un bassin simulant les états de mer.*
	Prototype échelle réduite *(Part-scale)*	Site d'essais en mer	*Le concept est validé à la mer, en site abrité.*
	Prototype échelle 1 *(Full-scale)*	Site d'essais en mer	*La première machine construite est testée en conditions réelles.*
	Pré-industriel *(Pre-commercial)*	Site de démonstration	*Un premier parc est installé en mer, afin de tester le comportement de chacune des machines mais aussi d'appréhender l'effet parc.*
Exploitation	Industriel *(Commercial)*	Site exploité	*Le parc est installé en mer dans l'unique but de produire et de vendre de l'électricité.*

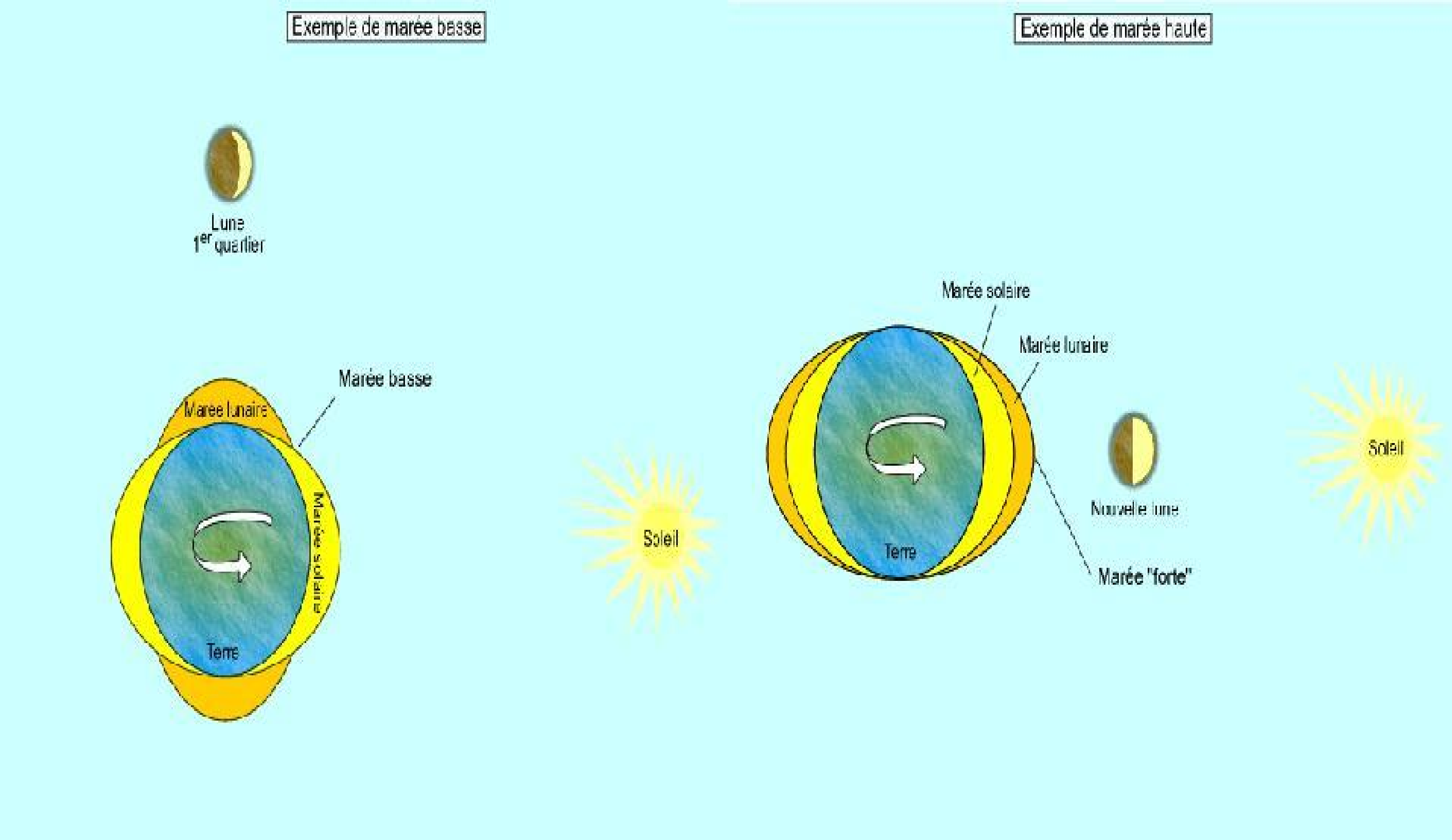
Floating Windmills







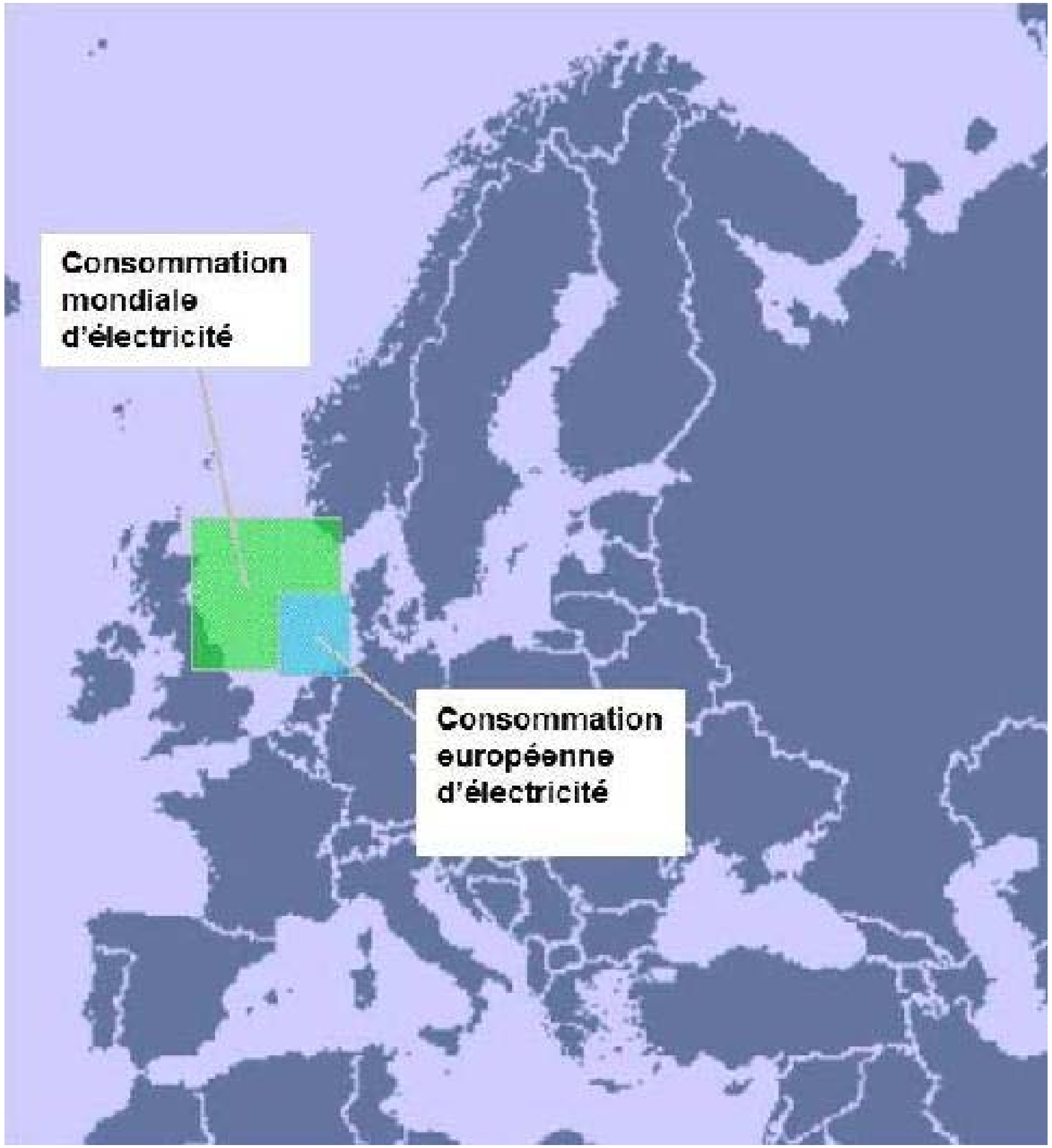
Tidal Energy



La Rance
the tidal plant of La Rance
in Brittany 240MW,
inaugurated in 1967

Lake Shiwa Corea inaugurated 29 august 2011 by President of Corea republic, LeeMyung-bak.
254MW

A huge Potential of offshore marine energy in North sea



Theoretical potential
(wind and wave)

In blue European consumption in electricity

In green
World consumption in electricity

Wave Energy

Wave energy modern technology

- Wave power devices are generally categorized by the method used to capture the energy of the waves, by location and by the power take-off system.
- Method types are point absorber or buoy; surfacing following or attenuator oriented parallel to the direction of wave propagation; terminator, oriented perpendicular to the direction of wave propagation; oscillating water column; and overtopping.
- Locations are shoreline, nearshore and offshore.
- Types of power take-off include: hydraulic ram, elastomeric hose pump, pump-to-shore, hydroelectric turbine, air turbine, and linear electrical generators.
- There are hundreds of patents !!

