

***K4RES-H*****KEY ISSUE 5 : INNOVATIVE APPLICATIONS****GEOHERMAL UTILIZATION FOR SEAWATER DESALINATION**

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INTRODUCTION

The World Health Organization (WHO) has estimated that 1000 cubic meters per person per year is the benchmark level below which chronic water scarcity is considered to impede development and harm human health.

97.5% of the total global stock of water is saline and only 2.5% is fresh water. Approximately 70% of this global freshwater stock is locked up in polar icecaps and a major part of the remaining 30% lies in remote underground aquifers. In effect, only a miniscule fraction of freshwater (less than 1% of total freshwater or 0.007% of the total global water stock) that is available in rivers, lakes and reservoirs is readily accessible for direct human use.

Geothermal energy is a Source of Renewable Energy and the Oceans are a Major Alternative Source of Water

Just as the earth is an alternative source of energy to meet future demands, the oceans are an alternative water resource. However, extraction of fresh water from the oceans requires significant development of desalination infrastructure. Desalination is very energy-intensive, and sustainable energy systems urgently need to be developed.

Desalination technology is providing safe drinking water even to some 'water-rich' nations where pollution reduced the quality of natural waters. Thus, as a means of augmenting fresh water supplies, desalination contributes significantly to global sustainability.

Desalination techniques such as those driven by geothermal heat have increased the range of water resources available for use by a community.

Seawater desalination is one of the most promising fields for the application of geothermal energy due to the coincidence, in many places of the world, of water scarcity, seawater availability and geothermal potential. During the 90s the Milos Project carried out a research project that successfully demonstrated the technical feasibility of geothermal seawater desalination using low geothermal enthalpy.

A shortage of fresh water is a very important problem that is continuously increasing, due to population growth and changes in weather conditions, and affects many countries in the world. These countries could have abundant seawater resources and a good geothermal conditions, which could be used to produce drinking water from seawater.

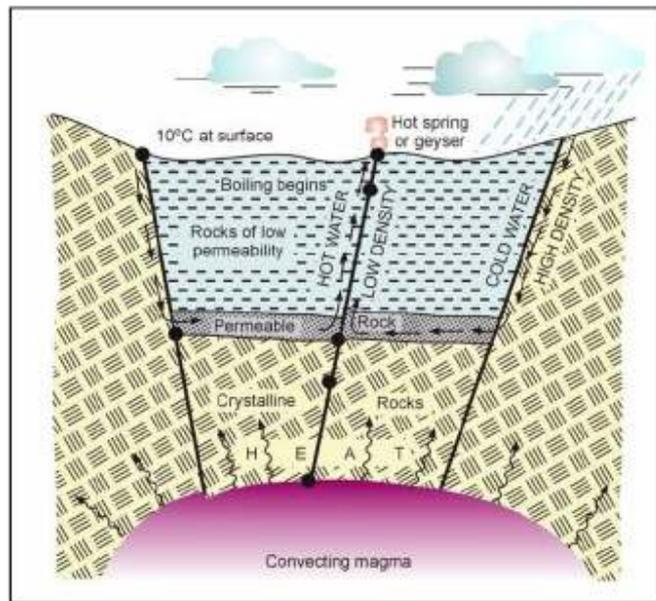


Fig 1: Schematic representation of high temperature hydrothermal reservoir

Desalination Technologies

The Inventory indicates that the world's installed capacity consists mainly of the multi-stage flash distillation and RO (reverse osmosis) processes. These two processes make up about 86 percent of the total capacity. The remaining 14 percent is made up of the multiple effect, electro dialysis, and vapour compression processes, while the minor processes amounted to less than one percent.

Based on these data, the installed capacity of membrane (RO) and thermal processes is about equal. Since a portion of the older units, which generally were distillation units, are now retired, it is probable that the capacity of operating membrane units exceeds that of thermal.

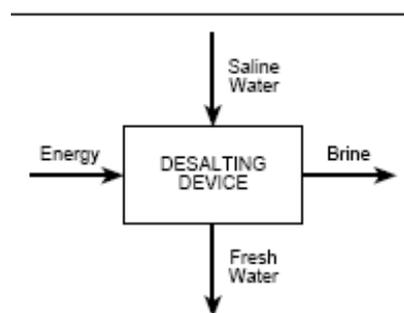
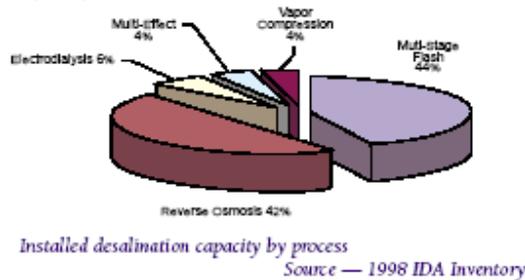


Fig 2: Installed desalination capacity (1998 left) and basic principle (right)

A desalting device essentially separates saline water into two streams: one with a low concentration of dissolved salts (the fresh water stream) and the other containing the remaining dissolved salts (the concentrate or brine stream). The device requires energy to operate and can use a number of different technologies for the separation. This

section briefly describes the various desalting processes commonly used to desalt saline water.

