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## **DESALINATION OF SEA WATER USING GEOTHERMAL ENERGY**

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### **GENERAL PRESENTATION**

#### ***Context***

**Desalination, desalinization, or desalinisation** refers to any of several processes that remove excess salt and other minerals from water.

Water is desalinated in order to be converted to fresh water suitable for human consumption or irrigation. Sometimes the process produces table salt as a by-product. It is used on many seagoing ships and submarines. Most of the modern interest in desalination is focused on developing cost-effective ways of providing fresh water for human use in regions where the availability of fresh water is limited.

Large-scale desalination typically uses extremely large amounts of energy as well as specialized, expensive infrastructure, making it very costly compared to the use of fresh water from rivers or groundwater. The large energy reserves of many Middle Eastern countries, along with their relative water scarcity, have led to extensive construction of desalination in this region. By mid-2007, Middle Eastern desalination accounted for close to 75% of total world capacity. The world's largest desalination plant is the Jebel Ali Desalination Plant (Phase 2) in the United Arab Emirates. It is a dual-purpose facility that uses multi-stage flash distillation and is capable of producing 300 million cubic meters of water per year.

#### ***State of the art***

The leading method is Multi-stage flash distillation (85% of production world-wide). The traditional process used in these operations is vacuum distillation—essentially the boiling of water at less than atmospheric pressure and thus a much lower temperature than normal. This is because the boiling of a liquid occurs when the vapor pressure equals the ambient pressure and vapor pressure increases with temperature. Thus, because of the reduced temperature, energy is saved.

In the last decade, membrane processes have developed very quickly, and most new facilities use reverse osmosis technology. Membrane processes use semi-permeable membranes and pressure to separate salts from water. Membrane systems typically use less energy than thermal distillation, which has led to a reduction in overall desalination costs over the past decade. Desalination remains energy intensive, however, and future costs will continue to depend on the price of both energy and desalination technology.

#### ***Geothermal solution***

Geothermal desalination is a proven process under development for the production of fresh water using heat energy. Claimed benefits of this method of desalination are that it requires less maintenance than reverse osmosis membranes and that the primary energy input is from geothermal heat, which is a low-environmental-impact source of energy.

Around 1995, entrepreneur Douglas Firestone Aquagenesis LLC from Nevada came up with an idea to use geothermal water directly as a source for desalination. In 1998, several individuals began working with evaporation/condensation air loop water desalination. The experiment was successful and a proof of concept, proving that geothermal waters could be used as process water to produce potable water in 2001.

In 2005 to 2009 some testing was done in a sixth prototype of a device referred to as a delta device, a closed air loop, atmospheric pressure, evaporation condensation loop geothermally powered desalination device. The device used filtered sea water from Scripps Institute of Oceanography and reduced the salt concentration from 35,000 ppm to 51 ppm. The unit was at one time at SDSU but it is no longer there; the university was paid for the use of the space. The university had no part in the development of the unit. When the unit was taken there, ICATS was not in existence, and did not have anything to do with the unit or design of the unit.

A total of six prototypes and six modifications demonstrated that, with process water approaching 210 degrees Fahrenheit (100 degrees Celsius) and a chill source about 35 °F (2 °C), a full-size device would produce about one acre foot (600 m<sup>3</sup>) of water per day. Salt concentration in the wastewater would only be about 10% above the level of the original water, thus, from, say, 35,000 to about 38,000 parts per million, well within the ability of osmoregulators to adjust.

SDSU ICATS continues to develop different devices for the same purpose with the goal of making desalination an environmentally friendly process.

The multi stage distillation (MED) powered by geothermal energy was tested and demonstrated in the Kimolos island (Greece) project. It is preferred to lower energy requirement in comparison with other desalination processes. MED method is based on the multi-effect distillation rising film principle at low evaporation temperatures (less than 70°C) due to low, almost vacuum, pressure prevailing in the vessels. The rising effect principle takes advantage of the fact that the inner tube surfaces are always covered by a thin film of feed water that prevents scale formation.

The evaporation through multiple – effect is a very energy efficient technology, as in each vessel the feed water boils utilizing the heat released by condensing vapour from the previous effect. The project did not proceed yet to industrial phase.

## **FOCUSING ON THE GEOTHERMAL SOLUTION**

### ***Current status of the solution***

		<i>Comments</i>
Scientific Project (only on paper or under preparation)	<input type="checkbox"/>	
Demonstration project	<input checked="" type="checkbox"/>	
Scientific Pilot	<input type="checkbox"/>	
Industrial Pilot	<input type="checkbox"/>	
Industrial stage		
Other?	<input type="checkbox"/>	

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## Advantages

	(1, 2, 3, 4 or 5) *	Comments
Environmental	5	Avoid the use of fossil fuels, no CO2 emissions.
Economical	5	Lower cost compared to fossil fuels.
Social	4	Acceptable by the local communities, improves employment perspectives
Scientifically	4	Scientifically proved
Others, financial	2	Saves foreign currency by avoiding the use of imported fuels.

Between 1 (very few advantageous) to 5 (totally advantageous)

### Advantages against other applications

The main advantages of geothermal desalination of sea water are:

- ✚ The lower cost per unit of produces fresh water.
- ✚ The avoidance of CO2 emissions resulting when using fossil fuels.
- ✚ It requires less maintenance than reverse osmosis membranes.

Drawback is the high cost of produced fresh water.

### ***Focusing on Economic Feasibility***

- Estimated costs  
The cost of the solution is still high.
- Impact on profitability

## **EXAMPLES/CASE STUDIES**

### **Location: Kimolos island, Greece**

#### **Technical characteristics of the operation**

- Type of exploitation: Pilot
- Production: The total daily production of water was 80 m<sup>3</sup>.
- Demonstration project
- Specifications: temperature of geothermal water used 60°C and flow of 60 m<sup>3</sup>/h, pumped from a geothermal well from a depth of 188 m.
- Impact on market: does not exist because of the nature of the project (pilot).

- **Economical aspects:** the cost of produced water was in the order of 1.6 €/m<sup>3</sup> (Including only annual operating cost).
- **Financial aspects:** Funding was done in the frame of European Commission Thermie Program

## **SOURCES AND CONTACTS**

EGEC Brochure <http://www.egec.org/>

**Analysis of heat transfer and evaporation in geothermal desalination units** .BOUROUNI K. ; MARTIN R.; TADRIST L., The International Workshop on Desalination Technologies for Small and Medium Size Plants With Limited Environmental Impact, Rome , ITALIE (03/12/1998) 1999, vol. 122, n° 2-3 (204 p.) (14 ref.), pp. 301-313 and

European Conference on Desalination and the Environment, Las Palmas, Gran Canaria, ESPAGNE (09/11/1999) 1999, vol. 125, n° 1-3 (300 p.) (6 ref.), pp. 147-153, published in 0011-9164/99/\$– See front matter © 1999 Elsevier Science B.V. All rights reserved

**Heat transfer and evaporation in geothermal desalination units.** Bourouni K.; Martin R.; Tadrisk L.; Chaibi M.T., In Applied Energy, Volume 64, Number 1, 1 September 1999, pp. 129-147(19), Elsevier