Technologies: Profusion
A selection is needed

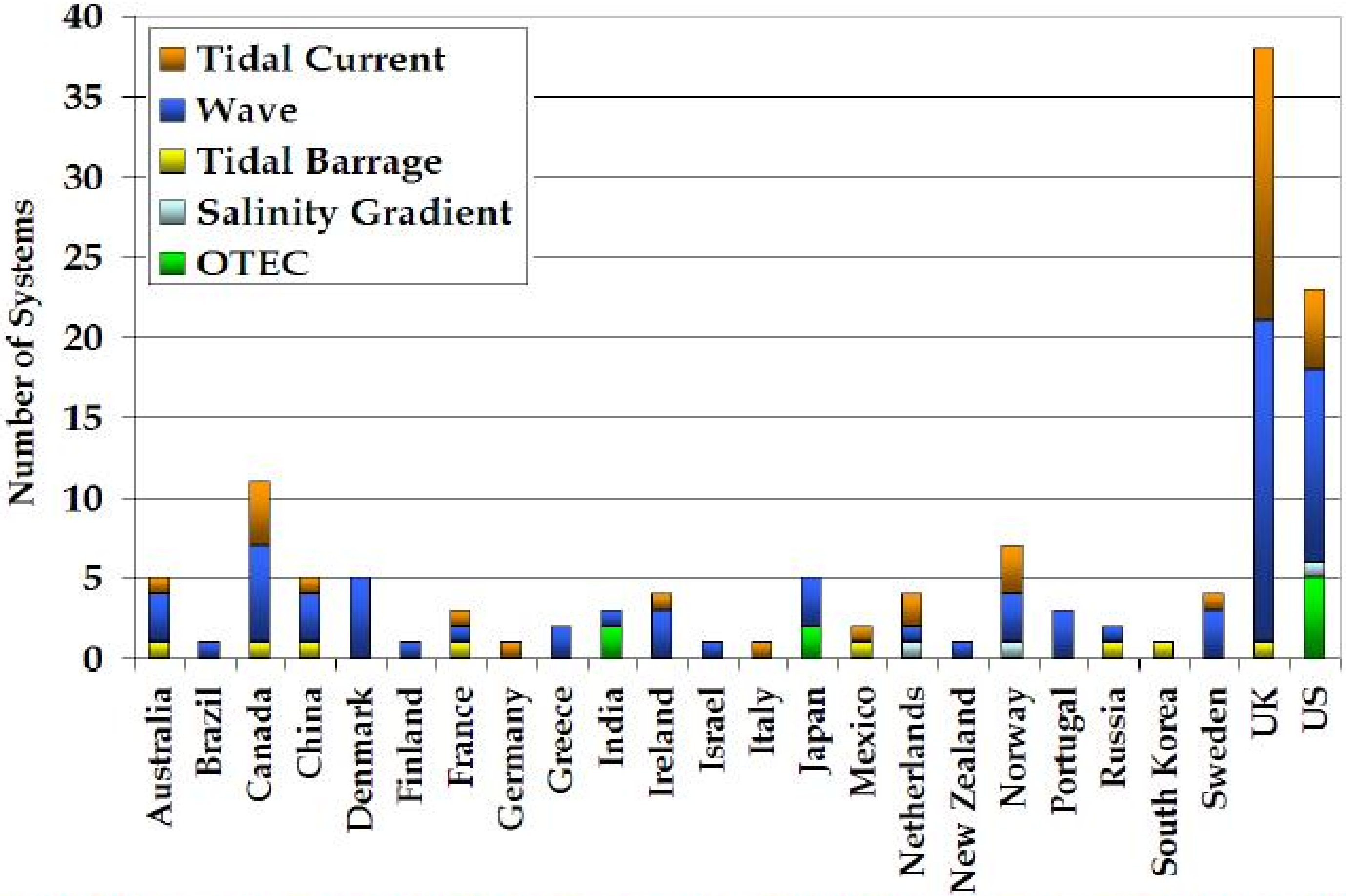


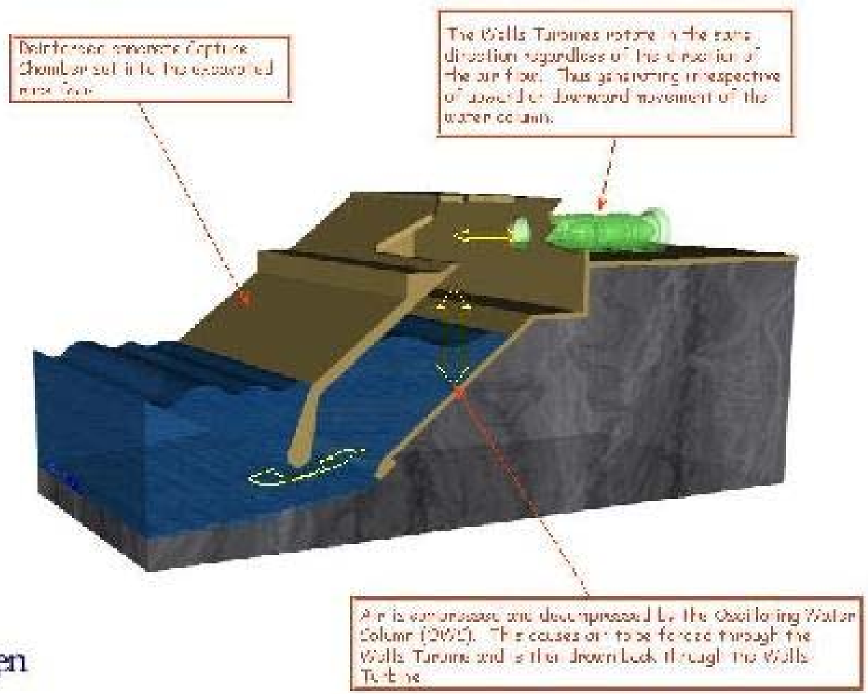
Figure 5: Ocean energy-related research, demonstration and commercial activities, as of December 2007

Wave Energy OWC

<u>Technology evolution</u>

Installations of first generation, on shore, use the strenght of deferlating waves, with the principle of oscillating water column (OWC)

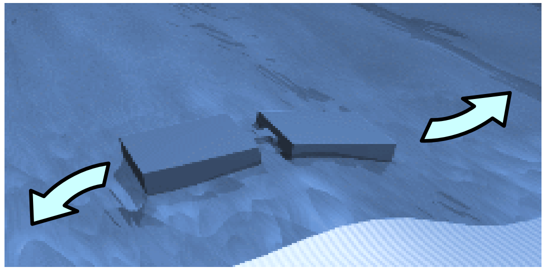
Limpet, Islay,
Ecosse
500 kW



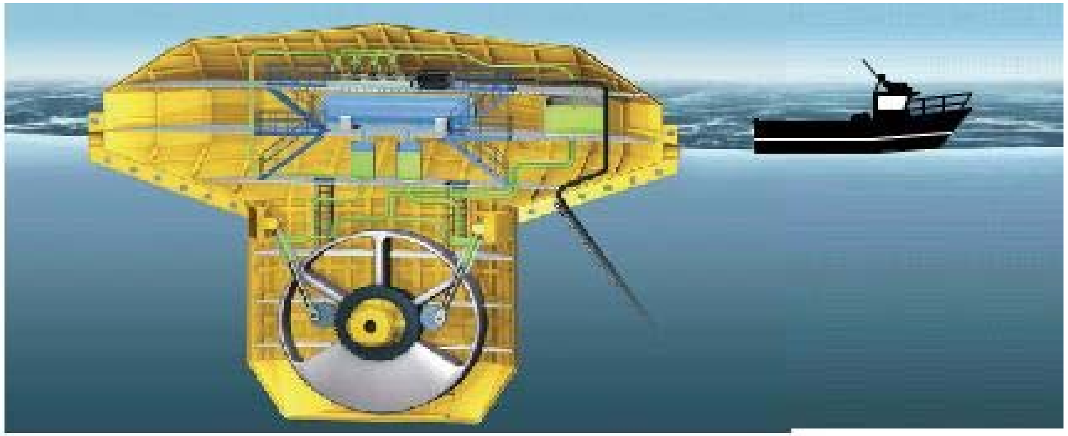
