Basic knowledge

Wave energy converters

Just like the wind and tides, waves are an inexhaustible source of natural energy. In contrast to wind energy, however, waves are presently rarely used to generate energy. Particularly in countries with a long, open coastline, the use of wave energy is an attractive option for the generation of electricity.

Waves are primarily created by wind. The size of the waves, and therefore also their energy content, depends on the wind velocity, the wave fetch (distance the wind has travelled over the water) and the duration of the wind's action. Waves can cover large distances and are thus able to transport energy from windy areas at sea to less windy areas on the coast.

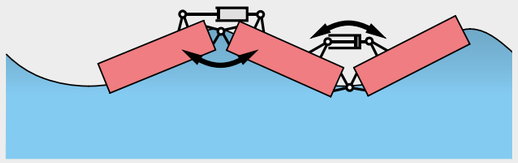
Systems for using waves

In the past years, several systems for the energetic use of waves have been developed. To make sure that the energy is transported efficiently, these systems are installed in coastal waters or even directly on the coastline.

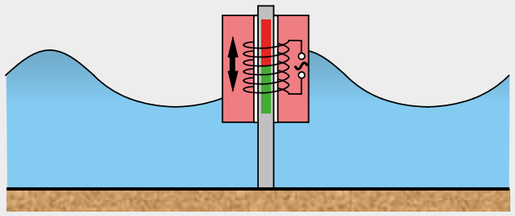
Until now, none of the concepts has reached market introduction. The reasons are the very high technical requirements due to the high mechanical loads. During heavy storms, waves can develop enormous power that the wave energy converters have to be able to withstand. Harsh weather conditions and the salt content of the sea place high demands on corrosion protection and the seals on electrical components. Moreover, maintenance, in particular of offshore systems, is often difficult and is affected by weather conditions.

Wave energy converters with different principles for using wave energy

1 the Pelamis "sea snake" wave energy converter harnesses the energy of the relative movements of hinge-linked buoyant elements

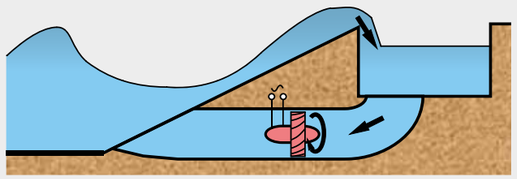


2 the wave energy buoy generates current by means of induction

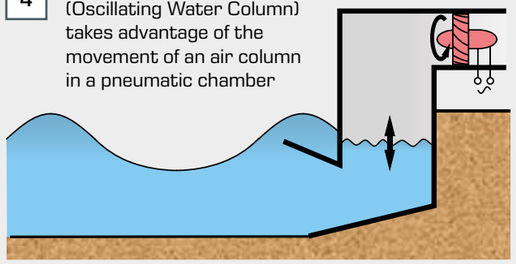


Both the "sea snake" and the "buoy" use wave energy directly. These power plants can be installed on the open sea.

3 the storage or ramp system power plant utilises potential energy from waves overriding a ramp



4 the OWC power plant (Oscillating Water Column) takes advantage of the movement of an air column in a pneumatic chamber



The "OWC" and "storage" principles use the energy of the wave indirectly to charge an air or water storage reservoir. This reservoir then powers a turbine. These power plants are best suited for installation in coastal areas.

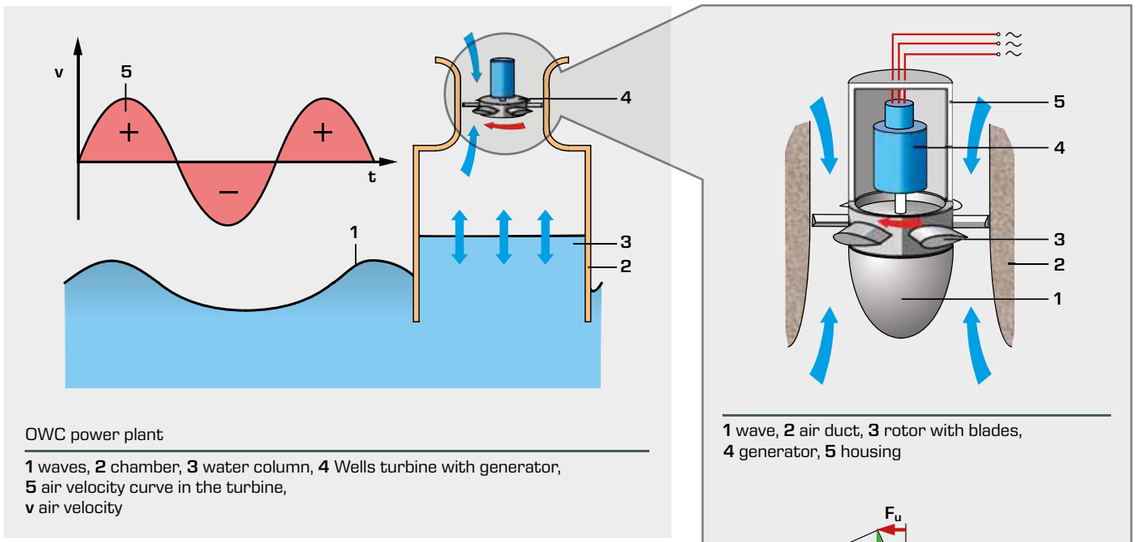
Key advantages of the OWC power plant

- the power plant can be integrated into the coastline directly, e.g. as a wave breaker.
  This means that, compared to offshore systems, access to it is easy.
- the generator is run by air and does not come into direct contact with the seawater.
- the turbine of the generator is of a simple design and therefore fault-resistant.

The OWC power plant

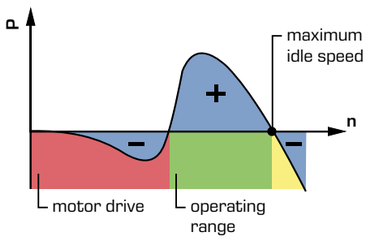
The incoming waves are led into a chamber. A water column is set into vertical oscillation. The water column acts like a piston and pumps the air above the surface of the water back and forth through a small opening. A Wells turbine is installed inside the opening. The air, as it streams back and forth, powers the Wells turbine.

The Wells turbine is of a simple design and does not have any moving parts except for the rotor. There is no guidance system. The blades have symmetric aerofoil profiles and generate thrust by means of aerodynamic forces. Here, the direction of rotation does not depend on the direction of the air flow. The turbine is powered by both incoming and outgoing flows.



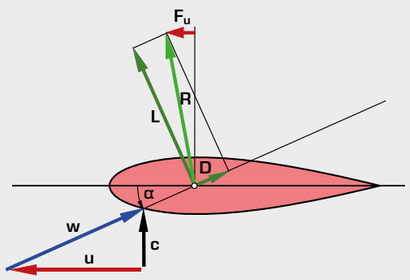
OWC power plant

1 waves, **2** chamber, **3** water column, **4** Wells turbine with generator,
5 air velocity curve in the turbine,
v air velocity



Because the incident flow is not always ideal, the turbine only generates power during a small portion of a wave period. This considerably reduces the efficiency and means that the turbine cannot start without assistance. The Wells turbine must therefore be kick-started with a motor until it has reached operating speed.

1 wave, **2** air duct, **3** rotor with blades,
4 generator, **5** housing



Velocities and forces in a Wells turbine

Velocities: **c** absolute air velocity,
u circumferential velocity of the blade,
w relative incident flow of the blade;
flow forces: **L** buoyancy force, **D** drag force,
R resulting force at the blade, F_u thrust force,
α angle of attack