Thermal Processes : About half of the world's desalted water is produced with heat to distill fresh water from sea water. The heat may be provided from a geothermal source. The distillation process mimics the natural water cycle in that salt water is heated, producing water vapor that is in turn condensed to form fresh water. In a laboratory or industrial plant, water is heated to the boiling point to produce the maximum amount of water vapor.

To do this economically in a desalination plant, the applied pressure of the water being boiled is adjusted to control the boiling point because of the reduced atmospheric pressure on the water, the temperature required to boil water decreases as one moves from sea level to a higher elevation. This reduction of the boiling point is important in the desalination process for two major reasons: multiple boiling and scale control.

1 Multi-Stage Flash Distillation : In the MSF process, seawater is heated in a vessel called the brine heater. This is generally done by condensing steam on a bank of tubes that carry seawater which passes through the vessel. This heated seawater then flows into another vessel, called a stage, where the ambient pressure is lower, causing the water to immediately boil. The sudden introduction of the heated water into the chamber causes it to boil rapidly, almost exploding or flashing into steam.

2 Multi-Effect Distillation : The multi-effect distillation (MED) process has been used for industrial distillation for a long time. Traditional uses for this process are the evaporation of juice from sugar cane in the production of sugar and the production of salt with the evaporative process. Some of the early water distillation plants used the MED process, but MSF units, because of a better resistance against scaling, displaced this process. However, starting in the 1980s, interest in the MED process was revived, and a number of new designs have been built around the concept of operating on lower temperatures, thus minimizing corrosion and scaling.

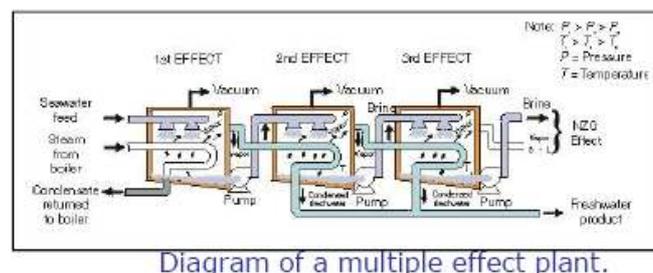


Fig. 3: Schematic of multi-effect plant

3 Vapor Compression Distillation : The vapor compression (VC) distillation process is generally used in combination with other processes (like the MED described above) and by itself for small and medium-scale seawater desalting applications. The heat for evaporating the water comes from the compression of vapour (a kind of “open loop” heat pump) rather than the direct exchange of heat from steam produced in a boiler.



4 Membrane Processes : In nature, membranes play an important role in the separation of salts, including both the process of dialysis and osmosis, occurs in the body. Membranes are used in two commercially important desalting processes: electrodialysis (ED) and reverse osmosis (RO). These processes are not suitable to be integrated directly into a geothermal system (ED may be used with geothermal power).

5 Other Processes : A number of other processes have been used to desalt saline waters. These processes have not achieved the level of commercial success that distillation, ED, and RO have, but they may prove valuable under special circumstances or with further development.

The existing desalination plants in general use process steam from combined cycle power plants or electricity generated in simple cycle units. So far, renewable energies (including geothermal) have played only a minor part in seawater desalination.



STATE OF THE ART

Up to now, just few projects were developed to prove geothermal utilization for seawater desalination could be efficient on cost and technical aspects.

We can focus firstly on the example developed in Greece in Milos Islands and Sousaki Korinthos :

1) Geothermal energy in seawater desalination in Milos Island (Centre for Renewable Energy Sources)

Milos island is located in the Aegean Volcanic Arc and is characterized by abundant geothermal resources of high temperature. Early geothermal exploration undertaken by the Institute of Geological and Mining Research of Greece includes temperature measurements in shallow wells drilled for this purpose and Schlumberger resistivity measurements of subsurface rocks.

The results indicate that the eastern part of the island and especially the plain of Zefyria is the region with the highest temperature gradients and lowest apparent resistivities, hence the parts of the island most promising for high enthalpy geothermal potential. Later drilling exploration undertaken by the Public Power Co (PPC) of Greece, summarized in Mendrinis, identified geothermal fluids of temperature 300-323 °C at depths 800-1400 m below sea level in the Zefyria plain.

By examining the results of the geochemical exploration financed by the PPC, we conclude that the region of the island most promising for exploitation of shallow, low enthalpy (<100 °C) geothermal resources, is the one where deep fluids are present in shallow aquifers, namely the east half of the island.

The CRES performed evaluation of exploration data, well test analysis, resource assessment and computer simulation of the Milos geothermal system and indicated that the deep geothermal fluids correspond to boiled seawater of 80,000 ppm salinity. The CRES also calculated that by cooling the upper 2 km of the hot rocks below Zefyria, Vounalia and Adamas by 90 °C would release 5×10^{18} J of heat (or 141 million TOE), which justifies the commissioning of 260 MWe geothermal power plant.

In parallel, the evaluation showed that the minimum heat flow from deeper rocks cannot be less than 87.8 MWth. This value is slightly higher than the natural conductive heat flow towards the surface of the island, which has been estimated as 77 MWth (CRES) due to the convective heat flow component.