Wave energy converter (WEC)

<u>Technology evolution</u>

Installations of second generation, offshore



The floats



Searev

25 m long, 15 m deep on average

1000 tonnes

500 kW

Survivability at sea

Wave Energy

Technology evolution

Installations of second generation, offshore

Pelamis

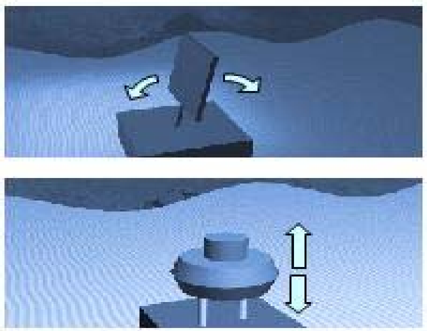
Articulated tube 140 m long, 3,5 m Ø, 350 tons weight, 750 kW

A wave farm of three Pelamis installed at the Agucadora Wave Park in Portugal in 2008

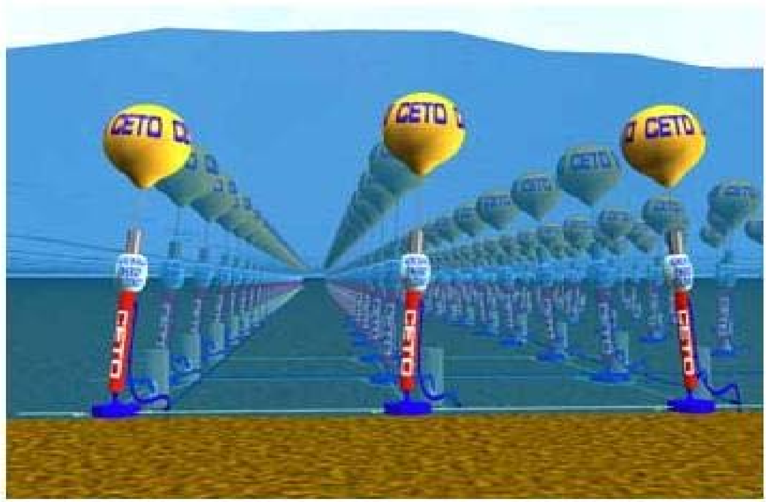
Wave energy converter (WEC)

