Making water – hold the salt

Desalination technology is becoming more efficient, and more feasible. Proponents say it now makes good sense in Australia, but critics argue that wider environmental impacts must still be taken into account. **Steve Davidson** reports.

Perth is doing it, Sydney is thinking about it and many Middle East countries have done it for years, yet some experts consider it a big mistake. Desalination – removing salt from sea, ground or waste water to produce fresh water – is a hot topic in Australia. Some see it as a logical, practical and sensible approach to our water supply problems in this dry, salty country surrounded by seawater, but opponents talk of the expense and negative environmental impacts.

What are the economic and environmental pros and cons of desalination and what part should it play in Australia? And does desalination have any runs on the board yet?

Dr Tom Hatton, Deputy Chief, CSIRO Land and Water, is enthusiastic about the prospect of desalination in Australia. 'We already have a dozen or so small-scale desalination plants up and running in Western Australia. Mining companies in various areas of the state are using these to supply water for mining operations and for remote communities. The inland plants convert low-quality groundwater or seawater into drinkable fresh water.'

Overseas, large-scale desalination is commonplace in the water-challenged Middle East, being widely used in oil-producing countries of the Saudi Peninsula and in Israel. It also supplies water in Florida and Texas in the United States, Spain, Trinidad, Cyprus, Malta and, closer to home, Singapore is now building a large desalination plant.

Meanwhile, Western Australia is going ahead with a government-funded seawater desalination facility at Kwinana that will be able to generate up to 45 gigalitres (45 billion litres) of drinking water per year or 130 million litres a day (see box on page 25). This is about 17% of the city's current restricted requirement.

The desalination debate

The big advantage of desalination is that it is independent of drought and climate change, unlike water supplied from rivers or reservoirs. This provides a reassuring robustness and certainty of supply in a country where climate variability is pretty well the norm. Our unpredictable climate means that a given population in Australia requires about five times the water storage of the same number of people in the United Kingdom.

One problem, though, is that desalination is an energy intensive process. Whereas nature has little trouble making rainwater by solar-driven evaporation from the oceans, when we attempt to mimic this, for example by thermal distillation of seawater, we have to use large amounts of energy. This usually comes from fossil fuels, so as well as the expense, there is the disadvantage of CO_2 emissions. Critics say desalination could worsen climate change, by adding to greenhouse gases, thereby exacerbating water shortages.

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However, proponents of desalination argue that, as the technology improves, energy inputs, and hence CO_2 emissions, are declining. Use of reverse osmosis membrane technology (essentially filtering water through a membrane under pressure) rather than distillation (boiling and condensation) drastically lessens the energy requirement because the water does not need to change state from liquid to vapour.

Reverse osmosis requires just one-quarter of the energy needed for thermal distillation. Ongoing R&D in membrane technology is also incrementally reducing the pressure necessary to drive the water through the membrane, further reducing energy use. Energy recovery technology is also improving with time.

At CSIRO Land and Water, in Western Australia, researchers led by Dr Olga Barron are planning trials of energy efficient, two-stage nano-filtration systems and of in-bore groundwater desalination. They are also developing a demonstration reverse-osmosis desalination plant in Katanning, in the WA wheatbelt. The latter will produce 250 kilolitres of fresh water per day from salty groundwater within a 40-hectare area, and will help mitigate waterlogging and salinity problems.

The WA Water Corporation intends to offset the CO_2 produced by desalination at Kwinana by planting enough trees, several thousand hectares, to lock up the equivalent amount of CO_2. Planting the trees could also help lower water tables in the state's troubled wheatbelt. Sounds good, but opponents worry that the effort may not continue for the life of the desalination plant. The challenge is there for the Water Corporation.

Incidentally, the desalination plant itself will produce no CO_2, but its electricity consumption means greenhouse gas emissions equivalent to 100 000 tonnes of CO_2 per 45 GL water per year.

Is desalination too expensive?

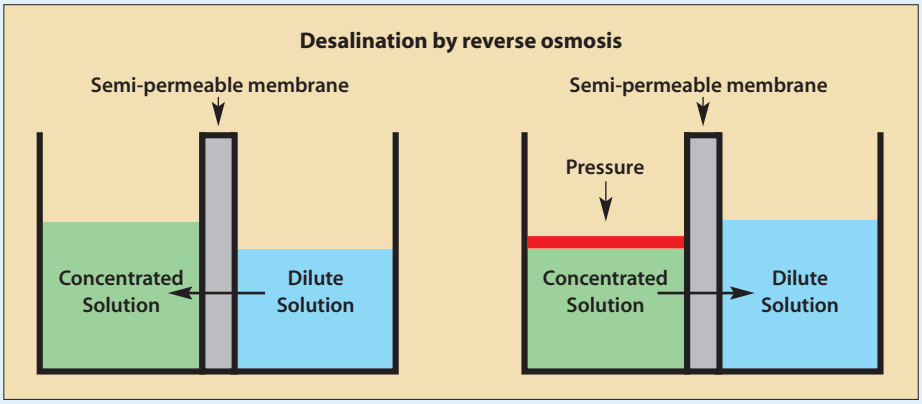
Another consideration is cost. Professor Uri Shamir of the Technion-Israel Institute of Technology, says the cost equation is changing and desalination is coming under increasing consideration in dry countries, at least for areas close to the coast. He says the viability of desalination improves as the cost of water from other sources rises – due to distance, quality and environmental effects, not to mention political pressure – and as the cost of desalination drops.

