seabreath®
wave energy

WAVE ENERGY OVERVIEW

"Think of the motion of the waves, the ebb and flow of the tides and the coming and going of the waves. What is the ocean? An enormous lost strength. How stupid the earth, not to make use of the ocean!"
(Victor Hugo - Novantatré, (1874), VII, 5)

Benefits of wave energy

1. High Energy Potential:

The amount of power that comes from wave energy is enormous. " *The total wave energy potential is estimated to be 32,000 TWh/yr (115 EJ/yr). This is roughly* **twice** *the global electricity supply in 2008 (16,000 TWh/yr or 54 EJ/yr)."* (Mørk et al.,2010)

Wave energy contains roughly 1000 times the kinetic energy of wind. Hence, it allows smaller and less conspicuous devices to produce power. Also, water being 850 times as dense as air results in much higher power produced from waves averaged over time.

2. Highly Predictable:

"Waves arrive day and night, 24 hours a day, and have more inertia than solar/wind conditions, with less potential for sudden changes in the resource potential" (IEA-OES, 2014)

Sea wave energy has the highest concentration of renewable energy. Sea waves are the result of the concentration of energy from various natural sources like sun, wind, tides, ocean currents, moon, and earth rotation.

Unlike wind and solar; power from sea waves continues to be produced round the clock whereas Wind velocity tends to die in the morning and at night and Solar power depends on sun exposure; cloud coverage and nighttime hours reduce this exposure and efficiency. Of course, these other forms of renewable energy are still better than fossil fuels.

3. Where Wave Energy Is Needed Most:

"Worldwide there are 1.3 billion people living without electricity." (International Energy Agency., 2014)

Two-thirds of the world's population – 4 billion people – live within 400 kilometers of a seacoast. Just over half the world's population – around 3.2 billion people – occupy a coastal strip 200 kilometers wide (120 miles), representing only 10 percent of the earth's land surface. With this population distribution, increasing human numbers and mounting development, the need for sea wave energy for these coastal regions becomes evidently undeniable. (EWP, 2015)

4. Wave Energy Reduces Environmental Impacts & Climate Change:

Ocean energy offers the potential for long-term carbon emissions reduction and the environmental risks from ocean energy are relatively low.

"Ocean energy has the potential to deliver long-term carbon emissions reductions and has low environmental impacts. Ocean energy technologies do not generate Greenhouse Gases (GHGs) in operation and have low lifecycle emissions, providing the potential to significantly contribute to emissions reductions. Utility-scale deployments with transmission grid connections can be used to displace carbon-emitting energy supplies." (Ocean Energy, 2011)

5. Green Jobs:

Remote communities and declining industries, such as, the shipbuilding industry are in despair when it comes to jobs and economic sustainability. The wave energy industry has the ability to create hundreds of thousands of 'green jobs'.

"In addition to electricity generation with low lifecycle GHG emissions, the possible benefits of wave energy include industry stimulation for local shipyards (device construction and/or assembly), transportation, installation and maintenance."(Ocean Energy, 2011) In addition, *"exclusion areas for wave farms may create wildlife refuges, which may be a net benefit to fishery resources"* (House of Commons, 2001)

The Organization for Economic Cooperation and Development (OECD) said, *" Growth potential for environmental employment is high."*

6. Helping To Decarbonize The Global Electric Power Supply:

Decarbonizing the electricity grid simply means reducing the carbon emissions produced as a result of using fossil fuels and other man-made contaminants that lead to greenhouse gas emissions and global warming.

"The traditional electric sector emits the most GHGs, responsible for 41 percent of the world Co2 emissions." "…The electric sector is not only the largest source of global GHG emissions, but trends indicate that electricity consumption will grow."(IEA-OES, 2011)

Wave Energy produces clean, zero-emissions electricity. It is not only a sustainable solution for the future, but a cost-effective one too.

7. Export Potential:

There is high exporting potential for wave energy. By adopting Wave Energy Converters (WEC) it is possible to exploit the abundant wave energy resource for electrical power generation production and export the electricity to surrounding areas and markets nearby benefiting economic growth locally.

