Blue Plan Notes
Environment and Development in the Mediterranean
N° 16 July 2010

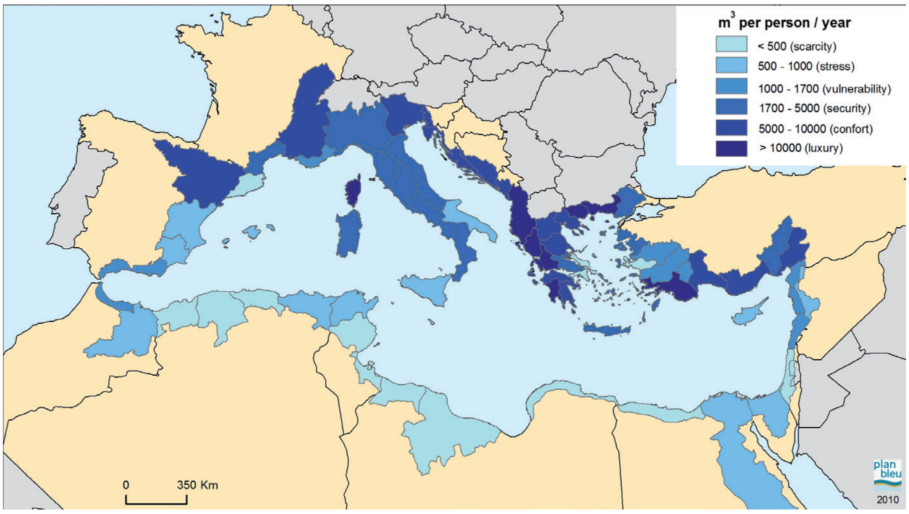
Sea water desalination: to what extent is it a freshwater solution in the Mediterranean?

Sea water desalination stands out, in a number of Mediterranean riparian countries in a water stress situation, as an option to secure drinking water supply for the population of coastal areas, and this, in view of the rapid growth in water demand in the agricultural and industrial sectors.
The major limitations of this system are related to its energy consumption per m^3 produced and to the environmental impacts due to the brines discharged into the environment. Despite these constraints, desalination plants are growing around the world and now, desalinated water supplies an increasing number of Mediterranean households.
Today, over 15,000 desalination plants in the world produce around 56 million cubic meters per day, while the world drinking water production capacity is in the order of 500 million cubic meters per day. In the Mediterranean, the production of desalination plants totals 10 million cubic meters per day.

Development of desalination to address water scarcity

The Mediterranean comprises 60% of the world so-called water "poor population", that is, those with less than 1000 cubic meters of renewable water resources per inhabitant and per year (*figure 1*).

Fig. 1: Renewable natural water resources per inhabitant in the various basic Mediterranean basins (between 1995 and 2005)



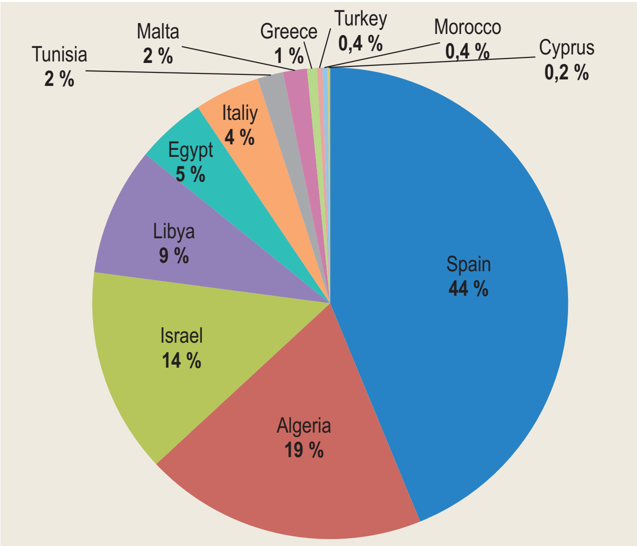
Sources: Various/Cartography Plan Bleu

Shortages have been observed over the past few decades, and global climate change impacts on the water cycle- precipitations, evaporation and runoff-, even though still difficult to quantify within foreseeable precise time, are very likely to impoverish the water resources in the region, under the effect of temperature rise and precipitation decrease.

