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Desalination: A Viable Answer to Deal with Water Crises?

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Key Points

- There are about 14,500 desalination facilities across the globe but the highest desalination capacity is located in the Middle East. Desalination plants are vital for economic development and social stability in many arid regions. The global demand for desalination units is projected to triple within the next six years.

- Desalination is the only climate independent source of water available. Other alternative sources, such as water recycling and storm water harvesting, still require sufficient amounts of water entering the water cycle to allow them to operate.

- A two-year project, run by the National Centre of Excellence in Desalination Australia (NCED), is testing a new desalination technology designed to supply enough quality drinkable groundwater for remote areas in Australia.

- The technologies most often applied to desalinate water are; multi-stage flash (MSF) distillation, which uses steam, and reverse osmosis (RO), which is a membrane technology.

- Desalination facilities have specific, expensive infrastructure and relatively high energy use, which challenges its economically sustainable development. Developments in desalination and energy efficient technology developments are vital to make the desalination option economically sustainable.

- The two main ways that a desalination plant causes environmental harm are through greenhouse gas emissions, when coupled to a power plant, and degradation of marine environments. Improvements are being undertaken to minimise environmental harm caused by desalination processes.

- When considering the viability of a desalination plant, a comparison of market drivers and restraints is essential. At present, key market drivers are in favour of an expansion in the global desalination market.

Analyses

To deal with the increasing global water crisis, desalination plants have become the latest vogue, providing alternative fresh water sources. There were about 14,500 facilities in 2010 and approximately another 240 units under construction. The global number of desalination plants is expected to continue to rise for the foreseeable future. This paper will look at the characteristics of desalination plants and outline the main economic and environmental challenges for their sustainable development. It concludes that this development is challenged by issues involving capital costs and energy consumption, gas emissions and the negative impact on the marine environment.

Figure 1 Global Capacity of Seawater Desalination Plants

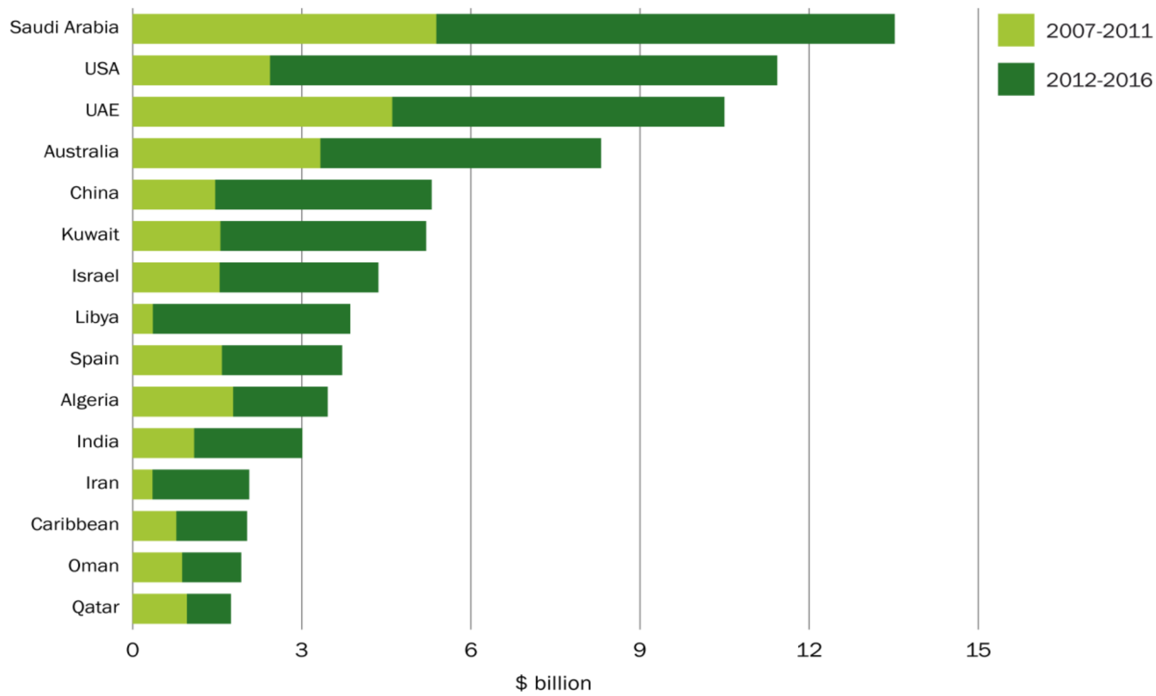
Source: http://www.desertec-australia.org/content-oz/cspdesalination.html