Shamir puts the cost of desalination using seawater, in Israel, at 52–55 US cents per cubic metre for large-scale plants, excluding delivery to the consumer. This is the contract cost for a large plant due to come on-line this year. The cost of water from smaller plants is slightly higher, while treatment of brackish or polluted groundwater is much cheaper.

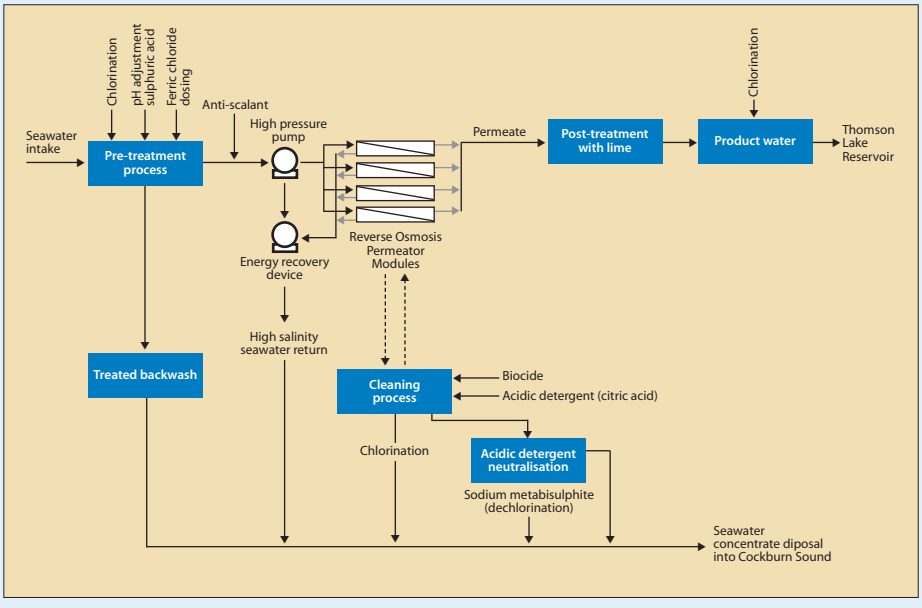
Although most desalting plants now use some form of energy recovery device to improve efficiency, energy remains the largest single operating and maintenance cost, usually exceeding 50% of the total. Hatton says this needs to be seen in perspective. People forget that other options – such as pumping water long distances, say from the Kimberley region to Perth (now under investigation), or building new dams – also burn up lots of energy and they too have environmental costs.

According to the WA Water Corporation, a Kimberley pipeline would cost $11 billion to build and have an annual operating cost of $100 million, whereas the capital cost of the Perth Seawater Desalination Plant is expected to be $346 million with an annual operating cost of just $24 million. In terms of energy, the desalination plant will use one-third the electricity (per cubic metre of water) that a Kimberley pipeline would.

The overall cost of desalination is declining by about 4% a year according to Hatton. Indeed, the improved economic and environmental credentials of desalination were used as justification for New South Wales Premier Bob Carr's change-of-heart on the merits of desalination last



Left: Under normal osmotic conditions, pure water diffuses through a semi-permeable membrane towards the solution of higher concentration, equalising solution strength. Osmotic pressure creates a height difference in columns. Right: Under reverse osmosis, applied pressure in excess of osmotic pressure reverses the water flow direction, forcing it back through the filtering membrane. Water Corporation



An outline of the desalination process to be employed by Perth's Kwinana plant. Water Corporation

year. The state has now allocated $4 million to a study investigating desalination.

Solar thermal technology

Desalination might also benefit from a revolutionary method for harvesting solar energy that has been developed by two-year-old company Solar Heat and Power (SHP). The company is currently building the largest solar array in Australia at Liddell power station, NSW, for Macquarie Generation.

Managing Director of SHP, Mr Peter Le Lièvre, says this solar thermal electricity technology could be a perfect partner for desalination plants, whether the are reverse osmosis or thermal systems. The new technology comprises an innovative, low-cost solar array system for producing steam, low-temperature turbines and underground thermal storage in pressurised water.