The figure of 87.8 MWth was based on small amount of natural convection through the geothermal system, due to the low permeability measured in the deep geothermal wells. Recent drilling in Vounalia, however, performed as part of the MIDES project, showed very high permeability and seawater infiltration to shallow rocks, as described above. This indicates that heat flow from deeper layers should be considerably higher.

The low enthalpy geothermal utilization project for electricity generation and seawater desalination

The main objective of this ongoing project is to construct and operate a low enthalpy geothermal energy driven water desalination unit producing 75 to 80 m³/h drinking water and an ORC power generator unit of installed capacity of 470 kWe on Milos island.

The only source of energy is geothermal heat and the unit is anticipated to be entirely self sufficient in thermal energy and to have the potential to become self sufficient in electricity as well.

Local community will benefit from the production of clear desalinated water, which will be produced at a very low cost (.15 EURO per m³) and from the utilization of a sustainable and environmentally friendly energy source, which is low enthalpy geothermal energy. The amount of water produced will cover completely the needs for drinking water of the island. The project will use geothermal water from the Vounalia concession of Milos SA and will have the flow chart shown in Figures 4 and 5.

Planning and supervision of drilling works and production testing was implemented by AUTH with the expert advice and assistance of CRES. The GIS database developed by GSDP proved a very effective tool for planning the drilling works. The GIS database includes all existing and documented information about the geology and geothermal potential of Milos. All data is digitalized and the frame is a topographic data package with an analysis of 4-meter height lines density combined with an evaluation of satellite images.

