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Title: Status of technologies for harnessing Salinity Power and the current Osmotic Power activities

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1. The power of osmosis.

It has been known for centauries that the mixing of freshwater and seawater releases energy. For example will a river flowing into the salty ocean releases large amounts of energy. The challenge is to utilise this energy, since the energy released from the occurring mixing only gives a very small increase in the local temperature of the water. During the last few decades at least two concepts for converting this energy into electricity instead of heat has been identified. These are Reversed Electro dialysis and Pressure Retarded Osmosis. With the use of one or both these technology one might be able to utilise the enormous potential of a new, renewable energy source. On global basis this potential represents the production of more than 1600 TWh of electricity per year.

The Reversed Electro dialysis (RED) is a concept where the difference in chemical potential between both solutions is the driving force of the process. The chemical potential difference generates a voltage that with the use of membranes for electro dialysis is converted into electrical current. This concept is under development in the Netherlands and there are preparations for the first prototype to be build.

For Pressure Retarded Osmosis (PRO), also known as osmotic power, the released chemical energy is transferred into pressure instead of heat. This was first considered by Prof Sidney Loeb in the early 70's, when he designed the world first semi permeable membrane for use in desalination trough reverse osmosis. In osmotic power one can utilise the natural occurring osmosis, which relates to the difference in concentration of salt between two liquid, for example sea water and sweet water. Sea water and sweet water have a strong force towards mixing, and this will occur as long as the pressure difference between the liquids is less than the osmotic pressure difference. For sea water and sweet water this would be in the range of 24 to 26 bars based on the salt concentration of sea water.

In a PRO system filtered sweet water and sea water are led into the system. Before entering the membrane modules the sea water is pressurised to approximately half the osmotic pressure, approximately 12-14 bars. In the module sweet water migrates through the membrane and into pressurised seawater. This results in an excess of diluted and pressurised seawater which is then split in two streams. One third is used for power generation in a hydropower turbine, and the remaining part passes through a pressure exchanger in order to pressurise the incoming seawater. The drain from a plant will to the main extent be diluted seawater that will be led either back to the river mouth or into the sea.

An osmotic power plant will to a large degree be designed of existing "off the shelf" technology. The two unique components are the pressure exchanger and the membrane. The majority efforts in order to commercialize osmotic power are the improvement and scale up of these components.

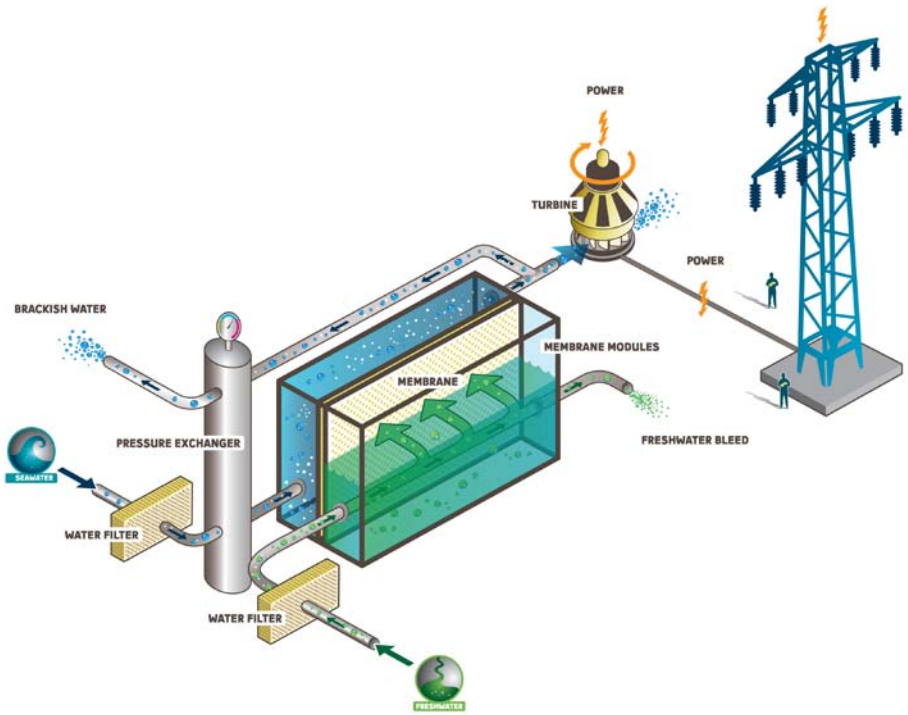

Illustration text: *The principle of osmotic power is utilising the entropy of mixing water with different salt gradients. In the process the water with low salt gradient moves to the side with the higher salt concentration and creates increased pressure due to osmotic forces. Given the sufficient control of the pressure on the salt water side, approximately half the theoretical energy can be transformed to electrical power, meaning that the operating pressure are in the range of 11-14 bars enabling the generation of 1MW per m^3 per sec fresh water.*

2. Current activities.

After the idea of using PRO was developed in the early 70's, limited effort has been made to bring this technology to a commercial level. There have been some minor studies and testing, but it was not until Statkraft started working with PRO that the development picked up momentum. Since this work started around 1996, research has been focused on designing a suitable membrane for PRO, and at the same time one has worked with system design and several studies of the feasibility of the concept as a commercial source of energy.

