OSMOTIC POWER

OSMOTIC POWER FACTS:

- Osmotic power production utilises the osmotic pressure difference between fresh water and sea water.
- Osmotic power has a great potential compared to other new renewable energy sources.
- Energy production from osmotic power is stable and predictable.
- Osmotic power is an environment-friendly energy source: CO_2-free, area efficient compared to other renewable energy sources, gentle environmental impact, and with a potential for green certificate.

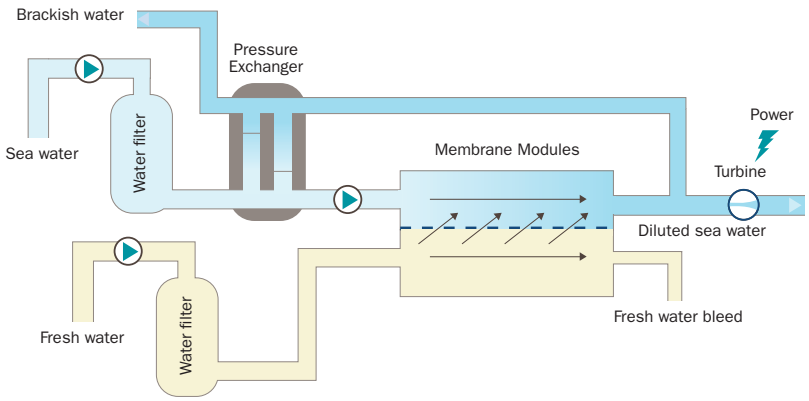
When a river runs into the ocean and fresh water mixes with sea water, huge amounts of energy are unleashed. Unlike the violent torrents in a waterfall or in steaming hot geysers, the energy released when mixing water with different salinity cannot easily be seen from the banks of the estuary. Nevertheless, the energy is there.

The process of osmotic power

When the mixing of fresh water and sea water is carried out by controlling the pressure on the saltwater side, the process is called pressure retarded osmosis (PRO). A simplified PRO process diagram is shown below.

Fresh water is fed into the plant, where it enters the membranes. In the membrane modules the fresh water is transferred by osmosis through the membranes into the pressurized sea water. The osmotic process increases the volumetric flow of high pressure water and is the key energy transfer in the plant.

Sea water is pumped from the sea and fed into the membranes, where it is diluted by the fresh water entering through the membrane.



Environmental aspects

The mixing of sea water and fresh water is a process that occurs in all river outlets in the world, and because rivers often run into the ocean in cities or other industrialized areas, most of the osmotic power potential can be utilized in urban areas.

Osmotic power plants can be constructed partly or completely underground, thus allowing them to play a discreete role in the local environment. The water management processes associated with operation of the plant can be designed without affecting the biotopes of the river, river outlet and sea. In addition, osmotic power plants are very area efficient compared to other renewable energy sources.

Statkraft
PURE ENERGY

THE HISTORY OF OSMOTIC POWER

→ **1973: Loeb discovers osmotic power**
Sidney Loeb discovered pressure retarded osmosis (PRO), a new method for generating power. Due to inefficient membranes, no particular progress was made during the 1970s and 1980s

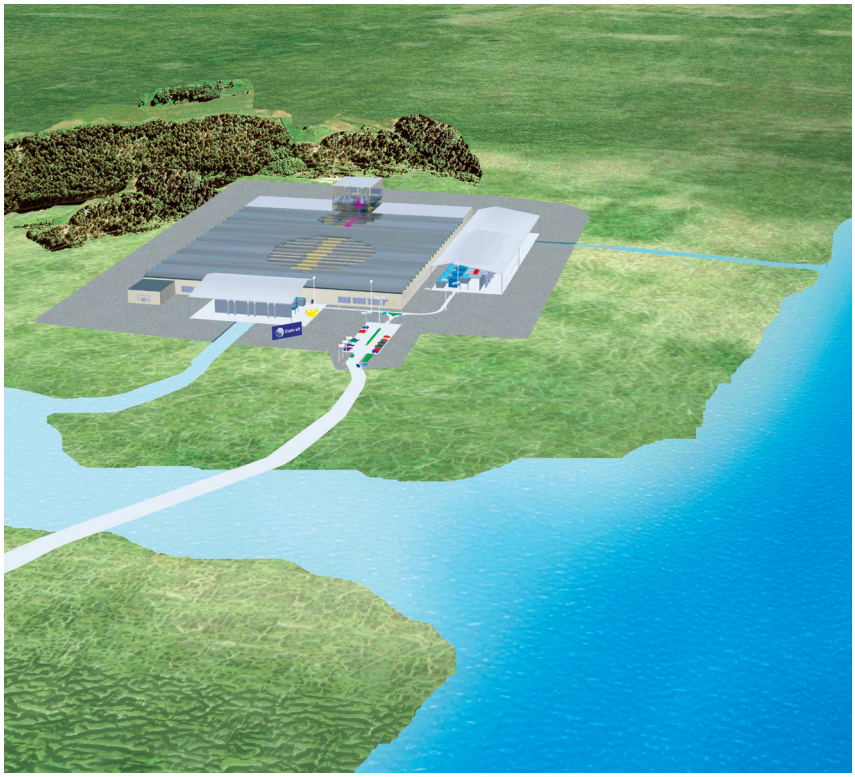
→ **1973–1997: Introduction of reverse osmosis**
During the 1980s and 1990s a breakthrough was made regarding membranes for RO, and the membrane technology was successfully introduced in many industrial applications.

→ **1997: Statkraft engages in osmotic power**
Statkraft engages in osmotic power technology development with a view to achieving cost-effective osmotic power production.

→ **2003: First operating pilot plant**
Statkraft builds the world's first pilot plant for PRO. Operation of the pilot plant begins in June 2003.

→ **2006: World leader**
Today, Statkraft is the world leader in the development of PRO, and has made significant state-of-the-artachievements during the last few years:

- A Salinity Power project (1999–2004) financed by the European Commission resulted in the design and production of a semi-permeable membrane optimized for PRO.
- A detailed survey of the environmental aspects related to construction and operation of an osmotic power plant has been made.
- Cost estimates made by Statkraft show that osmotic power would be competitive at today's energy price level.



Artist illustration of a PRO plant placed at sea level.

Plant designs

Several plant designs have been developed for PRO power generation. The illustration shows a typical plant located at sea level. Fresh water is taken from a river close to its outlet. Sea water is fed into the plant by underground pipes. The diluted water is pumped back into the estuary thus maintaining the flow of water in the river.

Statkraft has been developing osmotic power since 1997, and most of the conceptual challenges have been identified. All the aquired technology is in use in the water treatment industry today. Statkraft has focused its efforts on membrane development and has achieved an increase in power generation from less than 0.1 W/m^2 to almost 3 W/m^2. Commercial operation requires a membrane performance of 5 W/m^2.