In order to address this situation, Mediterranean countries resort to alternative supply sources, such as sea water or brackish water desalination (*figure 2*). Man-made fresh water production by desalination of sea water or of brackish water has started in situations of insular (Malta, Baleares, Dalmatia, Cyprus, Cyclades...), coastal (Libya) or desert isolation (Algeria).

It is now developing very rapidly all around the Mediterranean. The sea water desalination market is set for high growth in the coming years, with an expected doubling up by 2016. In 2030 the prospects point that the Mediterranean threefold, or

Fig. 2: Distribution of installed desalination capacity in the Mediterranean



Source: H. Boyé, Plan Bleu, 2008

even fourfold, its desalination production, thus reaching 30 to 40 million cubic meters per day.

Four countries located in the North, South and East of the Mediterranean have clearly opted for this alternative.

Spain, with around 1500 operating plants and an installed capacity of over 2.5 million cubic meters per day, ranks in the 4th position internationally.

Algeria commissioned 3 plants in Arzew, Algiers and Skikda, between 2006 and 2009, for a total capacity of 400,000 cubic meters per day. It is envisioning a total capacity of 2.5 million cubic meters per day based on the construction of 12 new plants by 2012.

In Israel, the Ashkelon plant has been producing 320,000 cubic meters per day since 2006 and covers the drinking water needs of over 1.4 million persons. The three companies (Veolia, Maris and H2ID) which operate in the field of desalination in the country have committed to increasing their drinking water production by 25% by end 2010 in their respective plants in Ashkelon, Palmachim and Hadera. The country pursues a desalination production growth target of covering at least 70% of the drinking water needs. Two desalination plants are under construction process in Sorek and Ashdod. Full output of the installations will be reached as from 2013 with a production of million cubic meters per day.

In Libya, the promising potential along 2000 km of coastline allows for the development of alternative solutions. The Libyan strategic plan to promote water resources grants a privileged position to sea water desalination with the objective of installing, by 2012, a total desalination capacity of 900,000 cubic meters per day.

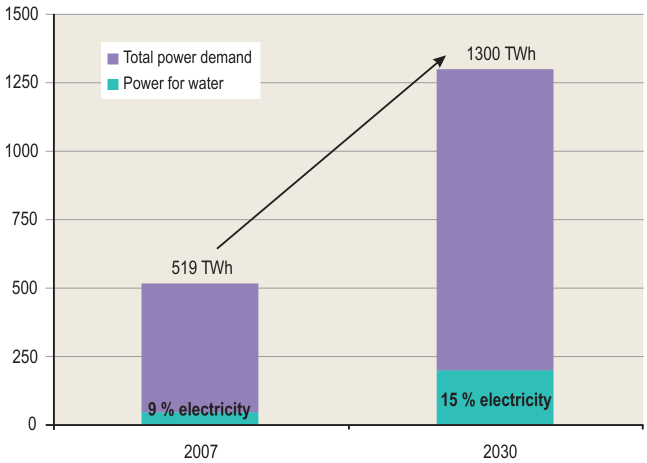
These examples attest to the interest and dynamism prevailing in the Mediterranean region for this type of process.

Energy for water in the Mediterranean: what share for desalination?

Energy and water are interlinked. Energy requirements for water are strongly on the increase, for pumping, transfer, treatment and desalination. Today, power consumption for water accounts for around 5% of power consumption in the NMCs[1] and around 9% in the SEMCs[2] (being around 15% in Israel). In most of the countries, these rates are set to rise in order to meet the increase in demand: resort to deeper boreholes and to more sophisticated transfers, as well as an increasing call of wastewater treatment and of desalination.

The energy needs for water are set to double up within 10 years. They are likely to account, by 2030, for 15% of the overall power demand for the SEMCs, as against 5% for the NMCs and 10% for the whole Mediterranean riparian countries (*figure 3*).