8. Low Energy Price Volatility:

Wave Energy gives you the security of energy supply in volatile fossil fuel pricing. With the rising and falling uncertainty of fossil fuel prices, wave energy is a great alternative.

Overview of the wave energy industry

Wave energy is the transport of energy by ocean surface waves, and the capture of that energy to do useful work – for example, electricity generation, water desalination, or the pumping of water (into reservoirs). Machinery able to exploit wave power is generally known as a wave energy converter (WEC).

The first known patent to use energy from ocean waves dates back to 1799 and was filed in Paris by Girard and his son. An early application of wave power was a device constructed around 1910 by Bochaux-Praceique to light and power his house at Royan, near Bordeaux in France. It appears that this was the first oscillating water-column type of wave-energy device. From 1855 to 1973 there were already 340 patents filed in the UK alone Modern scientific pursuit of wave energy was pioneered by Yoshio Masuda's experiments in the 1940s.

A renewed interest in wave energy was motivated by the oil crisis in 1973. A number of university researchers re-examined the potential to generate energy from ocean waves, among whom notably were Stephen Salter from the University of Edinburgh, KjellBudal and Johannes Falnes from Norwegian Institute of Technology (now merged into Norwegian University of Science and Technology), Michael E. McCormick from U.S. Naval Academy, David Evans from Bristol University, Michael French from University of Lancaster, Nick Newman and C. C. Mei from MIT.

In the 1980s, as the oil price went down, wave-energy funding was drastically reduced. Nevertheless, a few first-generation prototypes were tested at sea. More recently, following the issue of climate change, there is again a growing interest worldwide for renewable energy, including wave energy.

The market for the production of energy from renewable sources is definitely the economic sector of maximum expansion and not expected to slow down but instead will cover the market given the decreasing availability of non-renewable sources.

The production of energy from wave motion is in fact already a reality with devices still inefficient, but that in some cases closer to the cost of wind energy production.

Potential Resources

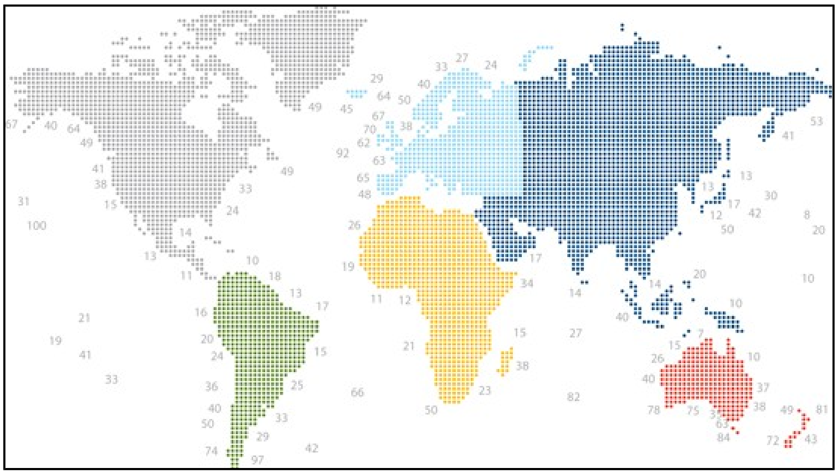
Given the growing demand for energy from emerging countries and the increasing cost of fossil fuels, unit to the need to limit emissions of CO_2 and the emission of pollutants into the environment, the future of production energy can only be given to the use of renewable energy sources.

Renewables are by their nature "discontinuous", therefore it is desirable a mix of sources renewable for the future to create a smart grid.