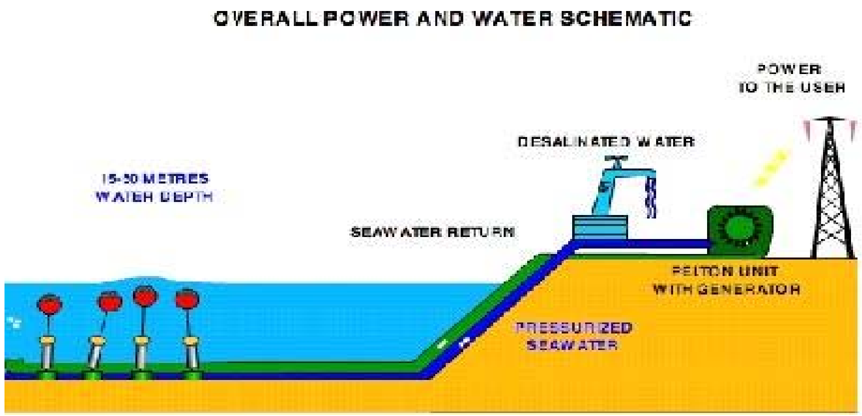
<u>Technology evolution</u>

Installations of second generation, in open sea

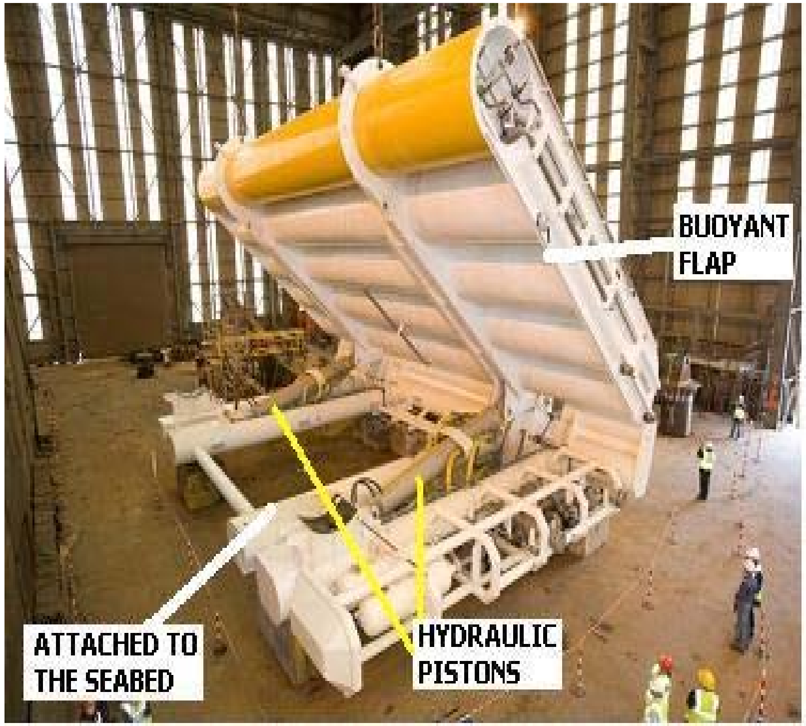


Immerged devices





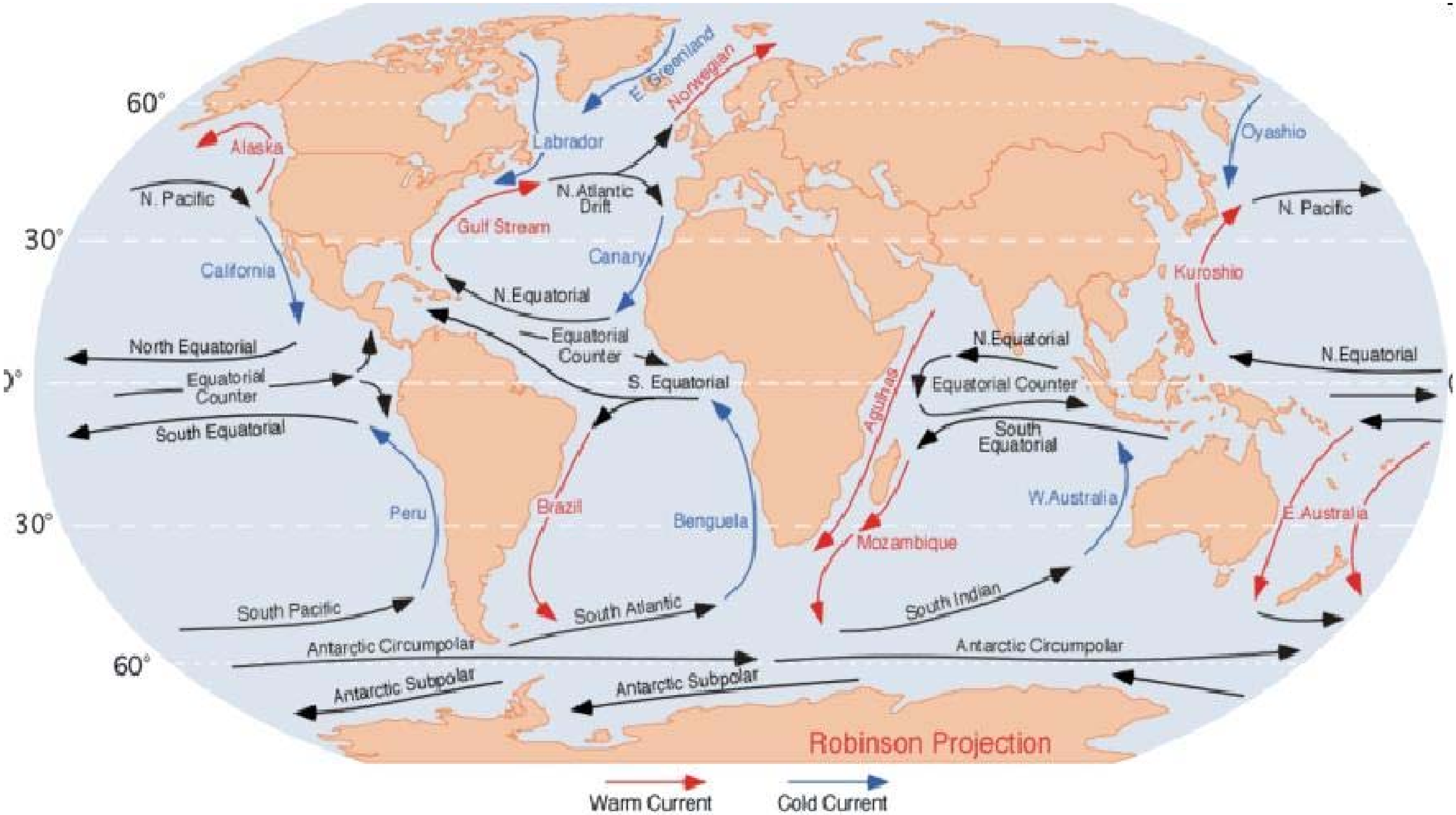
Wave energy the Oyster device



Some practical lessons learned in wave energy

- **Increase demonstration at sea**
- **(only real sea operation will allow to identify the best solutions – reliability and costs**
- **Test Centers**
- **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)**

Tidal and ocean currents

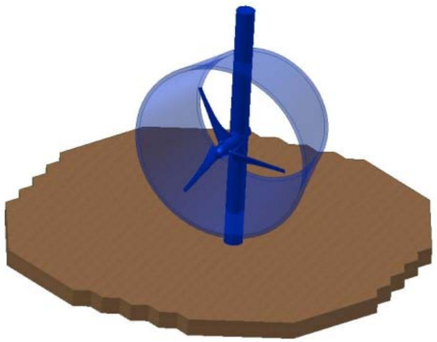


Ocean current power technology

Over the last fifty years there have been numerous inventions suggested for extraction of the large ocean currents. (like the Gulf Stream…)

Since the ocean currents are slow (1-2m/s) and the inherent energy is cubed to the velocity much can be won by increasing the actual flow over the turbine during power extraction, by different designs, where the most common has been to construct a ducted shroud over the turbine.