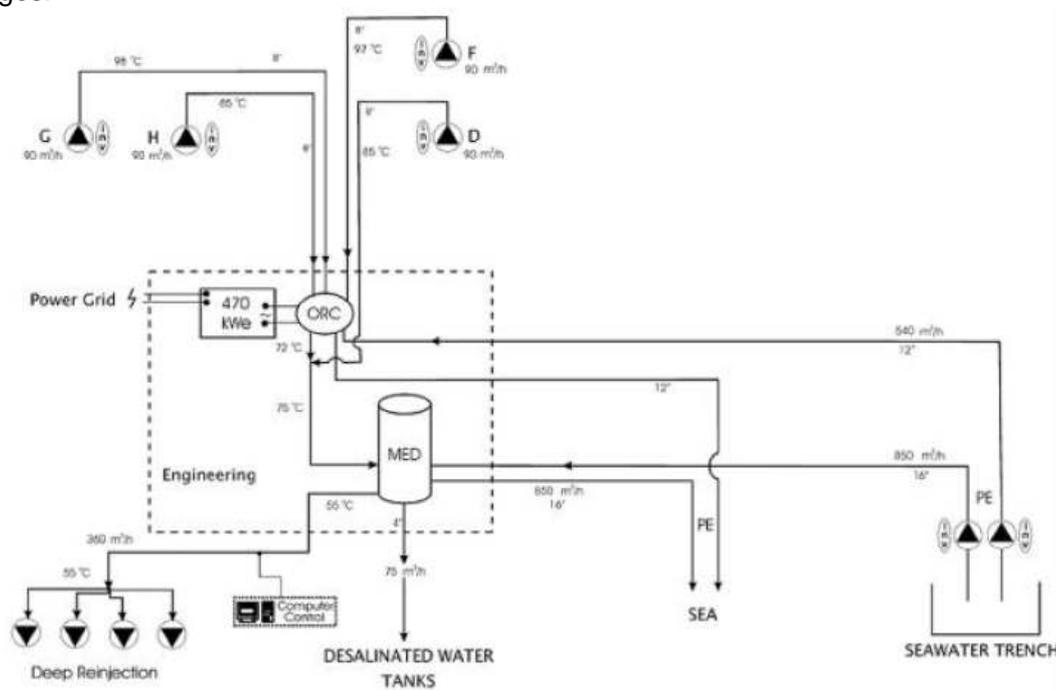


Fig. 4: Schematic of Power Plant in the Milos project

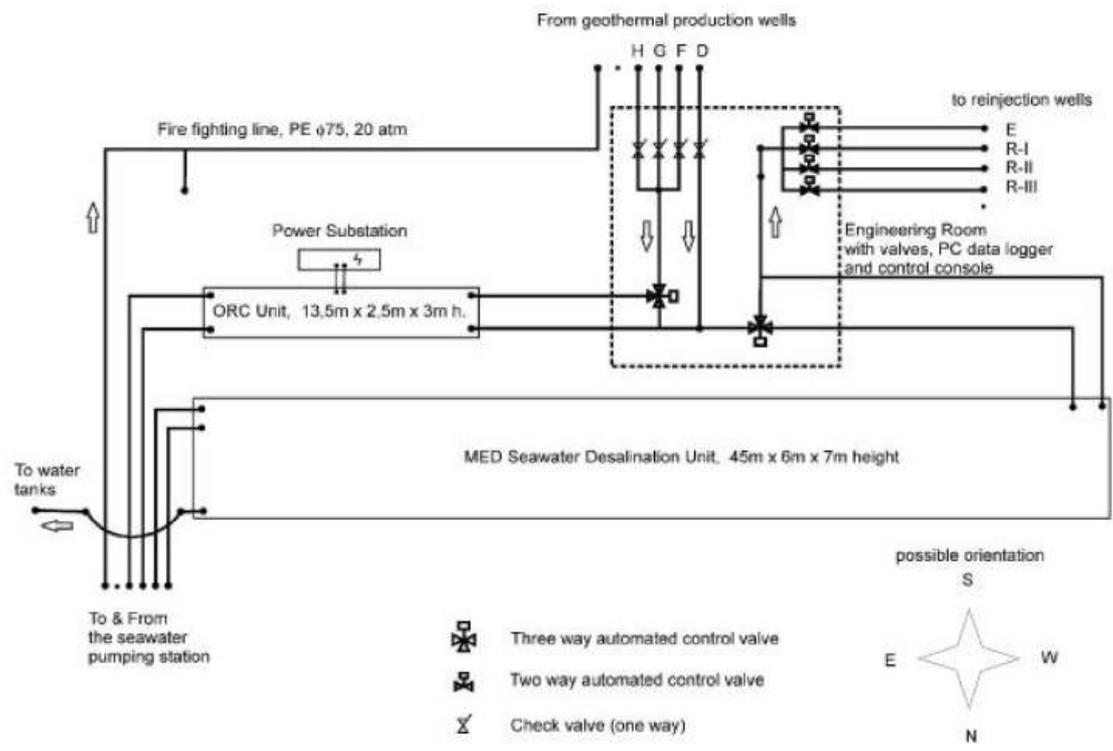


Fig. 5: Schematic of the desalination unit

The exploration area is in Vounalia, within the concession of Milos SA. Tests performed included air lift, pumping at 3-5 flow rate steps, as well as continuous pumping at high flow rate for at least 48 h.

Measurements included temperature profiles versus depth, static water level measurements, as well as water temperature, flow rate and water level during pumping tests.

In parallel, CRES implemented the optimal design study and integrated the engineering study which has led to detailed technical specifications of the entire application and of all necessary equipment.

The results of the production tests are summarised in Table 1, together with the energy potential of each well.

Tab. 1: Summary of Geothermal Well Data in Vounalia, Milos



Well	Well Bottom m	Casing Shoe m	Water Level m	Maximum Flow Rate m ³ /h	Water Production Temperature °C	Thermal Power MWth (T _{base} = 25°C)
A	150	149	74	20	98	1.70
B	71	67	-	0	-	0.00
C	184	183	86	25	84	1.71
D	158	152	65	100	85	6.97
E	125	122	19	125	55	4.35
F	89	82	54	100	97	8.36
G*	85	82.5	57	100	99	8.59
H*	106	86	35	75	85	5.25
R-I*	102	98	18	85	60	3.45
R-II*	63	61	24	125	50	3.63
R-III*, **	100**	98*	20**	125**		

* Final casing 10", otherwise 8"

** Proposed R-III reinjection well

Wells A and C are characterized by low flow rates, higher elevation, deep water level, low rock permeability, and temperature 84-100°C. Wells D, E, F, G and H are characterized by high flow rates, lower elevation, shallower water level and very high rock permeability. In fact, the maximum flow rate they can yield is limited by the horsepower of the pump and the pressure losses of the piping rather than the permeability of the production layers.

Production temperature varies from 55°C (well E), to 99°C (Well G).

All wells are relatively shallow, with well bottom at 70-185m, and stand with a water level approximately at sea level. With the sole exception of Well E, due to temperature close to the boiling point of water, which resulted in the presence of water vapor on top of the liquid surface due to evaporation, water level measurements were difficult and of questionable accuracy. This can be attributed to the condensation of water vapour directly on the water level sensor. The chloride content of the water varies between 11,200 and 25,000 ppm, indicating diluted to boiled seawater.

Geothermal exploration scheme

The geothermal power and desalination plant of the project will comprise the following components (based on CRES's engineering study please also refer to the plant flow chart in Figure 4) :

- Geothermal production wells: Production will be derived from the wells located closer to the sea, due to their high energy yield and the corresponding hot water transmission costs. Wells F, D, G and H will produce 300 m³/h of geothermal water 55-99°C.

Wells A and C will not be used due to their low energy output, their distance from the sea and their elevation, factors that raise considerably the capital costs and electricity needed for the production and transport of the geothermal water.



- Geothermal submersible pumps and inverters installed at the production wells.
- Piping network conveying the geothermal water to the main Plant. Buried steel or fiberglass piping will be used. Closed, pressurized at 10 bars maximum.
- Power and data transmission lines from the main plant to the wells.
- ORC unit, transforming approximately 7% of geothermal energy to electricity designed to generate approximately 470 kWe.
- MED-TVC seawater desalination unit providing 75- 80 m³/h desalinated water.
- Main heat exchanger, transferring the energy from the hot geothermal water exiting the ORC unit to the MED-TVC desalination unit.
- Reinjection wells (RE I and II) located at the margin of the geothermal field, close to the coast, downstream and at lower elevation of the main Plant, in order to minimize water transmission costs and avoid disturbing the hot part of the geothermal aquifer, well E will also operate as a reinjection well, due to its low well-head temperature (only 55 °C).
- Geothermal water transmission lines from the main heat exchanger to the reinjection wells: buried steel or fiberglass piping, closed pressurized system at 10 bars maximum, no extra pumping.
- Seawater transmission lines conveying 1000 m³/h cooling seawater to the MED-TVC unit plus 200-575 m³/h cooling water for the ORC unit: Buried polyethylene piping, seawater intake and disposal from a trench close to the sea line, pumping station close to the intake point.
- Desalinated water transmission line from the plant to the water tanks near the town of Adamas: Buried polyethylene piping.
- Power substation for power provision or delivery to the local power net: 500 kWe.
- Main computer monitoring and control system for real time data logging and automation control.