Global occurrence

Most of the global desalination capacity is located in the Middle East, followed by North Africa, the United States and Europe, as Figure 1 indicates. Global Water Intelligence suggests that China has the potential to become the world's second largest desalination market after Saudi Arabia. This prediction follows concerns that the recent drought in the Chinese Yangtze Basin challenges the viability of the South-North Water Transfer Project, intended to transport additional water to the North-East coast of the country.

Desalination plants are viewed as a last water supply option to support economic development and social stability in many arid, coastal areas around the world, where fresh water is not easily accessible. These areas are facing a scarcity of supply from traditional water sources, due to issues related to capturing water from them and /or the uneconomical transportation of collected water. Predictions indicate that the demand for desalination will almost triple over the next six years, resulting in a possible global desalination market that will top $30 billion by 2016 (Figure 2).

Figure 2 Value of regional desalination markets



Source:http://www.prlog.org/10987382-desalination-market-in-libya-to-reach-4781m-by-2016-new-gwi-report.html

Alternative water source

Water is the most important resource for the existence of human kind. Estimates show that 97.5 per cent of the earth's water is seawater and 2 per cent is in the form of ice, leaving only 0.5 percent as fresh water. The supply of desalinated water is possibly one of the only water resources that does not depend on climate patterns. Desalination stops dependence on long-distance water sources and even prevents local traditional water sources from being over-exploited. This alternative water source is suitable for dry countries. Australia, for example, depends on rainfall and aquifers to supply reservoirs and dams and most major cities are located on the coastline close to a source of seawater.

From a global perspective, desalination technology is applied for several purposes, such as: providing fresh water for industrial sectors; supplying high quality drinkable water for the domestic and public sectors; and acquiring water for emergency situations, such as army and refugee operations.

Brackish desalination in Australian remote areas

There are a number of reverse osmosis (RO) units, which desalinate brackish water, in remote areas across Australia and the globe. It seems however, that new desalination technology can become an important component in securing water supplies across Australia. The National Centre of Excellence in Desalination Australia (NCED), hosted by Murdoch University, is undertaking a two-year research project to develop a sustainable and appropriate desalination system. The aim is to supply good quality drinking water to remote areas such as the Tjuntjunjarra community, located 800 kilometres North East of Kalgoorlie in Western Australia.

A new desalination technology, developed by Singapore company Memsys, will be tested to make sure that the Tjuntjunjarra groundwater is drinkable. The Memsys unit is a small capacity thermal-driven membrane distillation (V-MEMD) desalination system, driven by solar-thermal energy and the waste heat produced by small-scale power generators. Project leaders have confidence that this kind of desalination unit will have a unique capability to supply drinkable water to remote areas.

Desalination technology

Desalination of seawater is one of the oldest techniques used to make water drinkable. Due to the improvement of desalination technology, this process can now be undertaken on a huge scale. The most common processes used to remove salt and minerals from seawater are evaporation and condensation, or membrane technology. The desalination process produces low-salinity water. Brine contains a high concentration of salt and is a waste product of the desalination process.

Desalination processes can be undertaken with several technologies. The most common are units based on multi-stage flash (MSF) distillation, which uses steam, and processes using RO, which is a membrane technology driven by electric pumps. MSF desalination technology is mainly used across the Middle East. In recent years, however, RO seawater desalination plants have become more popular, because of their sustainability, cost effectiveness and simplicity, achieved by technological improvement.