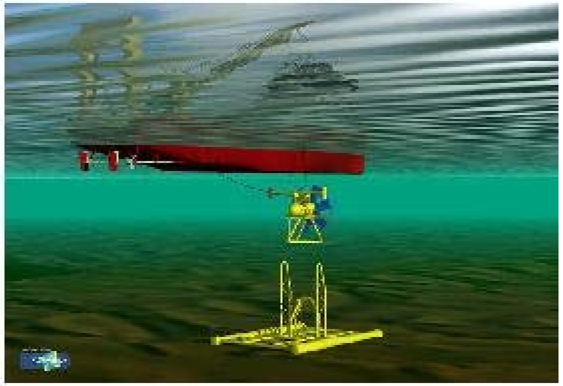
With a duct the water flow is dragged through the turbine by the experienced pressure gradient that develops from the shape of the duct and the increase in velocity becomes reflected in the conversion efficiency of the device



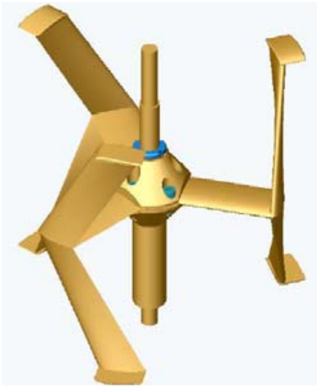
Tidal stream power

-Sabella

www.sabella.fr



-Harvest



www.grenoble-inp.fr/recherche/

adapté à l'environnement fluvial

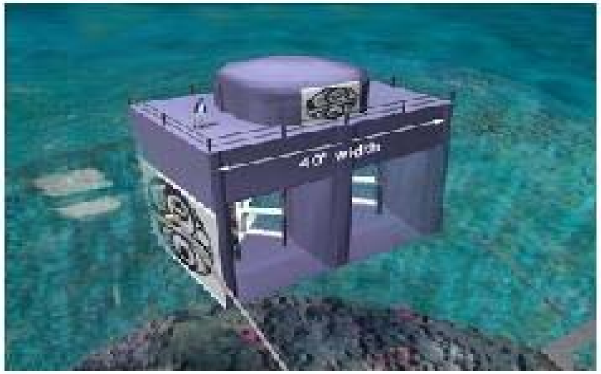
Tidal Current

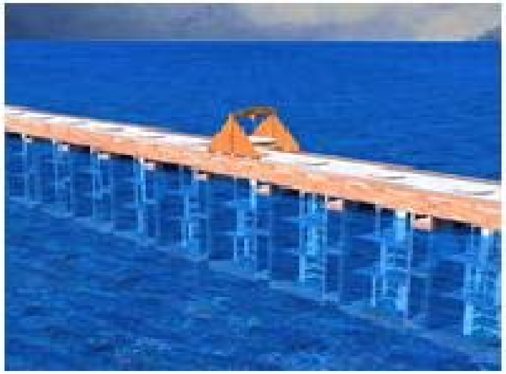
In open sea, between coast and island, or in estuary

Some Technologies « hydroliennes » :

Hydro-Gen www.hydro-gen.fr

Blue Energy www.bluenergy.com



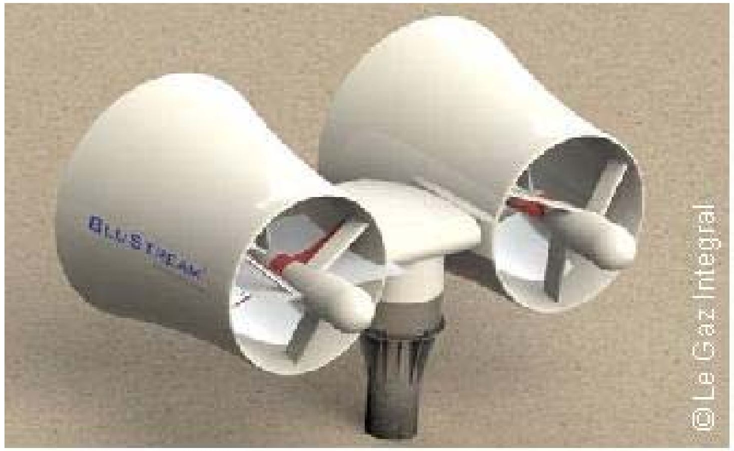


Tidal stream power

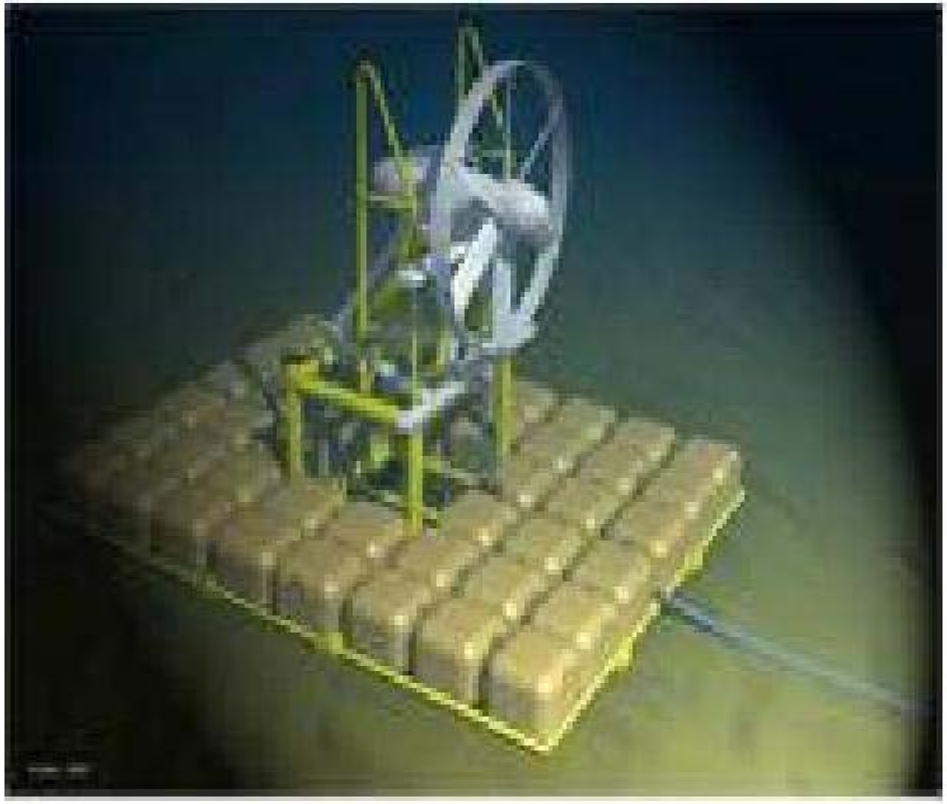
In open sea, between coast and island, or in estuaries

Tidal and ocean energy converters :

-BluStream www.gazintegral.com



Tidal current



ocean energy converters Sabella

ocean energy converters Open-Hydro (EDF Bréhat Paimpol)