Until now, drilling of production and reinjection wells has been completed. Construction works for the piping networks, the ORC power plant, the desalination plant and the electro-mechanical equipment, are expected to commence shortly.

Conclusions

The ongoing Milos low enthalpy geothermal energy utilization project, demonstrates that through the innovative and sustainable utilization of low enthalpy geothermal energy for electricity generation and seawater desalination in Milos, it can substantially contribute to the local water needs. It is sustainable, as it will use only a minimal fraction of the available geothermal potential. It can cover local water demand, as production wells

drilled in Vounalia can provide the necessary energy quantity for the seawater desalination plant.

Geothermal Exploration In Vounalia, Milos Isl.

- 10 wells (70 – 185 m)
- Total 550 m³/h
- Wellhead Temps. 55 – 100 °C
- 20.000 – 55.000 ppm
- The field can support:
 - Geothermal Desalination Med Unit delivering 75 m³/h fresh water
 - Binary power plant 600 kWe



2) Low enthalpy geothermal energy driven sea water desalination plant at Sousaki Korinthos (CENTER FOR RENEWABLE ENERGY SOURCES (CRES))

AIM OF THE PROJECT

The main objective is the introduction of an innovative desalination technology, which improves the energy efficiency and the cost effectiveness of low enthalpy geothermal driven desalination plants. This utilization scheme exploits part of the proven geothermal resources at Sousaki Korinthos for the production of 300 m³/day of fresh desalinated water, partially solving water sufficiency problems in the region, inducing industrial, tourist and agricultural development in the area of Aghioi Theodoroi-Sousaki. The innovative desalination method developed is the hybrid multi effect flash-distillation under vacuum unit {ME(F-D) unit}, which combines desalination at a first step within a flash vessel and in the subsequent second and third steps with distillation under vacuum



in vertical tubes. This innovative desalination plant can be considered as a second generation plant compared to previously developed first generation geothermal driven MED-VT desalination units.

PROJECT DESCRIPTION

The geothermal field of Sousaki Korinthos is located 5.5 Km west of the town of Aghioi Theodoroi, lying on the Northwest Edge of the active volcanic arc of the Aegean Sea. It is one of the most thoroughly investigated geothermal fields of Greece.

The proven, renewable and simultaneously the exploitable geothermal resource in the region has been calculated to be over 250.000.000 m³ at a flow-rate of 200 m³/h and with an average temperature of 70 °C. According to the results from the geothermal exploration, drilling activities and geochemical-hydrogeological investigations performed in the region since 1971 by numerous research institutes and researchers, the low enthalpy geothermal field of Sousaki Korinthos comprises of two reservoirs.

- The shallower geothermal lies at depths of 80 to 150 m, within conglomerates and ophiolites, with temperatures of 58.8 to 75.5 °C, being accessible through 4 productive boreholes drilled during the 1980's by IGME.
- The deeper geothermal reservoir lies at depths of 902 to 1080 m, within Triassic-Jurassic limestones, with temperatures of 59 to 62 °C, being accessible through 2 productive boreholes drilled during the period of 1992-93 by GEMEE-ETBA through funding of the VALOREN programme.

This results to a total exploitable potential of 170 m³/h at an average temperature of approximately 70 °C. The thermal energy transferred by the desalination process amounts to 2.600.000 Kcal/h, corresponding to a total temperature drop within the primary geothermal circuit of approximately 16 °C. The proposed geothermal driven Hybrid multi-effect flash-distillation under vacuum desalination unit {ME(F-D) unit} is innovative since it comprises of the hybrid combination of a first flash and subsequent second and third or even fourth distillation under vacuum effects desalination stages with no preheating necessary.

This unit can be regarded as a second generation desalination unit compared to the first generation simple MEDVT desalination unit being developed on Kimolos Isl. This innovation ensures an improvement of the energy efficiency and of the cost effectiveness of the desalination plant.

The desalination unit is designed in such an innovative way that, if the geothermal water chemical composition permits, it's feasible to desalinate the low enthalpy geothermal water itself, instead of the sea-water, further increasing the energy efficiency and cost effectiveness of the unit.

The total operation time of the unit per year is planned to be 6570 hours (Load factor = 75%), the total desalinated fresh-water production will be 82125 m³ per year.

