AGE Education Programme

# Water Desalination – What Future?

## In Brief

It is estimated that up to one fifth of the world’s population does not have access to clean and safe drinking water. This position is, of course, estimated to deteriorate as population growth continues to outgrow water availability. Although Australia is itself in the middle of growing concerns over water availability, by far the worst-affected regions are Asia and North Africa. In these arid and semiarid areas tensions are mounting over water resources.

If water cannot be obtained from a natural source, what then? Desalination of seawater seems to be the obvious answer. Desalination is the process of making drinking water from water that contains salt: either seawater or brackish water, or water that is otherwise not drinkable: recycled water.

However, the production of potable water from a saline source is not what could be considered by today’s standards to be an energy efficient or cost-effective process. Desalination currently relies primarily on fossil fuels and so contributes to increased levels of greenhouse gases. The production of potable water also creates a waste stream of brine that needs to be disposed of.

# Techniques

## Distillation

Distillation in its simplest and most widespread form includes evaporation from the sea’s surface to form clouds, which in turn form rain. This is equivalent to the process that commercial desalination plants have been employing for many years. However there are problems when distilling water in very large quantities to prove sustainable: initially, large amounts of energy are required to fuel the process, which in turn is very expensive. A popular method for overcoming this is to cogenerate: that is, use the waste heat from another process, such as a generator in a power station, to fuel a desalination plant.

The major technology in use is the multi-stage flash (MSF) distillation process, using steam, and gives purer water than that created using the Reverse Osmosis technique.

## Reverse Osmosis Technique (RO)

Osmosis is a natural process that occurs in all living cells, allowing salts and minerals to pass beyond a semi-permeable membrane to equalise the concentrations on either side. Reverse osmosis, commercialised in the 1970’s, is the opposite of this process, as it relies on a semi-permeable membrane to *separate* the salt from the water. The tiny holes in the synthetic membrane do not allow salt to pass through, thereby separating it from the water.

The process is not automatic and relies on applying high pressures on the salt solution, forcing the water across the membrane. The process also relies on a constant feed of the saline water, to ensure the osmotic pressure does not rise too far, and removal of the resulting concentrate and fresh water. This flow creates what is known as a ***cross flow*** and ensures that the membrane is continually flushed.

As simple and cost-effective as this may sound, it’s actually not – the process is run by electric pumps and requires very high pressures to force the water through the membrane. Reverse osmosis requires about 6kWh of electricity per cubic metre of water (although this is dependent on the salt content of the water). The MSF distillation process requires heat at 70-130°C and uses 25-200kWh/m3.

Other pre- and post-treatment steps are also required to ensure water of a very high quality. Pre-treatment involves processes that minimise membrane fouling by salt precipitation or microbial growth. Post-treatment consists of stabilising the water and preparing it for distribution. Post-treatment can also consist of adjusting the pH and sanitising the desalinated water.

## Integrated Nuclear Desalination

An obvious use of the power generated by a nuclear power plant is to additionally fuel a desalination process when grid load demands are low. In many cold-climate countries, nuclear energy has long formed the basis of heat and electricity generation. As the infrastructure is already in position, it makes sense to utilise the by-products of the facility and to utilise its energy when grid loads are lower.

Climatic conditions in most of the Russian territory are severe, which has lead to the development of nuclear reactors not only for electricity production but also for heat generation. Since 1974 Russia has been operating the Bilibino Nuclear Cogeneration Plant, providing safe nuclear electricity and heat supply of the city of Bilibino and the surrounding area. Additionally, they are able to run a desalination plant off the back of the nuclear plant.

Integrated nuclear desalination has also proven successful in Kazakhstan, successfully producing electricity and potable water for many years. Approximately 60% of its power was used for heat and desalination.

When comparing costs, a nuclear plant consisting of two VK-300 power units allows production of distillate (up to 300 000m3/ day) with the cost of US$0.58/m. In this case, the electricity supply to the power system is 357 MW(e) and the electricity cost is US$0.029/kWh.

## What the Rest of the World is Doing...

### Japan

In Japan, a dozen desalination plants linked to pressurized water reactors operating for electricity production have yielded 1000-3000 m3/day each of potable water.

### South Korea

South Korea has designed a nuclear reactor that generates both electricity and up to 40,000m3/day of potable water. The reactor has a long design life and only requires refuelling every 3 years.

### Spain

Spain is building 20 reverse osmosis plants in the southeast of the country to supply over 1% of the country’s water.

### UK

The UK is planning a reverse osmosis plant for the lower Thames estuary, which contains brackish water suitable for desalination.

Many other countries are considering the feasibility of building desalination plants, either standalone or based on a cogeneration scheme. Such countries include Algeria, Morocco, Tunisia, Argentina, Egypt and India. It is expected that these plants will be able to produce in excess of 150,000m3/day of drinking water for each region.

Safety and reliability are key considerations and most countries have requested technical assistance from IAEA (the UN’s International Atomic Energy Agency). Large scale deployment of nuclear desalination on a commercial basis will depend largely on economic issues. IAEA is researching and collaborating on this issue with more than 20 countries.

## Sydney’s Desalination Project

There are several factors that have determined Sydney building a desalination plant in Kurnell. Unpredictable climate and a rapidly increasing population are certainly the two major factors.

Rather than adopt the nuclear approach of most other countries in the world, Australia is proposing to run the desalination plant in Kurnell powered 100 per cent by green (renewable) energy. This green energy is derived from sources such as wind, hydro and solar sources and contributes absolutely no greenhouse gas emissions. The desalination plant is also designed to recover over 90% of the energy used in the process, thereby reducing energy loss and use.

The desalination plant is designed to have a production capacity of 250 million litres a day, or about 15% of the water supply. The plant can be increased in size to 500 million litres per day if needed. The estimated cost of the whole project is now around $1.76 billion.

The NSW Government's Metropolitan Water Plan details how Sydney will be able to meet its future water needs to 2015 and beyond. The focus of the plan is to save around 145 billion litres of drinking water a year by 2015. This will be achieved by:

* recycling 70 billion litres of wastewater a year
* investing $100 million a year inspecting and repairing leaking pipes
* saving 40 billion litres of drinking water every year by providing rebates for rainwater tanks and water efficient washing machines

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