Viability of desalination plants

There are a number of principles that need to be, or should be, considered to determine the viability of desalination.

Worldwide, there are a number of desalination plants that have been described as uneconomical and unproductive. Those plants are generally expensive, incorrectly promoted, badly designed or established in unsuitable terrain. Therefore, to make a desalination plant appropriate for a region, the advantages and disadvantages must be carefully studied. American Senior Research Associate with the Pacific Institute's Water Program, Mrs. Heather Cooley, states in her article *'Seawater Desalination: Panacea or Hype?',* that final decisions are influenced by several multifaceted reflections of "local circumstances and needs, economics, financing, environmental, and social impacts, and available alternatives".[1]

Economic and environmental factors are the most important issues in considering the sustainable viability of desalination plants.

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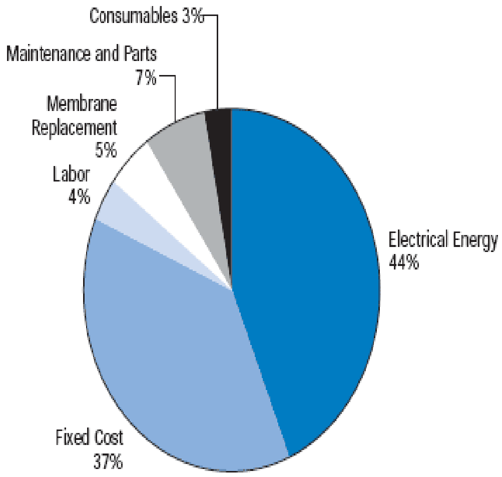
[1] Cooley, H 2010,' Seawater Desalination: Panacea or Hype?', *ActionBioscience.org*, accessed 25 March 2003, from <http://www.actionbioscience.org/environment/cooley.html>

Economic issues

Desalination plants' sustainable development is restrained because major plants use a huge quantity of energy and specific, costly infrastructure. The cost of desalinated water depends on each plant's capacity, location, the water's salt intensity, its energy source and the application of technology. Therefore, it can often be more expensive than collecting groundwater or water from rivers. For example, desalinated water from the Perth metropolitan desalination plant is estimated to cost around $1.17 per kilolitre, whereas supplies from traditional water sources cost less than $1 per kilolitre. In places away from the sea, like New Delhi and Mexico City, it is often more economical to transfer water from traditional resources than to desalinate it.

Energy is the most expensive component of running a desalination plant; it is often responsible for one-third to more than half of the cost of desalination. Therefore, the cost of desalinated fresh water is more vulnerable to the fluctuation of energy prices than any other water source. This influences the industry, especially in countries reliant on international energy prices. On the other hand, the Middle East, with an intense need for desalinated water and where no other solution exists, has water tariffs among the lowest in the world due to low energy prices.

Figure 3 Typical Costs for a Reverse-Osmosis Desalination Plant



Source: http://www.pacinst.org/reports/desalination/20060627.html

It is likely that desalination will remain the most expensive method of delivering water supplies unless more energy efficient technologies can be developed. A report by the United Nations Environmental Programme, explains that an alternative method of reducing a plant's energy consumption is "the development of energy recovery methodologies that will make better use of the energy inputs to the system".[2] Although the cost of desalinating water has decreased over the last decade, due to improved technology and competition in

2 UNEP 1997, *Source Book of Alternative Technologies for Freshwater Augmentation in Latin America and the Caribbean*,oas.org, accessed 25 March 2011from <http://www.oas.org/dsd/publications/unit/oea59e/ch20.htm>

the market, scientists hold different views on whether the cost to establish and manage desalination plants will keep decreasing or whether it has arrived at its cost reduction limits.

Environmental issues

A desalination plant's establishment and operation has the possibility to create different environmental impacts to the atmosphere and its location. The two main ways that a desalination plant causes environmental harm are through its greenhouse gas emissions and the degradation of marine environments.