Fig. 3: Power demand for water in the SEMCs in 2007 and 2030 (in TWh)



Source : Plan Bleu

By 2030, the sea water desalination of 30 million cubic meters per day would require 40 to 45 TWh, that is, around 20% of the total power demand dedicated to the water sector at this horizon. This would entail the installation of a minimum power capacity of 5000 MWe dedicated to desalination, i.e. the equivalent of some ten gas-fired combined cycle power plants, or 4 to 5 nuclear plant units.

In order to reduce energy consumption for water, a few research fields seem to be promising for the future: hybrid power plants, energy recovery from the brine generated by desalination plants and use of renewable energies for desalination.

The large solar and wind energy potential of Mediterranean countries can be tapped for desalination

At a global level, around a hundred desalination plants associated with renewable energies have been constructed over the past 20 years. Most of them are small-sized experimental or demonstration plants (0.5 to 200 cubic meters per day). Several of them are located in the Mediterranean (Egypt, Algeria, Tunisia, and Spain). They are powered by energy storage batteries entailing high costs and are hampered by lack of local expertise, especially with regard to maintenance. However, experience shows that well designed, properly operated solar and wind powered

1 Northern Mediterranean Countries
2 Southern and Eastern Mediterranean Countries

small capacity desalination plants can supply in fresh water isolated sites at costs that are, as of now, rather reasonable (*Box below*).

In Morocco, the Office National de l'Eau Potable (National Drinking Water Utility) envisions the construction of a desalination plant of 9000 cubic meters per day connected with a 10 MW wind farm. With a total cost of over 20 million dollars, this project provides for sub-contracting the operation of the plant to a private developer for a 20-year time period. The project is CDM[3] eligible.

In Libya, the General Electricity Company (GECOL) envisions the installation of a pilot-plant of a 300 cubic meters per day capacity for reverse osmosis (RO) sea water desalination, powered by renewable energy sources (wind and photovoltaic).

In Egypt, the Red Sea Province envisions the construction of a mechanical vapour compression (VC) desalination plant powered by a wind farm.

In Spain,

- The city of Murcia has installed the first reverse osmosis (RO) floating desalination plant, powered by a 2.5 MW wind energy unit. Sited in 40 to 80 m deep waters, it transfers its desalinated water via sub-marine pipes to the coast. According to preliminary estimates, the generator would allow a production of 2500 hours/year, generating 2 million cubic meters of drinking water per year, for the supply of a population of 30.000 inhabitants. Besides its energy advantage, this project is significantly environment friendly. Indeed, the disposal of brine will take place in deeper waters, thus facilitating its dilution and minimizing pollution.
- UA solar powered pilot plant will soon be constructed. The cost of the cubic metre would be 0.47 € for a production of 12,000 cubic meters per day. This production would also allow a CO_2 emissions reduction by 14,000 tons.

Sources : varoius

Environmental impacts of desalination plants: Constraints and progress

All desalination processes present drawbacks : i) significant energy needs, ii) disposal of concentrated brine-hot in case of distillation-into the sea, or infiltrated into the soil, iii) use of chemical products for membrane cleaning, iv) traces of heavy metal released by the installations, v) noise caused by high-pressure pumps and certain energy recovery systems, such as turbines.

High-concentration brine discharges (around 70 g/l) and insufficient dilution can impoverish or destroy water ecosystems and cause deterioration of water quality. In order to mitigate this environmental impact, the solution currently adopted consists in installing diffuser systems allowing control over the dilution of brine in sea water, thus limiting the scope of the impacted area.

Evaluation and monitoring of brine and chemical products discharges should also be accompanied by monitoring of the land and-above all-marine fauna and flora.

Finally, GHG emissions are higher if the desalination electrical energy is generated from fossil fuels.

3 CDM: Clean Development Mechanism

Is desalination the future of coastal populations?

The operating costs are mainly impacted by the energy item (*figure 4*), yet the significant drop in cost makes desalination increasingly competitive. The capacity installed worldwide grows by over on average 10% per year. In the Mediterranean region, the installed capacity is likely to pass from 5 million cubic meters per day in 2007 to over 30 million cubic meter per day by 2030.

Any approach aimed at extending desalination must be undertaken with caution. Indeed, large-scale desalination is a large power consuming option.