The development of an efficient membrane for osmotic power has been the major focus of the efforts made by Statkraft. The current power density of the membrane is approximately 3 W/m^2, which is up from less than 0.1 W/m^2 a few years back. This research has for most part been done in Germany, Norway and the Netherlands, there are however other groups working on similar topics both in North America and Asia.

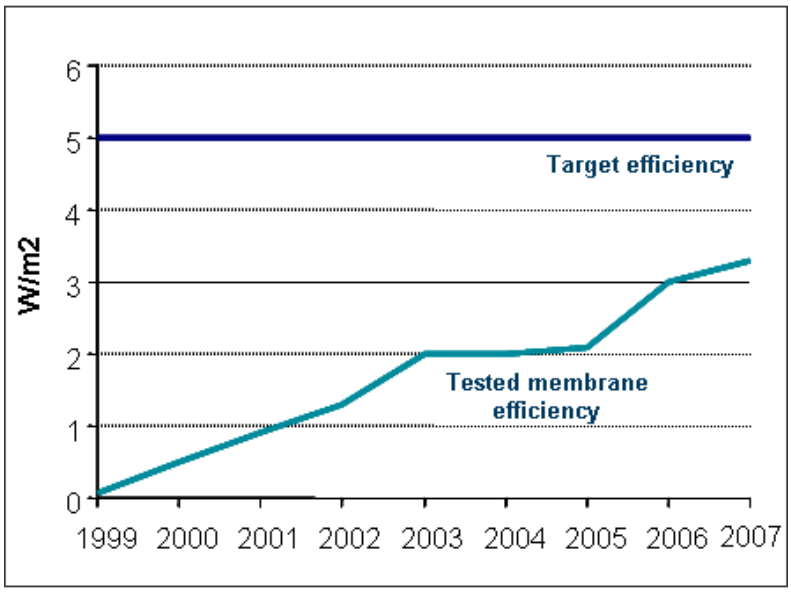

Illustration text: *The power efficiency of membranes has been increased from 0.1 to approximately 3 W/m2.*

The world's first prototype of osmotic power is now under construction and the plant will be put into operation in January 2009 in the southeast of Norway.

Illustration text: The *Prototype at the East coast of Norway*

The main objectives of the prototype are twofold. Firstly, confirming that the designed system can produce power on a reliable 24-hour/day production. Secondly the plant will be used for further testing of technology achieved from parallel research activities to substantially increase the efficiency. These activities will mainly be focused on membrane modules, pressure exchanger equipment and power generation (turbine and generator). In addition there will be a focus on further development of control systems, water treatment equipment, as well as infrastructure with regards to water inlets and outlets.

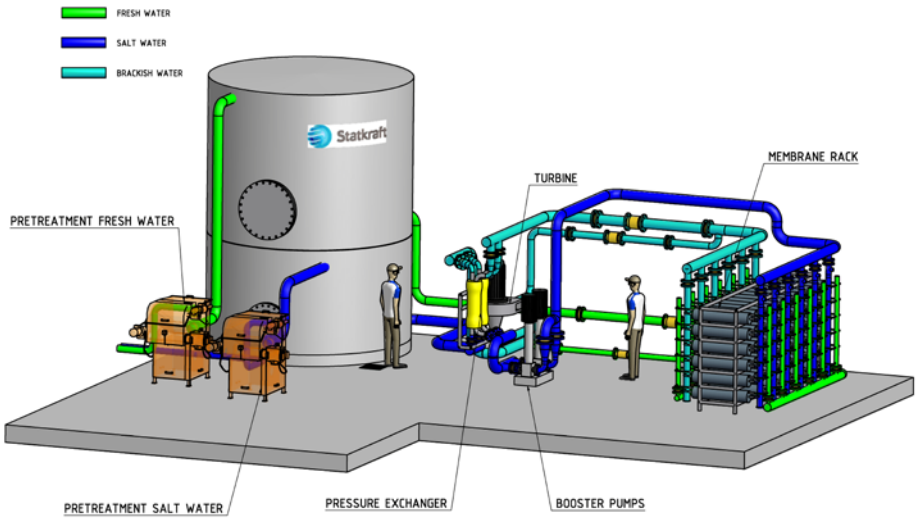

Illustration text: *Prototype illustration*

3. Environment and market potential.

Osmotic powers excellent environmental performance and CO_2-free power production will most likely qualify for green certificates and other supportive policy measures for renewable energy. The estimated energy cost is comparable and competitive with the other new renewable energy sources, such as wave, tidal and offshore wind being in the range of 50-100 €/MWh.

With a potential of more than 1600 TWh a year world wide, where 170 TWh a year is in Europe, this will likely prove to be a major contribution to the growth of renewable energy, and to represent a new attractive business potential for both the commercial power companies and technology suppliers.

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