Greenhouse gas emissions

The majority of desalination plants in operation (and planned future plants) use energy from fossil fuels or nuclear power. For countries in the Middle East, which have a huge quantity of domestic petroleum sources that seems the obvious choice.

Energy generation from both these sources includes serious interlinked environmental concerns. Therefore, growth in the number of desalination plants could result in a larger reliance on fossil fuels and in an increase in greenhouse gas emissions that contribute to climate change. Globally, the use of renewable energy technology as part of the main power supply is becoming more popular. Solar or wind generated energy can be used as a low temperature heat source. For example, by the end of 2011, Western Australia will derive about 30 per cent of its fresh water from two seawater RO desalination plants operated by renewable energy, such as wind. The construction of another plant of the same type for Esperance and Karratha is under consideration.

Marine environment

Construction and long-term operation of a desalination facility can harm the local marine environment. Globally, there have been a number of very badly designed desalination facilities that have produced a common concern among scientists that the huge amount of water taken from the ocean can have harmful consequences to the marine habitat. Marine organisms such as: "adult fish, invertebrates, birds, and even mammals, are killed on the intake screen (impingement); organisms small enough to pass through the intake screens, such as plankton, eggs, larvae, and some fish, are killed during processing of the salt water (entrainment)". [3] Issues of impingement and entrainment, however, have been taken under serious consideration, to minimise the effects as much as possible, especially by the Australian and US desalination industries. Desalination plants have been designed to keep the flow rates at a specific level, so that maritime organisms close to the intakes are able to swim away.

A desalination plant's brine discharge is believed to cause the most significant harm to the marine environment surrounding the plant. Normally, brine contains double the amount of salt found in water collected from the ocean. The release of brine into the sea increases the sea temperature around the outlet. The waste water can also contain the remains of maritime life killed during the desalination process. These issues result in thermal pollution,

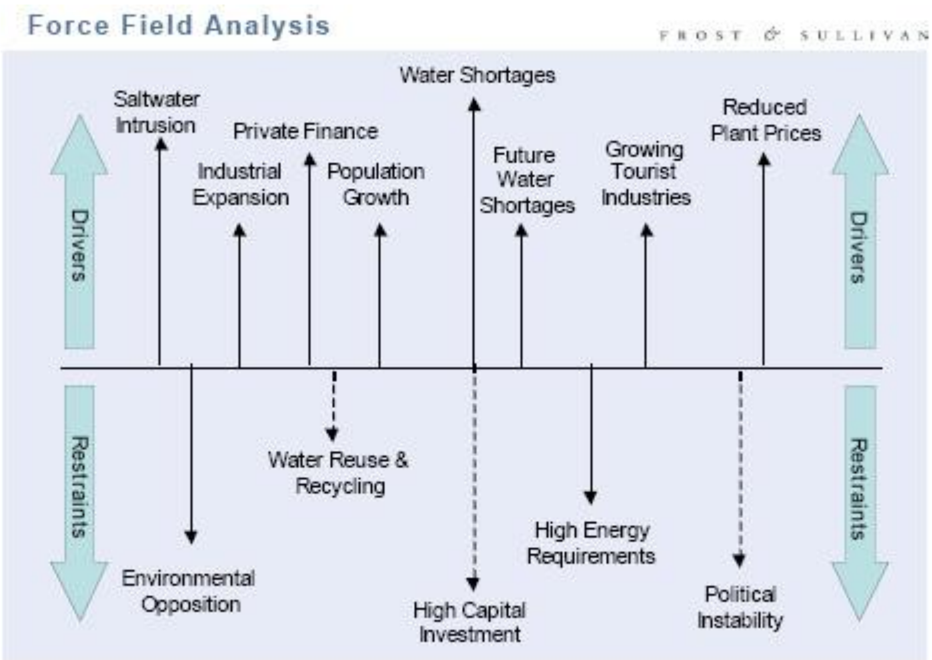
[3] Cooley, H 2010,' Seawater Desalination: Panacea or Hype?', in *ActionBioscience.org*, accessed 25 March 2003, from <http://www.actionbioscience.org/environment/cooley.html>

causing further harm to marine organisms. For example, the Persian Gulf and Red Sea are regions with low water turbidity and a high salt intensity. These areas have already indicated the potential threat of seawater desalination plants to the local maritime ecosystem. There is a global increase in the number of projects, but strict environmental regulations are being implemented to minimise the impact of brine on the surrounding environment, including minimum dilution rates.