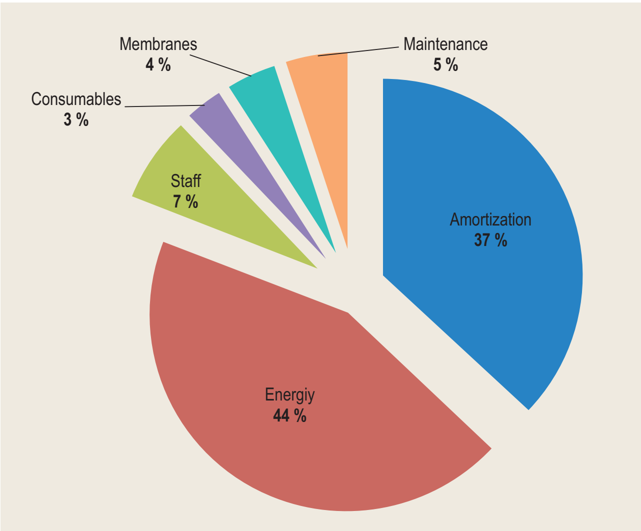
Practically all additional power produced being currently of thermal origin, the risk of a high increase in GHG emissions and untreated brine discharges is high.

Yet, low CO_2 emissions options are possible. More energy-saving desalination processes must be optimized: reverse osmosis (*See Box next page*), with optimisation in combination with thermal power stations, recovery of high output energy and upgrading of existing installations.

Renewable energies (wind, solar photovoltaic and concentrated solar power), applied to desalination, are promising future alternatives, even though their development remains dependent on financing and competitiveness issues. Nuclear energy is a possible medium term option (by 2020), but whose adoption remains dependent on technical and political considerations still the subject of much debate.

Desalination, thus, emerges as a climate change adaptation option whose adoption should not be as a substitute for other "sustainable" possibilities, such as rational water use. Besides, it should grant priority to the production of drinking water for human consumption.

Fig: 4: Share of energy in the operating costs of a reverse osmosis desalination plant (2008)



Source: S. Degrémont

Distillation and desalination by reverse osmosis (RO) are the most common processes, though there are other processes, such as the flash distillation (FD) process used in the Middle East, or electrolysis. The reverse osmosis desalination technology is gaining market share and becoming dominant. In 1990, RO accounted for 40% of the installations worldwide. Today, this process claims around 60% of the installations. By 2025, projections predict 70 % for RO, as against 20% for Distillation and 10% for the other techniques (IAEA-CEA).

Reverse Osmosis (RO): “Membrane”-based technique resting on pressurised ultra-filtration through membranes whose pores (holes) are so small that even salts are retained. A rapidly growing technique, with a fairly moderate energy cost (≈ 4-5 kWh per cubic meters), it currently presents a proven system that has demonstrated its reliability.

Multiple-Effect Distillation (MED): This system provides very pure water but with high energy cost (15 kWh per cubic meters).

Multi-Stage Flash Distillation, or Flash System (MSF): It is used in the Gulf countries where it produces water whose residual salt rate is non negligible. The energy cost remains high (10 kWh per cubic meters).

Vapour Compression (VC): It produces pure water for a fairly moderate energy cost (5 kWh per cubic meters).

Distillation by Depression (DD): Based on the principle that evaporation temperature depends on pressure, this system produces very pure water at a low energy cost (2 to 3 kWh per cubic meters). It is used for small-sized plants.

Solar Distillation (SD): The solar furnace concentrates, within a limited area, the heat rays based on a parabolic reflector in order to bring to high temperature the element containing the water intended for evaporation.

Wind systems for water production by condensation: the principle consists in drawing up ambient air then letting it condense via a cooling process powered by electricity produced by a wind turbine. The condensation aggregate forms ultimately the water that will be stored in the mat before it is filtered for consumption.

Electrolysis: A power current causes the ions to migrate to the electrodes. A quite cost-effective system for small salinities: the energy to be deployed is a function of the salt concentration (1kWh/kg of salt extracted). This system is very cost effective for brackish water, but is prohibitive for sea water.

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Ashkelon 320,000 cubic meters per day: The largest operational unit in the Mediterranean

Source: http://www.water-technology.net/projects/israel/

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