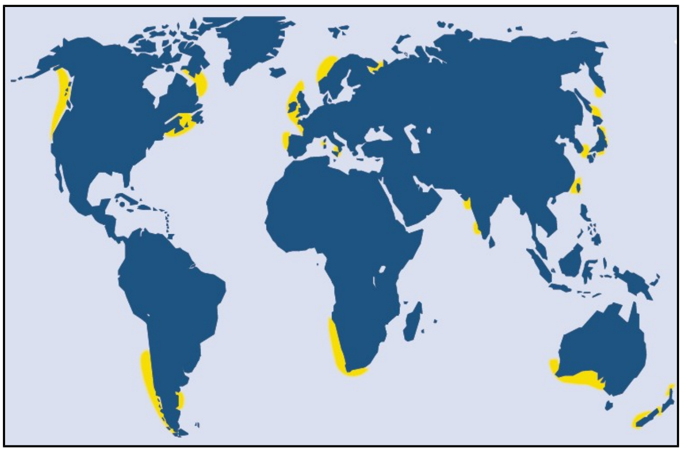
In addition to traditional energy sources it looms for the future the use of a source that until now it has been excluded: the exploitation of the enormous amount of energy contained in the oceans.

The waves are a form of renewable energy created by wind. The capture of wave energy has been shown to be technically feasible in different forms.

Annual average wave energy flux in kW per meter of wave front



Wave energy has significant global potential with the USA, North & South America, Western Europe, Korea, Japan, South Africa, Australia and New Zealand among some of the best wave energy sites around the world



Compared to other forms of renewable energy, such as solar photovoltaic (PV), wind or ocean currents, energy from wave motion is continuous but highly variable, even though the levels of wave at a given location can be confidently predicted a few days in advance and the PLF (Power Load Factor) linked to this source may be very high: 80-90%.

$$f_{Load} = \frac{\text{Average load}}{\text{Maximum load in given time period}}$$

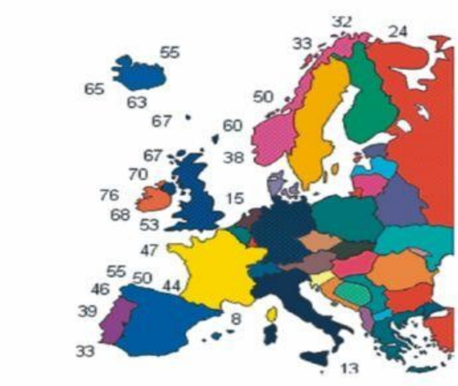
Because the wind is generated by an irregular solar heating, the energy of the waves can be considered a form of concentrated solar energy. The levels of solar radiation which are of the order of 100 W/m2 are transferred into waves with (...) of wave front. The transfer of solar energy to the waves is greater in areas with strong winds (especially between 30 ° and 60 ° of latitude), near the equator thanks to the persistent winds, and near the poles due to storms polar, and also, at the increase of distances the quantity of energy stored increase.

The waves are also effective "carriers" of solar energy. In deep water waves can travel thousands of miles and to hold on much of the energy. The wave energy[1] is dissipated after it reaches sea bottom that are less than ~ 200 m depth. At a depth of 20 m the wave energy is reduced generally to about one third of the initial energy. It has been estimated that the total annual energy available from waves off the coast of the United States (including Alaska and Hawaii), calculated at a water depth of 60 m, is 2,100 terawatt hours (U.S. Department of the Interior). This estimate was performed at a water depth of 60 m indicate (regardless of the distance from the coast in which this occurred depth) in order to allow comparison of 'energy from wave motion between the different coastal areas, and to eliminate the possible and unpredictable loss of energy of the wave given by its interaction with the seabed of smaller depth. The wave energy is available in the U.S.: in areas of open sea in the Atlantic 2-6 kW / m, 12 to 22 kW / m in

[1] The common measure of wave power, P, is as follows: P = ρg TH ² ² / 32π watts per meter (W / m), the length of ridge (distance along a ridge individual), where: ρ = density of 'seawater = 1025 kg/m3, g = acceleration due to gravity = 9.8 m / s / s, T = wave period (s), and H = wave height (m).

regions like Hawaii and 36-72 kW / m in the North West of the United States in coastal areas near Washington and Oregon.

European potential



EU Member States are increasingly interdependent for energy, as they are in many other areas –i.e. a power failure in one country has immediate effects in others. A radical change is clearly required in the way energy is produced, distributed and consumed. This means transforming Europe into a highly efficient, sustainable energy economy. Europe's dependence on imported energy has risen from 20% at the signing of the Treaty of Rome in 1957 to its present level of 50%, and the EC forecasts that imports will reach 70% by 2030. If energy trends and policies remain as they are, the EU's reliance on imports will continue.