Tidal stream in an attoll pass
The Atoll of Hao in the Tuamotu

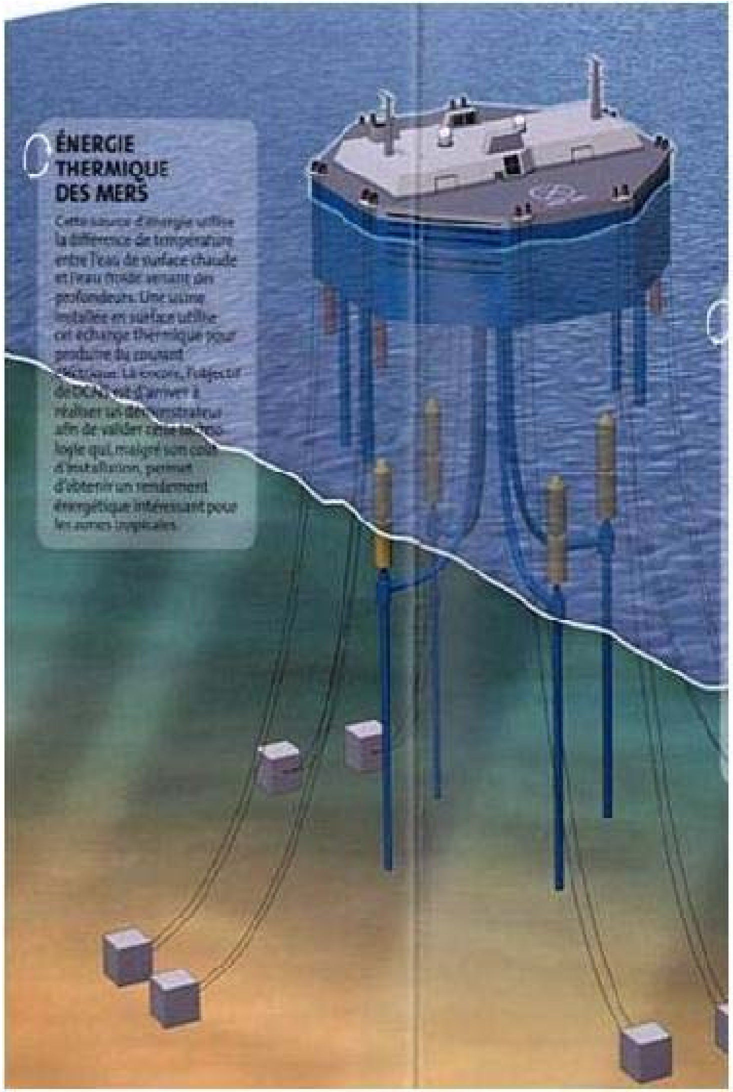
The lagoon of Hao is one of the biggest in Polynesia, Open on the Ocean by a unique pass (the Kaki pass at North extremity), where the tidal current may reach 20 knots

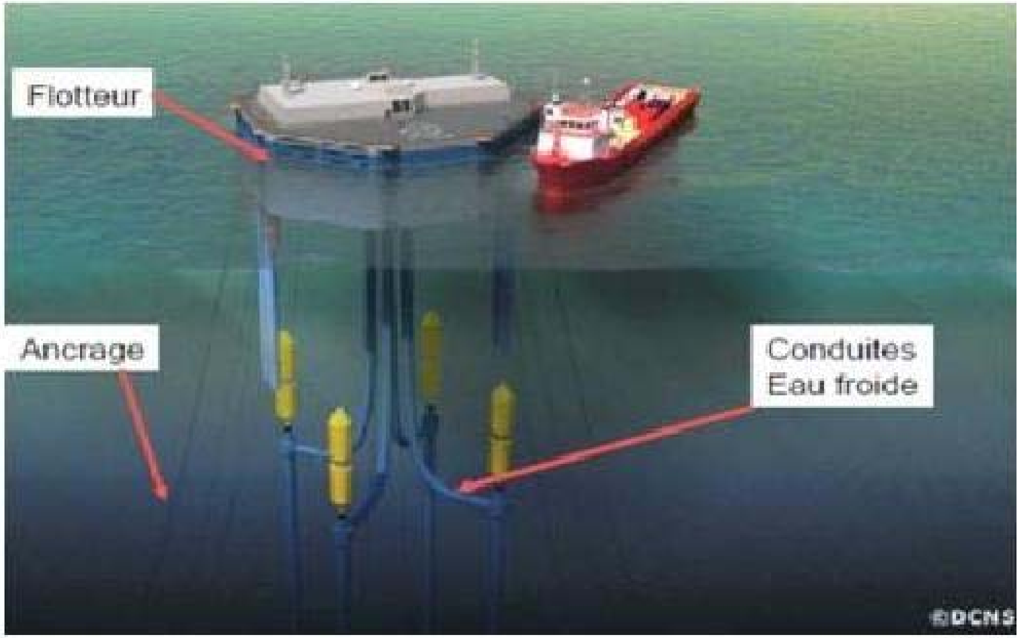
What is OTEC?
Ocean thermal Energy Conversion

OTEC Ocean Thermal Energy Conversion) uses temperature differences in the water., between warm water As the sun heats the surface of the sea and the global ocean circulation drive deep sea currents with cold dense water from the Polar Regions a substantial vertical temperature gradient is built up in low latitude oceans.

While the surface water is heated to about 25-30° C in the tropics the deep water around 1000 m depth keeps a low temperature around 4-7° C. By heat exchange technology this temperature difference (ΔT) can be utilized to drive electricity generating turbines; Power can be generated on base load, 24h, 7 days.