Market forces

Consideration of market forces is essential to determine a desalination plant's viability. Figure 4 indicates key market forces (drivers and restraints) that influence the desalination plant market in Europe, the Middle East and Africa. The length of the arrows highlights the significance of each influence. The dotted arrows show where the importance of a particular force is decreasing. Figure 4 indicates, however, that the main drivers favour an expansion of the desalination market. Key market forces that have not been mentioned previously, will be discussed below.

Figure 4 Key Desalination market forces



Source:http://www.idswater.com/Common/Paper/Paper_27/An%20Overview%20of%20the%20Desalination%20 Plant.htm

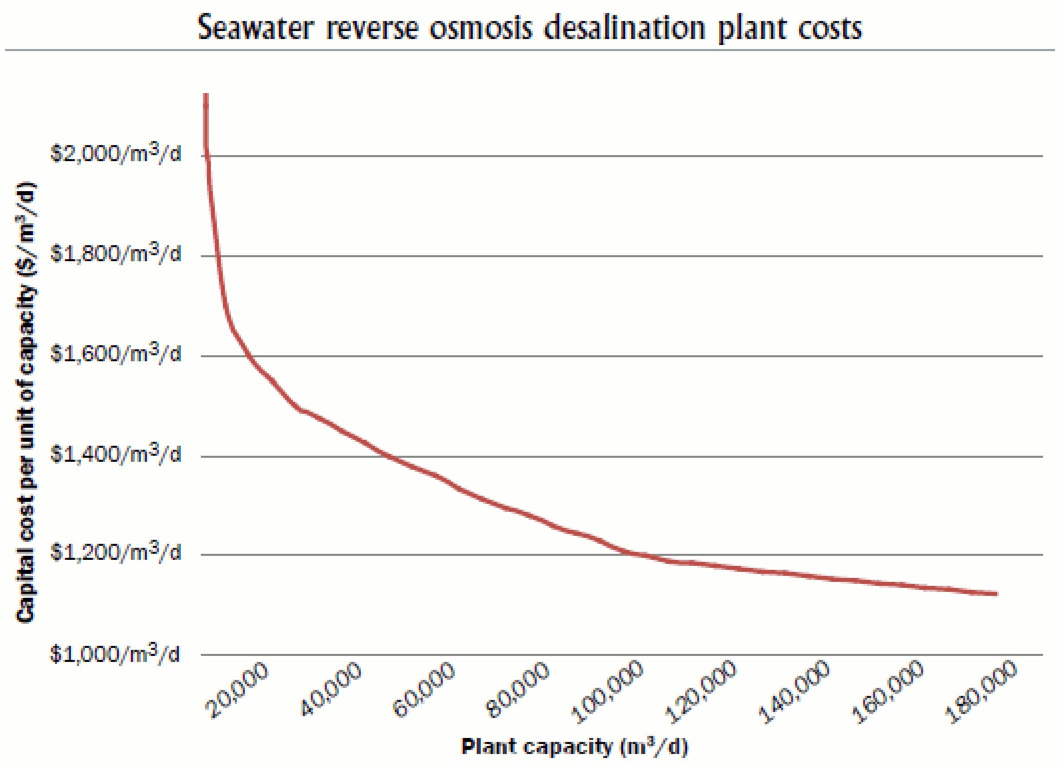
Private Finance

Private financing has become a powerful driver in the increasing construction of desalination plants. Large private enterprises arrange the financing of desalination plants by using financial models on a build, own, operate and transfer basis. Market Analyst Ms. Mili Shah states in her short paper *'An Overview of the Desalination Plant Market in Europe, The Middle East and Africa'*, that "private financed desalination offers large-scale projects to companies with a guaranteed long-term fixed income and is a trend that is being encouraged across Europe, the Middle East and Africa".[4] There are plants in Israel, such as the Ashkelon Desalination Plant, which are run by large private companies.