Ocean energy generation has the potential to rise to 3.6 GW of installed capacity by 2020 and close to 188 GW by 2050, a significant proportion of this to come from wave energy. It is projected that wave energy could have 529 MW installed by 2020 and nearly 100 GW by 2050. This represents 1.4 TWh/ year by 2020 and over 260 TWh/year by 2050, amounting to 0.05% and 6% of the projected EU-27 electricity demand by 2020 and 2050 respectively.

Seabreath can be the industry leader with the largest market share. Because today is unique patented device does not need a wave climate particularly energy load and is suitable for almost the totality of the types of coasts with a minimum activity of wave motion with minimal cost and high efficiency.

Policy Landscape

The number of policies in place to support investments in renewable energy continued to increase in 2011 and early 2012. Governments continued to revise policy design and implementation in response to advances in technologies, decreasing costs and prices, and changing priorities. Policymakers are increasingly aware of renewable energy's wide range of benefits—including energy security, reduced import dependency, reduction of GHG emissions, prevention of biodiversity loss, improved health, job creation, rural development, and energy access—leading to closer integration in some countries of renewable energy with policies in other economic sectors.

Targets for Renewable Energy

Targets for renewable energy in 2011 existed in at least 118 countries, more than half of which are developing ones.

Targets for renewable energy include indicators like following: renewable energy shares in primary or final energy supply, in heat supply; installed electric capacities of specific technologies, and others.

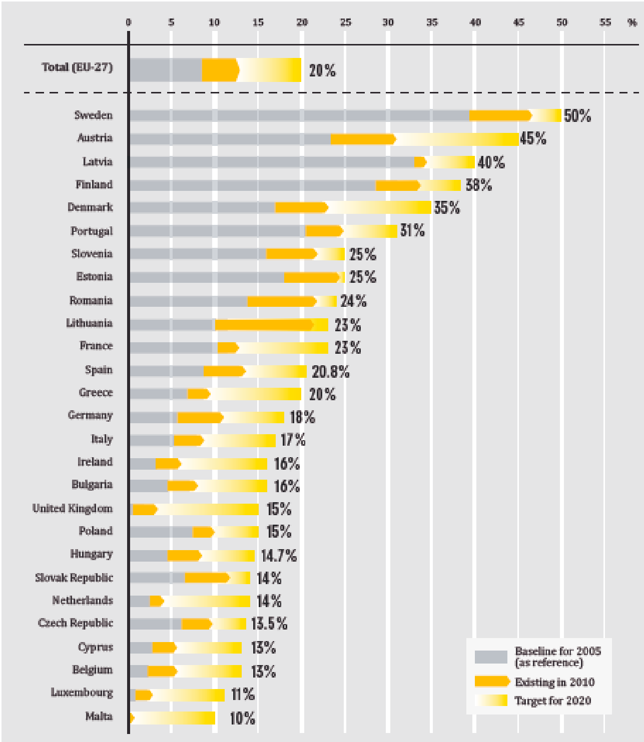
Figure 2 represents 27 EU countries renewable sources shares in final energy, for 2005, 2010, and objects for 2020. 13 of them has set 20% or even more ambitious targets.

Some of the countries (world) adopted particular targets for electric capacities of Ocean energy technologies.