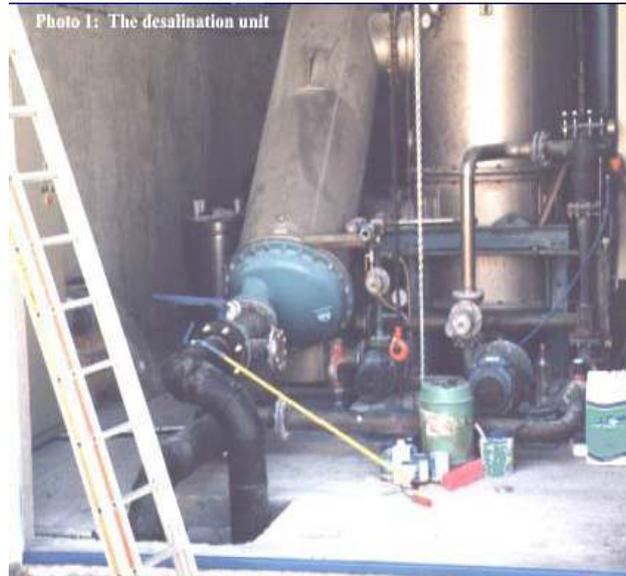
STATE OF ADVANCEMENT

The project started on the 1st April 96. The first phase of this project (Optimum Design) has been completed (Nov.1996) and the order for the manufacturing of the desalination unit and the other equipment, based on the optimum unit design, has been placed.

References : See also project GE./00438/94/HE/..

Kimolos Geothermal Water MED : Desalination Unit Desalination Unit

- Geothermal well Prassa 1
- Depth 188 m
- Flow-rate 80 m³/h
- Wellhead Temperature : 61,5 °C
- Desalination Technology MED
- Geothermal Water : Heating and Feed-water



3) heat transfer of air–water–vapour mixtures in a desalination plant

The heat transfer of air–water–vapour mixtures in a desalination plant, using the aero-evapo-condensation process, has been studied theoretically and experimentally. It consists of a falling-film evaporator and condenser, made of polypropylene. It was designed to work at low temperatures (of 60–90°C) utilizing geothermal energy. A model for heat-and-mass transfers in the plant is developed, resulting in a set of classical equations.

Two experimental pilot studies were used. The latter, installed in France and the south of Tunisia, were supplied by fuel and geothermal energy respectively.

The influences of different thermal and hydrodynamic parameters on the unit performances were investigated. Experimental results were compared with the model predictions.

From this comparison, it can be learnt that the model is well able to predict the trends of the heat-and-mass characteristics of the evaporator. The present process was compared with other desalination techniques. It was shown that in areas where geothermal water resources are available, the process is promising either for cooling or desalting geothermal water.

MARKET POTENTIAL

Economics

Since desalination facilities exist in over 100 countries around the world, specifying exact costs for desalting is not appropriate. What can be said with certainty is that the capital and operating costs for desalination have tended to decrease over the years.

At the same time desalting costs have been decreasing, the cost of obtaining and treating water from conventional sources has tended to increase because of the increased levels of treatment being required in various countries to meet more stringent water quality standards. This rise in cost for conventionally treated water also is the result of an increased demand for water, leading to the need to develop more expensive conventional supplies, since the readily obtainable water sources have already been used.

Many factors enter into the capital and operating costs for desalination : capacity and type of plants, plant location, feed water, labor, energy, financing, concentrate disposal, and plant reliability. In general, the cost of desalted seawater is about 3 to 5 times the cost of desalting brackish water from the same size plant.

In any country or region, the economics of using desalination is not just the number of euro per cubic meter, but the cost of desalted water versus the other alternatives. In many water-short areas, the cost of alternative sources of water is already very high and often above the cost of desalting.

Any economic evaluation of the total cost of water delivered to a customer must include all the costs involved. This includes the costs for environmental protection (such as brine or concentrate disposal), distribution and losses in the storage and distribution system.

Fig. 2: Indicative cost calculations for MED geothermal desalination unit, the case of Nisyros

Cost category	Cost (€)
MED unit cost (300m ³) + sea water intake system	500.000
Geothermal production well	60.000
Miscellaneous	60.000
Total cost	620.000
Maintenance costs 3% (distillation unit) +2% (other equipment) per year	16.200
Other operating costs	88.800
Total annual operating cost	100.000
Amortisation (5%, 12 years)	71.950
Grand total of annual cost	171.950
Cost of water at annual water production (90% load factor ≈ 98.550 m ³)	1,74



Nisyros has a very significant proven and financially exploitable geothermal energy potential (over 200 MWth). The thermal power station of Nisyros is used as a back-up Power station as the island is connected by a submerged cable to the grid of the neighbouring island of Kos. Thus, the case of utilising waste heat from the Power station seems unlikely.

Tab. 3: Key data for Nysiros plants

ISLAND	NISYROS
Permanent Residents	913
Power Station Capacity (kW)	770 (back up)
Water Quantity transported annually (m ³)	80.108
WNI (Water Needs Index)	87,7
Cost of Water per m ³ from Geothermal MED unit	1,74 EUR
Cost of proposed Geothermal MED unit MED (300m ³ /d), Geothermal well (100m ³ /h at 75°C)	620.000,00 EUR

Geography

The Islands and Mediterranean areas are arid lands but with abundant geothermal energy and this needs to be exploited for large-scale production of freshwater from the oceans.

Desalination units are driven by low to medium enthalpy geothermal energy to produce water for domestic and irrigation uses in sites (e.g. islands) with poor water reserves.

Water desalination projects using low and high enthalpy geothermal energy have been built in two Greek islands and they should become a growth sector within a short time along the Mediterranean shores and isolated European islands.