High Capital investment

The cost to construct and operate desalination facilities is relatively high compared to other water sources. Therefore, it is often only large water supply companies, with a high number of consumers and large industries, which have considered the desalination option. Figure 5 indicates typical capital costs of an RO-seawater desalination plant. If the price to establish and operate desalination plants continues to decrease, however, this key market restraint is predicted weaken.

Figure 5 RO-desalination capital costs



Source: http://www.globalwaterintel.com/archive/10/11/analysis/seawater-reverse-osmosis-desalination-plant-costs-chart.html

Political stability

Political stability is an ideal requirement for the establishment of desalination facilities. Conflicts result in economic insecurity, producing high inflation and currency fluctuation. Therefore, the global desalination market could be affected by a shortage of domestic funding and a lack of international investment into unstable economies. For example,

[4] Shah, M 2011,'An Overview of the Desalination Plant Market in Europe, The Middle East and Africa', in *idswater.com*, accessed 22 March 2011, from <http://www.idswater.com/Common/Paper/Paper_27/An%20Overview%20of%20the%20Desalination%20Plant.htm>

regions in the Middle East suffer from this market restraint. The Middle East has become one of the most unstable political and economic areas, due to major events such as the Iraq war and the conflict over Palestine.

Environmental opposition

Although limited research has been undertaken on the environmental impacts of desalination plants on the maritime ecosystem, developers are encouraged to include environmental considerations in the design of desalination infrastructure and improvements to desalination technologies. To weaken this market restraint and secure desalination plants as a viable option, several principles need to be considered.

To be suitable, the location must be in an industrial zone with enough available land. The location should be away from residential zones and schools, due to the enormous noise pollution of desalination facilities. Desalination plants should be close to a power station and the ocean, to minimise the length and cost of pipe lines. Environmental institutions should provide an environmental assessment before a plant is built or expanded. It is also essential that a plan is established to deal with environmental issues caused by brine discharge.

Finally, to minimise, or even prevent, environmental consequences, permanent observation of the plant must be established. Finally, to minimise, or even prevent, environmental consequences, permanent observation of the plant must be established. The need for integration of sustainability principles into all projects is especially being recognised in Australia and the US.

Conclusion

Desalination plants have been established in arid, coastal areas around the world to improve economic and social development. In the future, the number of desalination plants is likely to increase, especially in areas where traditional water sources struggle to meet the demand for fresh water. Desalination of water can potentially be a viable, option to deal with the global water crisis. As this report clearly indicates however, the establishment and long-term operation of desalination facilities involves economic and environmental sustainability challenges. The global desalination market's effectiveness and sustainability can only be secured if economic and environmental challenges and other market restraints are minimised.

High capital cost is a significant challenge for desalination plants' sustainable development. The costs of desalination are influenced by many factors, such as the plant's size, location, salt-intensity and the development of applied technologies. Desalinated water prices are vulnerable to energy price fluctuations due to the plants' high energy consumption during operation. The capital and operational costs of desalination can be reduced by improving desalination and energy efficiency technologies.

Environmental issues, such as a desalination plant's greenhouse gas emissions when coupled to a power plant and its negative impact on the marine environment, have to be addressed to meet the precautionary principle of sustainable development, which highlights a 'better safe than sorry' approach. To achieve environmental sustainability, requires a suitable location, plans to deal with the negative impact of brine, and the establishment of permanent observation of plants. In recent years, desalination industries, especially in Australia and the US, have made great improvements in addressing environmental concerns.

Any opinions or views expressed in this paper are those of the individual author, unless stated to be those of Future Directions International.

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