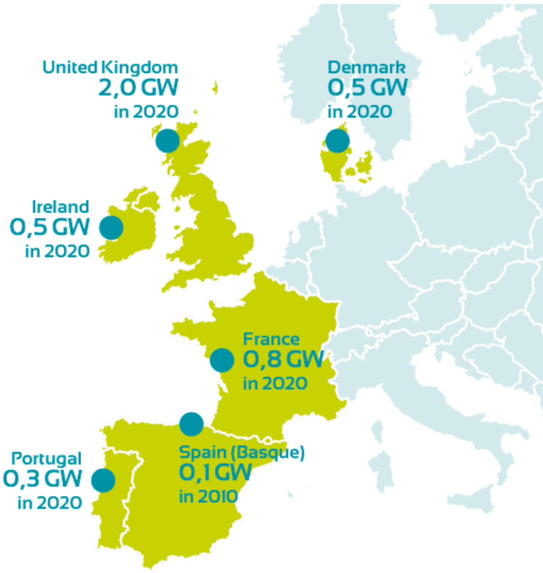
Renewable energy targets – Ocean energy

Country	Capacity target
South Korea	6,159 GWh by 2030
UK	2 GW by 2020
France	800 MW by 2020
Ireland	500 MW by 2020
Denmark	500 MW by 2020
Portugal	300 MW by 2020
Spain	100 MW by 2020
Philippines	70.5 MW by 2030

EU Renewable shares of final energy, 2005, 2010, and targets for 2020. % [2]



Current and future targets for ocean energy in European countries (EU-OEA, 2010)



[2] http://www.ren21.net/Portals/0/documents/Resources/%20GSR_2012%20highres.pdf

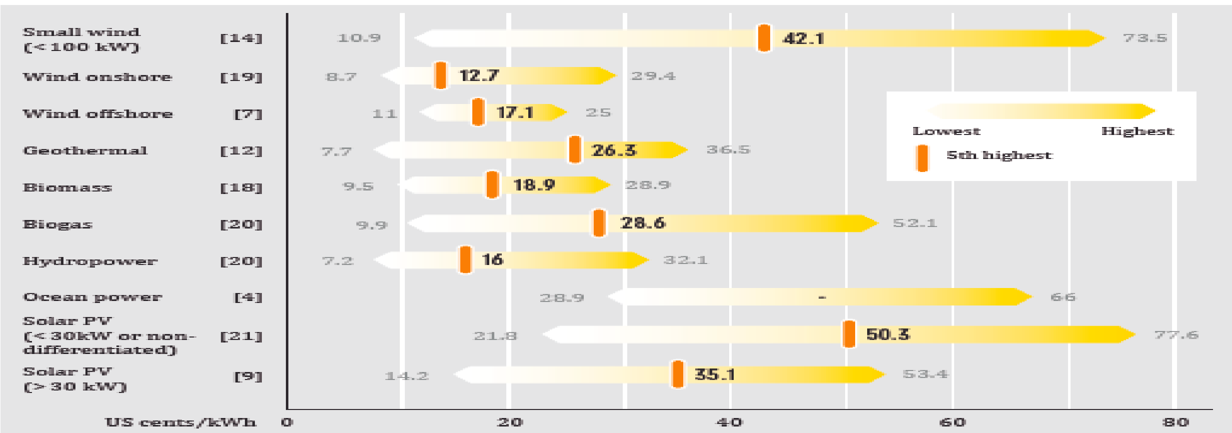
With the adoption of the most recent Renewable Energy Directive (2009/28/EC), the EU has committed to reducing its greenhouse gas emissions by 20% by 2020. A reliable mix of electrical power generation will have to be established to meet these objectives. Wave energy is a renewable source of energy and as such it does not emit carbon dioxide or other particles.
As a result, wave energy is suitable for replacing energy generation from fossil fuels. It has been estimated that 300 kg of CO2 could be avoided for each MWh generated by ocean energy. Therefore, for 20 GW (49 TWh/year) of installed wave energy, the CO2 emissions avoided could be as much as 14.5 Mt/year.

Power generation policies

At least 109 countries by early 2012 had some type of renewable support policy to promote renewable power generation. More than half of these countries are emerging economies.
All these policies can be divided into three categories: Regulatory policies, Fiscal incentives, and Public financing. The most common policies/incentives are the following:

- Feed-in-tariffs (FIT): is a policy mechanism designed to accelerate investment in RE technologies. It achieves this by offering long-term (15-25 years) contracts to renewable energy producers based on the cost of generation of each technology. There are many variations in FIT design. Levels of support provided under FITs vary widely and are affected by technology cost, resource availability, and installation size and type:

FIT payments in selected countries, 2011-2012



- Electric utility quota obligation/renewable portfolio
- standard (RPS): a mechanism that places an obligation on electricity supply companies to produce a specified fraction of their electricity from renewable energy sources.
- Capital subsidy, grant and rebate
- Investment and production tax credits
- Reductions in sales taxes, energy taxes, CO2 taxes, VAT and other taxes
- Energy production payment
- Public investment, loans and grants
- Public competitive bidding

Renewable Energy support policies

Number of incentives		
2-3	4-5	6-8
Australia	Belgium	Canada
Cyprus	Estonia	Denmark
Ireland	Finland	France
Japan	Germany	Italy
Malta	Greece	Netherlands
Norway	Israel	Portugal
	Malaysia	United Kingdom
	South Korea	United States
	Spain	
	Sweden	
	United Arab Emirates	

Analysis Renewable Energy support policies

	Feed-in-tariffs (FIT)	Electric utility quota obligation/ renewable portfolio standard (RPS)	Capital subsidy, grant and rebate	Investment and production tax credits	Reductions in taxes	Energy production payment	Public investment, loans and grants	Public competitive bidding
Australia	■		■				■	
Belgium			■	■	■			■
Canada	■		■	■	■		■	■
Cyprus	■						■	
Denmark	■		■	■	■		■	■
Estonia	■		■		■	■		
Finland	■		■		■	■		
France	■		■	■	■		■	■
Germany	■		■	■	■		■	
Greece	■		■	■	■		■	
Ireland	■							■
Israel	■				■		■	■
Italy	■	■	■	■	■		■	■
Japan	■		■				■	
Malaysia	■	■			■		■	■
Malta	■		■		■			
Netherlands	■		■	■	■	■	■	
Norway			■		■		■	
Portugal	■		■	■	■		■	■
South Korea		■	■	■	■		■	
Spain	■		■	■	■		■	
Sweden		■	■	■	■		■	
United Arab Emirates		■				■	■	■
United Kingdom	■	■	■		■	■	■	
United States	■	■	■	■	■	■	■	■

Analyzing ocean energy targets and renewable energy policies and incentives in various countries the most attractive countries for development and implementation of marine technologies are: in EUROPE: Italy, France, Spain, Portugal, Denmark, UK and Ireland; ASIA: South Korea and all isles; AMERICA: US and Canada.

Adaptability and cost-efficient and high demand of Renewable Energy Resources in developing countries: East African Coast, (South Africa, South America Colombia, Chile, Argentina and Brazil) and Caribbean Islands (Haiti, Dominican Republic, Cuba and Jamaica).

The Technologies Already Used

Currently, only few plants use the energy of the sea in commercial installations, are much more numerous experimental facilities and prototypes, which are showing in many cases full economic feasibility and leave great hope for the future of these technologies.

Recently begin to emerge environmental impact problems given by both wind and photovoltaic plants. Notwithstanding that small plants spread of these sources do not subtract land and have little impact or almost zero, the problem arises for large industrial plants, as well as landscape problems begin to arise also problems of disposal of old systems, especially solar. These two areas are in decline.

Take in consideration the possibility of producing energy from cold fusion even if they are from a few decades that follow each other announcements and denials and is yet to be verified the possibility of having production levels that are economically convenient.
The other sources of energy from the oceans[3] according with the U.S Department of Energy are:

- **Ocean currents.** global resource potential estimated at below 1,000 TWh/yr.
- **Salinity gradient** with global potential resources estimated around 2,000 TWh/yr.
- **Thermal conversion** with global potential resources estimated at around 10,000 TWh/yr.
- **Tidal** with global potential resources estimated at around 250 TWh/yr

These systems above have limits given by: small number of sites available for installations, greater environmental impact both landscape and wildlife, and lower efficiency.
The industrial production of energy from wave, with estimated global potential energy up to 80,000 TWh/y exploitable, does not present too many problems landscaped and does not require the use of toxic or polluting substances.

A variety of technologies are being studied for capturing energy from waves.
The various technologies are given by: terminators, attenuators, absorbers, and overtopping devices.