Geothermal Desalination

At sites where drinking water is scarce and geothermal resources with temperatures of 80-100 °C can be developed at acceptable costs (< 7.5 €/GJ and < 2.2 €/m³, respectively), it may be appropriate to consider the option of geothermal desalination. However, such applications are in short supply. For reservoirs with higher temperatures there is also the option to generate geothermal power for use in a desalination plant . But this does not alter the conclusion that the role of geothermal energy for seawater desalination is limited.



BARRIERS TO GROWTH

Although we can recognize a potential of geothermal energy to seawater desalination, the process is not yet developed at commercial level. The main reason for this is that the existing technology, although already demonstrated as technically feasible, cannot presently compete, on produced water cost basis, with conventional distillation and reverse osmosis technologies.

Nevertheless, it is also recognized that there is still important room to improve desalination systems based on geothermal energy.

In sum it can be concluded that under current conditions power generation from renewable energies is not apt to reduce the costs of seawater desalination. Rather, technical design problems and high investment costs associated with power plants based on renewable energy sources will make RO-distillation more expensive. Thus the thermal distillation techniques directly heated from geothermal heat will be the method of choice in most geothermal desalination plants.



RECOMMENDATIONS

Desalination technology has been extensively developed over the past 50 years to the point where it is routinely considered and reliably used to produce fresh water from saline sources. This has effectively made the use of saline waters for water resource development possible. The cost for desalination can be significant because of its intensive use of energy. However, in many areas of the world, the cost to desalinate saline water is less than other alternatives that may exist or may be considered for the future.

Desalinated water is used as a main source of municipal supply in many areas of the Mediterranean and Middle East. Desalting could also be used or considered for many coastal urban areas, and other areas and where it is proving more economical than available conventional sources.

There is no “best” method of desalination. Generally, distillation and RO are used for seawater desalting, while RO and electro dialysis are used to desalt brackish water. However, the selection of a process should depend on a careful study of site conditions and the application at hand. Local circumstances will always play a significant role in determining the most appropriate process for an area.

The “best” desalination system should be more than economically reasonable in the study stage. It should work when it is installed and continue to work and deliver suitable amounts of fresh water at the expected quantity, quality, and cost for the life of a project.

Conclusions :

Water scarcity is an increasing problem around the world and everybody agrees that seawater desalination can help to palliate this situation. Among the energy sources suitable to drive desalination processes, geothermal energy is one of the most promising options, due to the coupling of the dispersed nature and availability of geothermal energy with water demand supply requirements in many world locations.

During the 90s, a Geothermal Desalination Project carried out in Milos, demonstrated the technical feasibility of geothermal seawater desalination, through low enthalpy geothermal energy utilization.

An objective is the development of a least costly and more energy efficient seawater desalination technology based on Multi-Effect Distillation process. Specific proposed technological developments (new design of absorption heat pump, hybridization with other energy, cogeneration and recovering of salt) are expected to both improve the energy efficiency of the process and process economy.

The expected result would be an enhanced MED technology with market possibilities and suitable to be applied in the Mediterranean area and similar locations around the world.

. Seawater desalination in itself is an expensive process, but the inclusion of geothermal energy sources and the adaptation of desalination technologies to this renewable energy supplies can in some cases be a particularly less expensive and economic way of providing water.



. The utilization of conventional energy sources and desalination technologies, notably in conjunction with cogeneration plants, is still more cost effective than solutions based on only renewable energies and, thus, is generally the first choice.

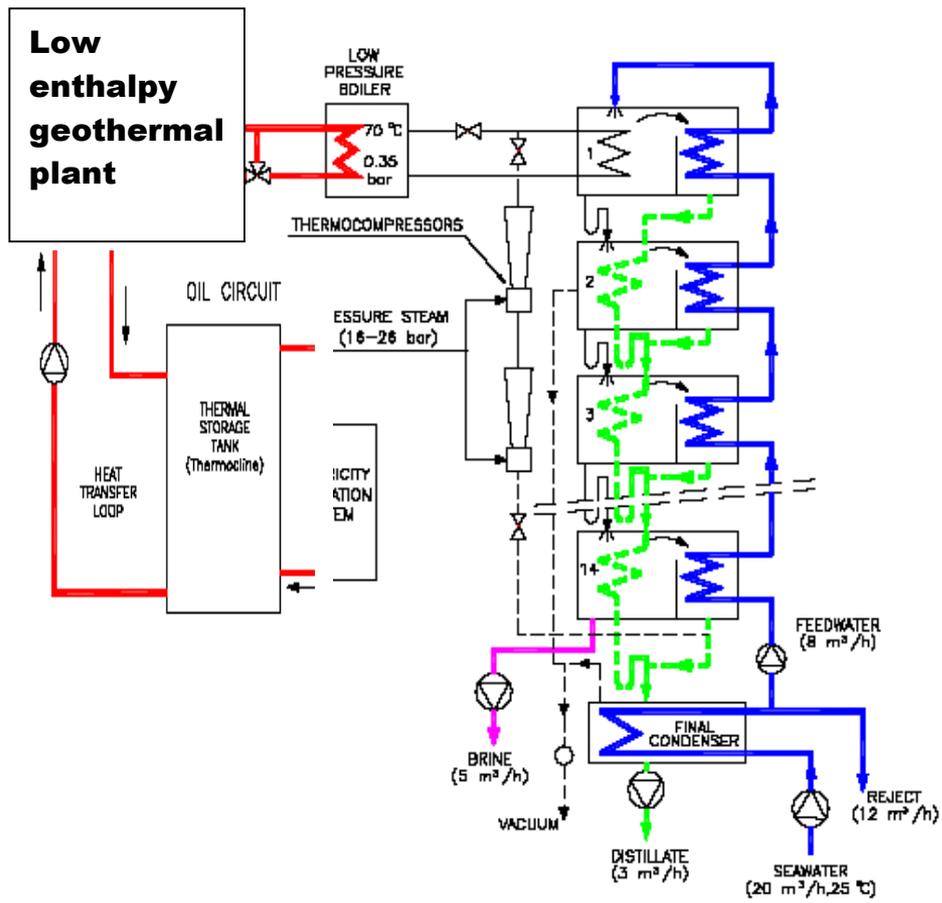
. The use of geothermal energy for thermal desalination can be justified only in niches (e.g. in the presence of cheap geothermal reservoirs) or in decentralized applications focusing on small-scale water supply in coastal regions (e.g. village communities), provided the ability and willingness to pay for desalting is sufficiently large.