'Within five years,' says Le Lièvre ' the technology will be capable of large-scale electricity generation at a price competitive with fossil fuels. If used, say, to power desalination, it would eliminate greenhouse gas emissions.'

'To cut a long story short, we have done the sums and we think we can desalinate at a cost similar to or even less than fossil-fuelled plants and with zero air pollution,' says the Chairman of SHP, Dr David Mills. 'We have advised the NSW government and Premier of our progress.'

Stage one of Solar Heat and Power's solar array at the Liddell power station in NSW. Solar Heat and Power

Professor Stuart White, Director of the Institute for Sustainable Futures, is not a great fan of desalination plants. He and his colleagues argue that desalination should be left as a last resort, given its cost relative to improving water efficiency.

'Improved water efficiency provides water at a lower unit cost than new supply options like desalination plants or even large-scale effluent re-use,' says White. 'We suggest that Australia should be investing in water efficiency strategies first … and so far we have only seen the tip of the iceberg in terms of the level of water savings that can be achieved.'

Progress on Perth's plant

The Kwinana Plant, being undertaken by Water Corporation, is an ambitious project. Using membrane technology to separate salt and impurities from seawater, pumped from the nearby ocean, it will, when completed, be the largest desalination facility in the Southern Hemisphere. The plant will complement dam water and groundwater as a third water source for Perth and some other towns.

'Desalination is a proven technology capable of delivering large quantities of water independent of the weather,' says Michelle Rhodes, Project Environmental Manager at Water Corporation. 'Our rainfall in this region has been significantly below average for some eight years now and both our underground and surface water supplies are not receiving sufficient recharge to meet water demands.'

A view of Kwinana, looking south. The Perth Seawater Desalination Plant will be located south of the Western Power inlet and outlets and north of James Point as shown. Water Corporation

She says desalination provides a source of water that is independent of the vagaries of weather and will bring balance to the region's portfolio of water sources. At this stage, the Water Corporation is on target to have the plant 'up and running' by summer 2006.

'Water Corporation considers the desalination plant an important step towards weather-proofing Perth's water supply,' says Rhodes.

Two consortia, Perth Desalination Company and a Multiplex and Degremont joint venture, prepared bids for the project. In April this year, the Western Australian Government announced that the joint venture was the winning tender and would build the plant. Water Corporation expects the plant to be completed by October 2006.

And what if rainfall returns to normal? The Water Corporation says that this is not the prediction for southern WA, but if the region does experience wetter periods and water storages once again fill to the brim, the desalination plant can still be managed, for example it could be geared down, according to circumstances.

More information:
Water Corporation Kwinana Project: www.watercorporation.com.au/water/water_sources_desalination.cfm

Contact: Michelle Rhodes, (08) 9420 3681, michelle.rhodes@watercorporation.com.au

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The Point Lisas Desalination Plant, Trinidad

Mills puts it differently. 'We need to use water more carefully and also obtain sources of fresh water that do not harm the environment. Whether we use one or the other should be based upon the socio-economic cost. But remember that dams remove fresh water from the natural environment by diverting water from fragile river systems or by depletion of ancient aquifers.'

'By contrast, desalination imitates the natural renewable rain cycle,' says Mills. 'I would suggest that the best way to have a minimal impact on the environment would ultimately be to desalinate all of our water from the oceans, using solar technology, and then recycle this in order to keep the cost down.'

What about salt discharge?

Of course, the water leaving desalination plants at brine outfalls is saltier than the feed water going into them. Is this a concern for the environment? The Water Corporation points out that for every two litres of water coming into the plant, one litre of water is returned with the same amount of salt. Therefore salt is not being added to the environment but rather fresh water is being removed. The salt in-take is returned. But this leaves the question of whether the higher salt concentration of the discharge water has any effects.

The Environment Protection Agency has set strict criteria for discharge salinity. It requires that the salinity immediately after discharge, within 50 metres of the discharge point, must be within plus or minus 1.2 parts per thousand (ppt) of background levels. By the time the discharge is more than a kilometre offshore, salinity must be within 0.8 ppt of background levels, which naturally ranges between 33 and 37 ppt in Cockburn Sound.

The Water Corporation's hydrodynamic modelling shows that the discharge at the edge of the mixing zone (50 metres from the diffuser) will be within the naturally occurring variation. The international consultants' modelling was peer reviewed by oceanographers at the University of Tasmania. Some stakeholders, however, have raised concerns about salinity and stratification in the deeper waters of Cockburn Sound.

A team at the University of New South Wales is undertaking a review of the modelling so far. It will be interesting to see their findings and recommendations that were due to be released in March this year.

More information:
Solar Heat and Power:
www.solarheatpower.com

Contact:
Tom Hatton, (08) 9333 6208,
Tom.Hatton@csiro.au
Stuart White, (02) 9209 4356,
Stuart.White@uts.edu.au
David Mills, (02) 9351 3311.