Terminators:
Devices such as "Terminator" are usually installed on the ground or near-shore, floating versions have been designed for off-shore applications. The oscillating water column (OWC) is a form of termination in which the water enters, from an opening located

[3] Source http://www1.eere.energy.gov/water/resource_assessment_characterization.html

below the surface, into a chamber in which air is contained. Wave action causes a movement of the level as a piston and pushes the air towards a turbine. A prototype full-scale 500-kW was designed and built by Energetech (2006) is being tested in the sea at Port Kembla in Australia, another project is under development in Rhode Island.

A project, which under construction has moved much closer to Seabreath, is the IVEC PTY LTD Australian, but has less efficiency because it does not provide by external valves of compensation.

Floating offshore project that uses the OWC is also the "Mighty Whale", under development at the Marine Science and Technology Center in Japan since 1987.

Attenuators

Attenuators are long multi-segment floating structures. The different heights of level along the length of the device causes a bending in the connecting segments which are connected to hydraulic pumps or other converters. Among the attenuators with more advanced development is worth mentioning the McCabe and Pelamis by Ocean Power Delivery, Ltd. (2006).
The pump wave McCabe has three pontoons linearly hinged together. The pontoon in the middle is connected to a submerged damper plate which causes a resistance than caissons placed on the bow and stern. Hydraulic pumps are applied between the center and frames and are activated by the movement of the same. The hydraulic fluid under pressure can be used to activate a generator or to pressurize the water for desalination. A prototype full-size of 40 m has been tested off the coast of Ireland in 1996, and the device is already in the process of commercialization.

A similar concept is used by the Pelamis (designed by Ocean Power Delivery Ltd. [2006]). The Pelamis has four cylindrical floating caissons are 30 m long and 3.5 m in diameter connected by three hinged joints. The decline of the hinge joints, caused by the movement of the waves, active hydraulic pumps located in the joints. A full-scale prototype in four segments of 750 kW has been tested sea for 1,000 hours in 2004. For this test was followed by a first order in 2005 and a commercial WEC by a consortium led by Portuguese electricity Enersis SA. Currently the project Pelamis is stopped due to problems of structural failure.

Absorbers

A device of this kind is the PowerBuoyTM developed by Ocean Power Technologies. The construction includes a floating structure with a relatively immobile component, and a second component in motion caused by the waves (a buoy floating within a fixed cylinder). The relative motion is used to drive energy converters electromechanical or hydraulic. A demonstrator prototype PowerBuoy of 40 kW was installed in 2005 for a sea trial opened in Atlantic City, New Jersey. In the Pacific Ocean have been made other tests in 2004 and 2005 off the coast of Oahu Hawaii basis.

The WEC AquaBuOYTM under development by the Group AquaEnergy, Ltd. (2005) is an absorber which exploits the vertical movement of the buoy as a piston contained in a long tube under the buoy. The movement of the piston puts pressure sea water. The AquaBuOY was tested on a scale prototypes, and a demonstration plant offshore of 1 MW has been realized in Makah Bay, Washington. The Makah Bay demonstration consists

of four units rated at 250 kW located 5.9 km (3.2 nautical miles) offshore in water about 46 m deep.
Other absorbers tested are the Archimedes Wave Swing (2006), which consists of a cylinder full of air which moves up and down to move the wave. This movement with respect to a second cylinder fixed to the seabed is used to drive an electric generator linear. A device with a capacity of 2 MW has been tested at sea in Portugal.

Overflow devices

The devices have overflow tanks which are filled by 'shock waves to levels above the surrounding media. The released water tank is used to drive turbines or other conversion devices.

The overflow devices have been designed and tested both for onshore and offshore floating. The devices include the offshore DragonTM Wave (Wave Dragon 2005), which provides that wave reflectors focus waves towards the center of the structure and therefore increase the effective height of the wave.

The device overflow WavePlaneTM (WavePlane Production 2006) has a smaller tank. The waves are channeled directly into a room that conveys the water to a turbine or a conversion device.