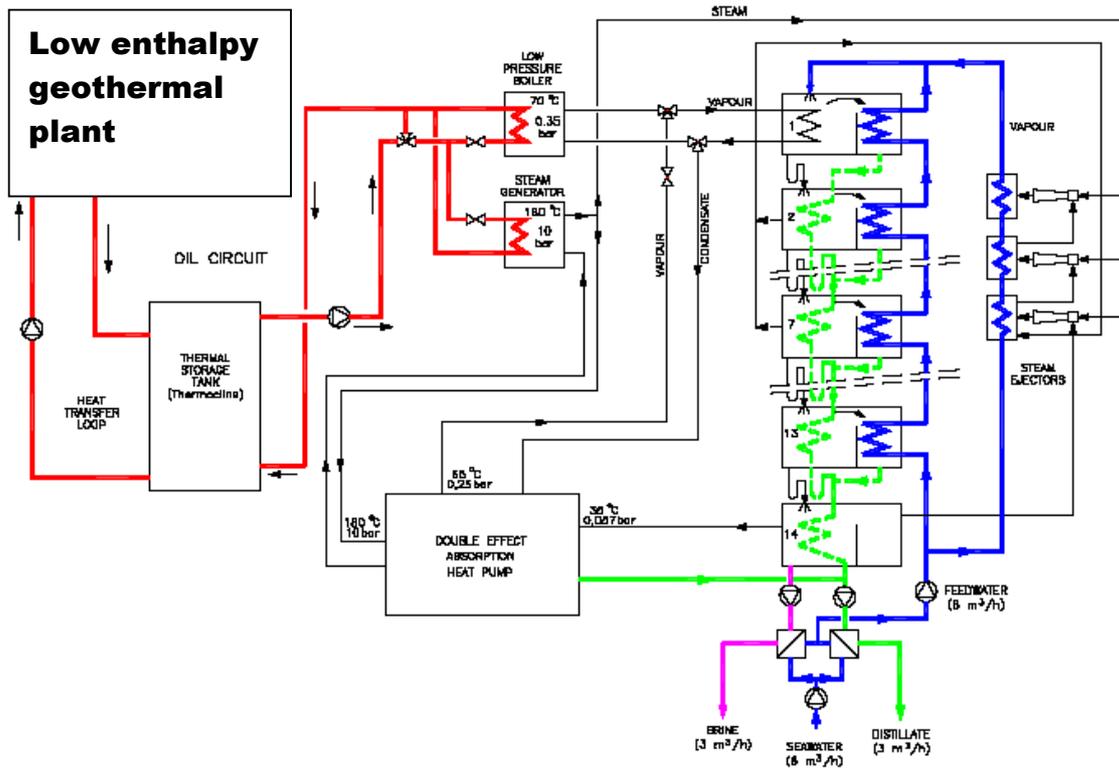
. What may also prove a feasible option is the use geothermal power from cheap reservoirs in coastal areas to desalt seawater in RO-plants.

The Milos project with low enthalpy geothermal energy utilization, demonstrates that through the innovative and sustainable utilization of low enthalpy geothermal energy for electricity generation and seawater desalination, it can substantially contribute to the local water needs.

This technology is sustainable, as it will use only a minimal fraction of the available geothermal potential. It can cover local water demand, as production wells drilled in Vounalia can provide the necessary energy quantity for the seawater desalination plant.

ANNEX







Reference to more detailed sources of information

- *The current geothermal exploration and development of the geothermal field of Milos island in Greece*
Constantine Karytsasa, Dimitrios Mendrinosa, George Radogloub
Geothermal Department, Centre for Renewable Energy Sources, 19th km Marathon Ave,
Pikermi-Attica, Greece
GHC BULLETIN, JUNE 2004
- *Integrated Power and Desalination Plants*
UNESCO-EOLSS
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