OTEC Ocean thermal Energy Conversion



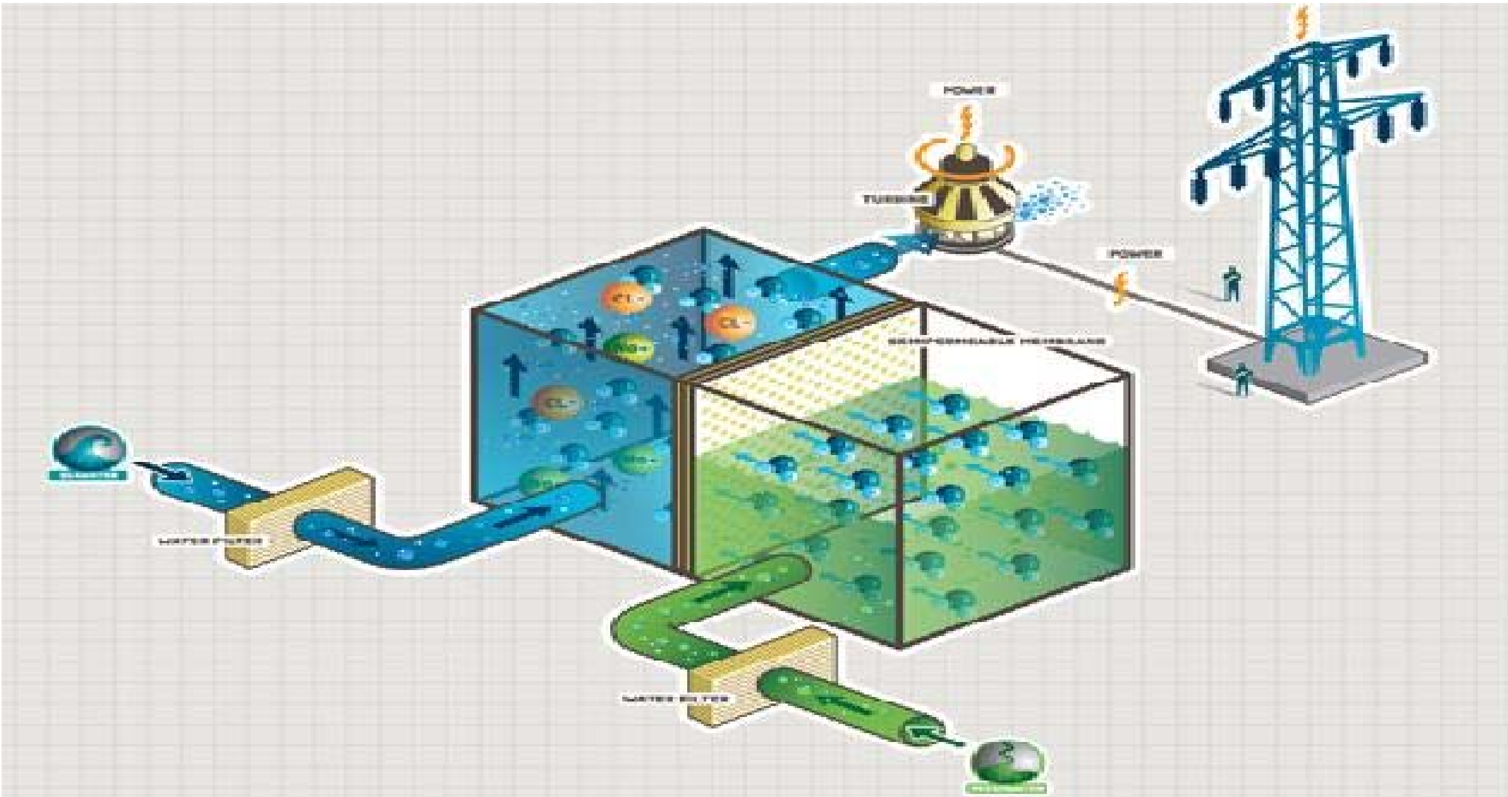


A difficulty : the cold water pipe

Osmotic Energy

Osmotic power or **salinity gradient power** is the energy available from the difference in the salt concentration between seawater and riverwater. The process rely on osmosis with ion specific membranes as the result of natural forces that are being harnessed: the flow of fresh water into seas that are made up of salt water.

A pilot concept in Norvege, an idea in Reunion Island



Public Policies and barriers

- Simplification of licensing procedures for projects and entrepreneurs
- Access to the electrical grid
- Access to field data
- Promote internal market : •Feed-in tariffs ,
- Define internal market (% of energy mix)
- In spite of the very high expectations on wave energy, present costs are high and no operational experience is still available.
- A large number of barriers can be identified, most of which may be removed or significantly reduced with proper public policies

The cost of Renewable energies

- Cost now, cost to –morrow ?
- Financing ? Who pays, for what ?
- Feed-in Tariffs ?
- Or targeted grants ?
- For R&D, technologies and Projects
- Industrial Policy,
- Manufacturing.

Stakes for development of MRE
Building an Industry
Financing and Incentive

- R&D grants   They form the most important ingredient in stimulating the R&D industry.

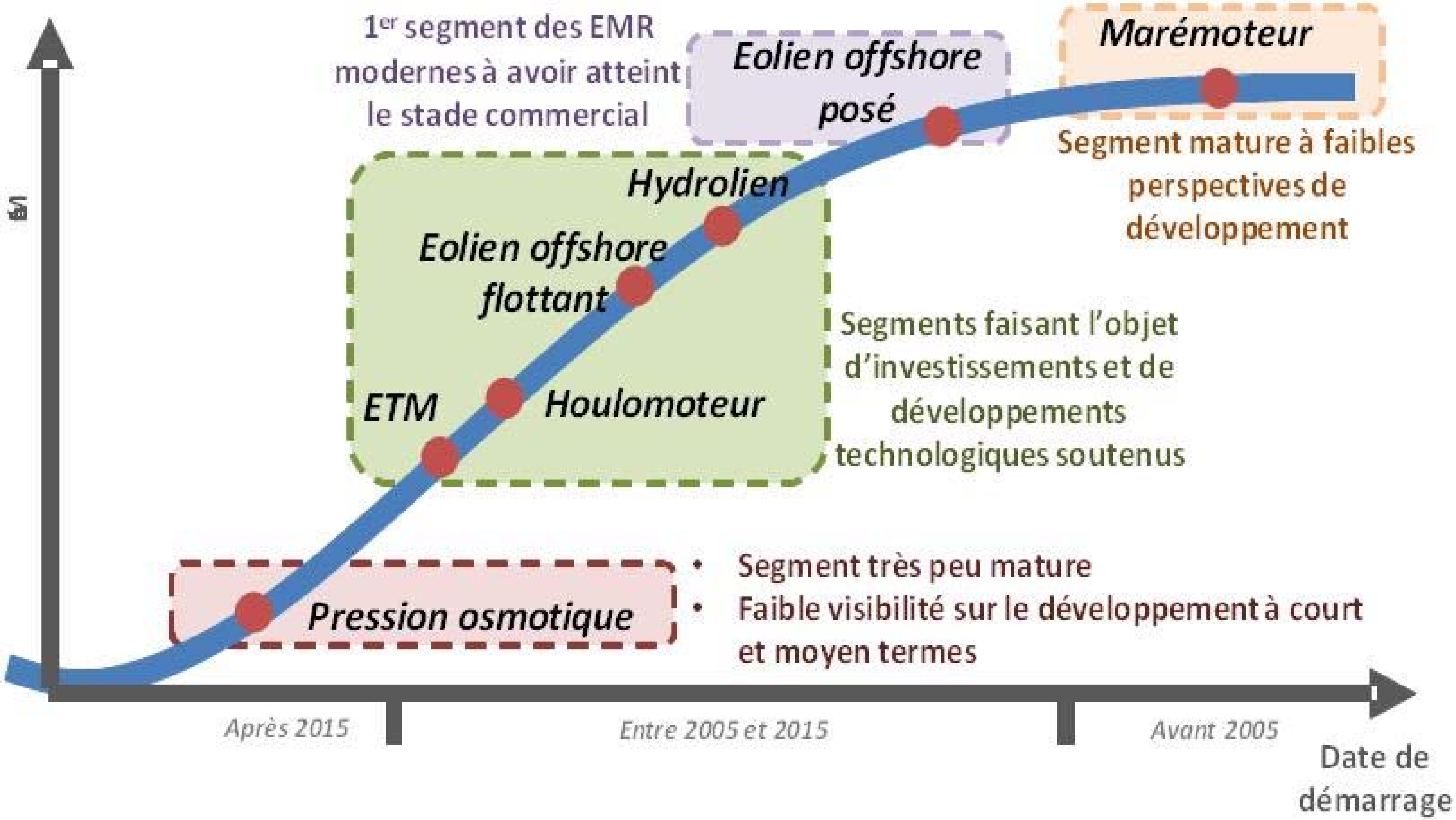
- Test sites   are an important infrastructure where precommercial designs can be validated. Test sites are usually government funded facilities