Other minor tens of devices are currently under study and experimentation. *However Seabreath has the highest level of technology known for the production of energy from wave motion.*

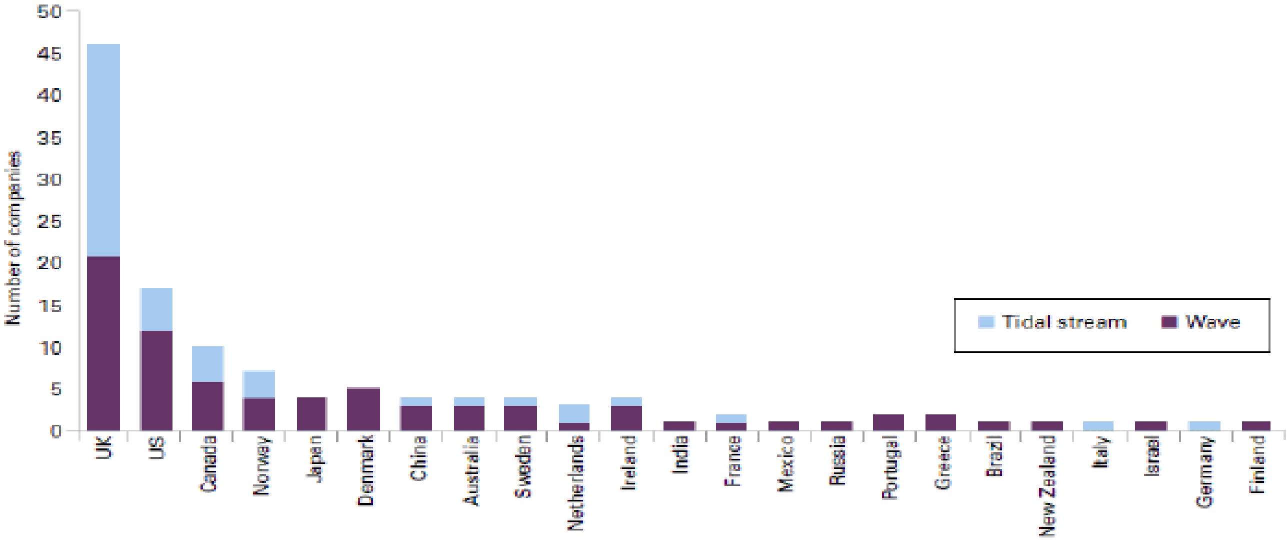
Types of ocean energy sources and technologies

OCEAN ENERGY SOURCES	DESCRIPTION	TECHNOLOGY TYPES
Ocean wave	Energy sourced from movements of water near the surface of the earth in an oscillatory or circular process	Attenuator, Collector, Overtopping, Oscillating Water Columns, Oscillating Wave Surge Converter (OWSC), Point Absorber, Submerged Pressure Differential, Terminator, Rotor.
Tidal current	Energy sourced by natural currents created by the movement of the tides.	Horizontal/Vertical-axis turbine, Oscillating Hydrofoil, Venturi.
Salinity Gradient	The application of salinity gradients to store solar energy or to exploit the entropy of mixing fresh and salt water.	Semi-permeable Osmotic Membrane.
Ocean Thermal Energy Conversion	OTEC draws energy from the thermal gradients that exist between the warm surface water and the cold deep water of the ocean.	Thermo-dynamic Ranking Cycle

Technologies Innovation

Unlike large wind turbines, there is a wide variety of wave energy technologies, resulting from the different ways in which energy can be absorbed from the waves, and also depending on the water depth and on the location (shoreline, near-shore, offshore). Recent reviews identified about one hundred projects at various stages of development.

The number does not seem to be decreasing: new concepts and technologies replace or outnumber those that are being abandoned. Several methods have been proposed to classify wave energy systems, according to location, to working principle and to size (“point absorbers” versus “large” systems). See Top Ocean technologies in Figure 11, according with the level of development.



Some links of ocean top technologies:

Fixed:[4] Isolated: Pico, In breakwater: Sakata, Tapchan

Floating: Mightywhale,Oceanenergy,Sperboy,Oceanlinx, Aquabuoy, IPS , Buoy,FO3,Wavebob,PowerBuoy, Pelamis ,PS frog, Searev, Waveroller,oyster, AWS, Wavedragon

Oscillating water column: IEA Technology

4 : , 2013