- Revenue support In order for targets to be met, and to attract developers, revenue support schemes have been developed and implemented in many European countries. The most popular schemes now fall into two categories :

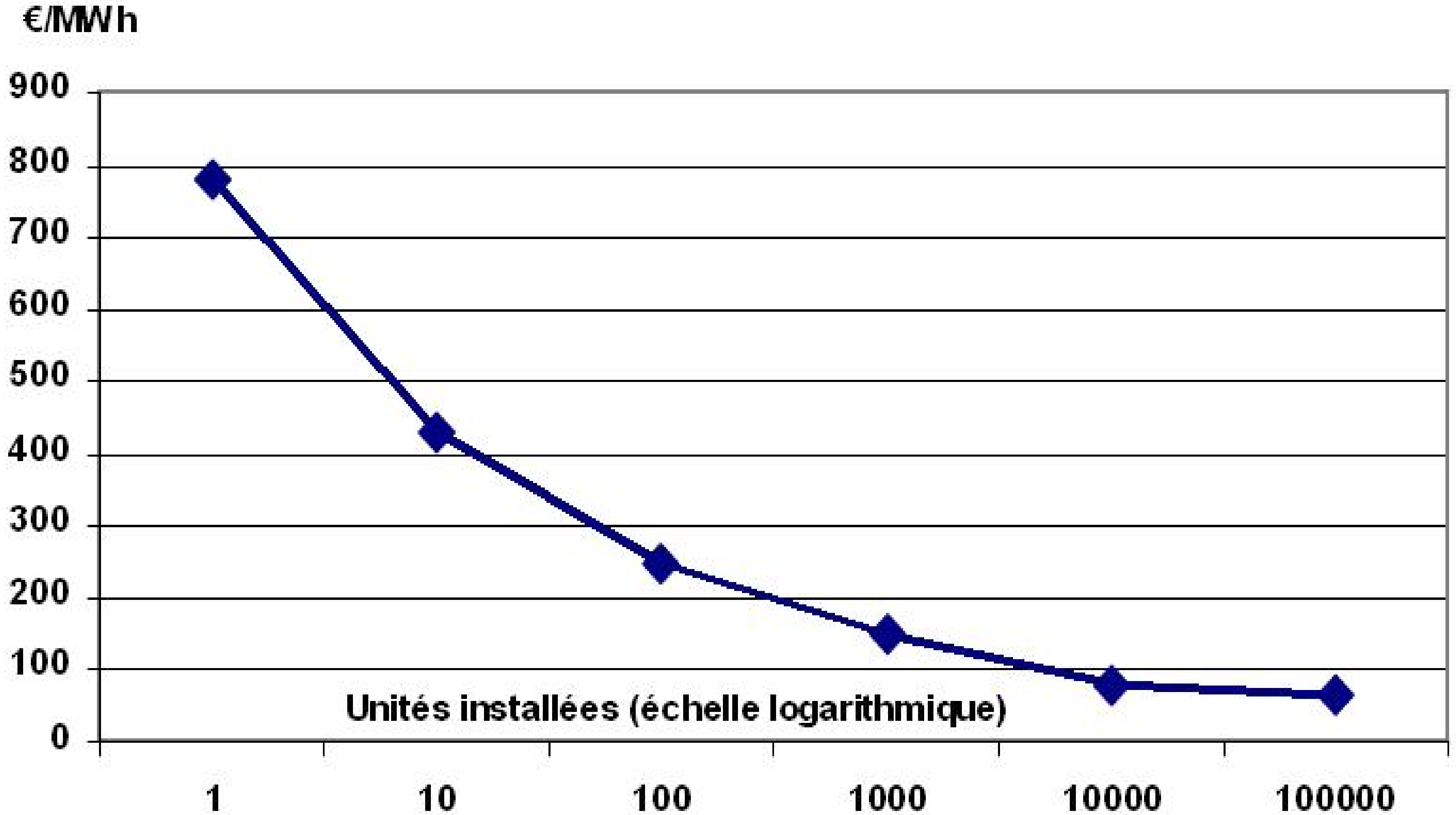
- · Feed-in tariffs (FIT)

- · Renewable energy certificates (ROCs)

Industrial Challenge of Marine Energy
Level of Maturity



Industrial Challenge of Marine Energies
Reduced Cost by Economy of scale



Building an industry ?
Some costs and competitiveness

	IInvestment(M€/MW)	Operating Costs (€/MWh)
Offshore windmills	2010 : 3 to 3,5	2010 : 150 to 170 2025 : < 100
Floating Windmills	2015 : 4	2015 : 180 to 200 2020 : 150 2030 : < 100
Current energy	2015 : 4 à 5 2020 : 3,5	2015 : 200 à 250 2020 : 150
Wave energy	2015 : 4 à 5 2020 : 3,5 2030 : 2,5	2015 : 200 to250 2020 : 150 2030 < 100
OTC	2015 : 20 2025 : 10	2015 : 400 2025 : 250

Operating cost s=

- 8 to10% of investment
  - manufacturing
  - implementation
  - connection to grid
  - dismantling
- 5 à 8 % de l'investissement
  - opération (navires…)
  - maintenance (spare parts…)
  - insurance (2%)
- load ratio
  - from 30% (wind)
  - to 90% (OTC)
- span life 20 years

Financing and Incentives for MRE

- What are the available mechanisms?
- Which support instruments for renewable electricity are currently being implemented (in the individual Member States of the EU)?
- 1. Investment Based Mechanisms (subsidies, credits, loans)
- 2. Quota systems (Tradable Green Certificates, tendering)
- 3. Fixed price systems (Feed-in Tariff)

Non technical Barriers for MRE

- Grid connection   There are two major barriers faced with Grid connection: · Grid connection charges, · Grid capacity

- Regulatory barriers – Manufacturing

- A successful manufacturing industry requires healthy national R&D as well as a local development industry which will provide a guaranteed home market for its product

- Logistical barriers – Development Service ports and O/M personnel   Easy access to service ports and availability of skilled service personnel with appropriate equipment are essential ingredients for a development and deployment industry in MRE

- Financial barriers – R&D, manufacture and development Cost evaluation of a project is often left to the last stage of a project valuation, and the most important factor is the cost of materials and reliability

- Other barriers – conflict of use and environmental impact

Feed-in tariff (FIT)

- A policy mechanism designed to accelerate investment in renewable energy technologies. It achieves this by offering long-term contracts to renewable energy producers, typically based on the cost of generation of each technology. Technologies such as wind power, for instance, are awarded a lower per-kWh price, while technologies such as solar PV and tidal power are offered a higher price, reflecting higher costs.

- FITs typically include three key provisions : guaranteed grid access, long-term contracts for the electricity produced, purchase prices based on the cost of generation

Feed-In Tariffs

- Ex : PORTUGAL Feed-In Tariff for Marine Renewables at 0,33 Euro/kwH
- In USA, National Energy Act, (NEA), including the Public Utility Regulatory Policies Act (PURPA) to encourage energy conservation and the development of new energy resources, including renewables.
- Tariffs different for Peak - Baseload – Intermittent