New Developments in Desalination

During Ozwater'23 in Sydney the Desalination Specialist Network held a live Member Circle by way of panel discussion facilitated by **Gary Crisp**, Chief Engineer, Sequana Partners | Desalination Specialist Network Committee Member and Panel Members:

- **Rob Heilbronn**, Principal, Plexus Water & Energy
- **Professor Greg Leslie**, Director, UNSW Global Water Institute and a Director of UNESCO Centre for Membrane Science and Technology
- **Scott Chalmers**, General Manager – Strategic Growth, Osmoflo

Following is a transcript of the member circle.

Water Security

Given that the governments have invested in desalination plants to provide this security, do you expect that desalination plants in the future to be increasingly utilised for 'baseload/bulk' water supply, rather than reliance on traditional sources for bulk water supply?

Undeniable facts:

1. The quantity of water in our World remains the same - the form the water takes, changes.
2. Liquid water is not always where you want it – massive flooding in Italy – worst ever recorded drought in Tunisia. In Australia Lismore has experienced two "once in 100-year" flooding events in the space of one and Perth almost in permanent drought.
3. We can only recycle the water that enters our system – less water entering, less water available for recycle.
4. 96.5% of the Earth's water is in the ocean.
5. Lastly, desalination is typically one of the more expensive ways to produce potable water.

There is no one answer to the question that has been asked and each situation must be modelled on its merits, but one thing is sure, there will always be seawater available. It is a Climate Independent solution, which makes it very appealing to technologists and governments alike.

One case in point is Perth where the decision to firstly, instal a desalination plant at Kwinana and secondly, to use desalination as a base load was a relatively easy one from a technical standpoint. Since the turn of the century our population and demand has increased by almost 30% and our annual rainfall run off has dramatically decreased by 70%.

At the same time supplying artesian water was becoming increasingly environmentally unappealing because our heavy dependence on groundwater in Perth meant that were reaching a point where we were extracting more groundwater than was being replenished by rainfall.

A climate independent solution was the only practical way to proceed.

1. Kwinana desal plant was built in 2006 and supplied 16% of potable water when first commissioned.
2. Binningup started production in 2011 and together with Kwinana is supplying around 50%.
3. A new desalination plant at Alkimos in Perth outer Northern suburbs will begin construction next year (2024) and, together with the plants at Kwinana and Binningup, will supply 54% by 2028.
4. With Phase 2 of the Alkimos plant in operation from 2032 they will provide a total of 64% of Perth's potable water supply.

So, we are seeing a very interesting trend as Perth becomes more and more reliant on seawater desalination and less on conventional sources of supply.

[The only time this is reduced is when we have high inflows to our dams, we then generally reduce production from SSDP (as this is the most expensive desal water) to ensure that the probability of spilling to a minimum.]

Seawater desalination is fundamentally a base load reality for Perth, as it is in for almost all Middle Eastern countries because, put simply, the lack of alternative sources leaves us very little choice and cost of treatment is of lesser importance.

However, because of the relatively high cost of desalination and the need to be close to the ocean, each specific case needs to be modelled. There is no one single solution however there is a thought that one solution lies in a mixture of seawater & brackish water desalination, together with recycling and more specifically Managed Aquifer Recharge.

A proposal that Water Supply and Water Security planning has been historically based around the "Hydro-illogical cycle" (Drought > Concern > Rain > Apathy) with Desal being considered during the drought phase of that cycle. Increasingly it seems governments are recognising the costs and difficulties in executing projects in an urgent manner, and the increasing unpredictability of rainfall patterns – make a climate - or rainfall independent source of water, (i.e., Desal) a very attractive and certainly a useful part of a truly resilient any secure water supply strategy.

Regional Water Authorities are also increasingly aware and looking at what role Desal may play in the supply side.

For example, in 2020 Hunter Water proposed an emergency response Desalination plant at Belmont, and despite reservoirs being fully replenished, the Lower Hunter Water Security Plan recognizes the need for a rainfall independent source, and the project has been reinvigorated and is now under design and planned as a permanent facility producing 30 MLD, with approval expected in 2024.

Sustainability

How will the transition to a more sustainable, low carbon and circular economy change the purpose, design, and operation of desalination plants in the future?

The combined effects of ESG investing and a move to net zero will present a number of challenges for seawater desalination schemes that will require new ways of doing business.
First, Desal plants in addition to providing climate independent water sources, are increasingly seen as stable, long term investment for superannuation and pension funds.

Consequently, desal operations (both private and public) will need to conform to expectations of ESG investing, requiring independently audited and verified actions demonstrating a commitment to minimizing impacts on the environment, implementing actionable plans enabling long-term sustainability and ensuring governance systems are transparent and responsible.

Second, strategies to offset carbon emissions will be impacted by the transition of electricity grid to net zero. In the absence of large-scale batteries or energy storage, desal plants, like other energy intensive operations, cannot operate directly off green energy. Thus, as long term off set contracts expire, existing and new desal plants will have to compete for carbon offsets in a more competitive market. Moreover, as power prices vary during the day, desal plants may need to look at other areas of the water sector that take advantage of low tariff times for maximum production impacting reservoir and storage strategies.

Third, an element of credible sustainability plans, desal plants will need to develop strategies for disposal of used elements. In addition, future research will need to shift focus from the current enthusiasm for novel materials, to research into the use of green chemistry and strategies to extend the useful life (>5 year) and repurpose components from used membrane elements to minimize waste diverted to landfill. Also, plants will exploit footprint by maximizing onsite PV. As Gary Crisp notes *"More and more desalination plant projects in the Middle East include the addition of solar power. At a desalination plant in the Red Sea, a large international digital solutions company has provided full power distribution and process automation solutions. The plant is 15% solar powered, with 2,500 tCO2 avoided annually. They have also recently completed a project in Saudi Arabia, coupling a photovoltaic plant and desalination plant."*

Refer publication Multi-effect distillation: a sustainable option to large-scale green hydrogen production using solar energy – ScienceDirect

Innovation

What are the latest developments in desalination technology?
What impact could the use of AI to optimise desalination plant have on the operating expenses of Australian plants?

SUB-SEA DESALINATION – DUPONT & WATERWISE

Sub-sea desalination presents the potential for a more sustainable way to turn seawater into freshwater. It uses the natural hydrostatic pressure found at the depths of the sea to run the reverse osmosis process with the following claims:

1. Reduces typical desalination energy demand by 40 percent.
2. Requires 80 percent less coastal land than land-based plants.
3. Requires lower amounts of pre-treatment chemicals.
4. Eliminates the discharge of concentrated brine into coastal waters.

A pilot project in Boknafjorden, Norway, has so far demonstrated a 40 per cent reduction in energy compared to conventional reverse osmosis (RO) technologies.

At a depth of 400m, the plant is connected via an "umbilical connection", a cable that provides electricity and communication, as well as a pipeline that brings water back to the shore.

The brine discharged is only 1.3 times [the salinity of seawater]. This is mainly because of the low -recovery design: instead of 65 bar pressure needed with conventional plants, they are working at 40 bar because of lower recovery and the membranes selected.

The distance to the shore will depend on the location to reach the 400m depth, but on average, the company said this would be between 5-7km from the shore.

Results from the Norwegian trial have shown an energy consumption of 1.8-2 kWh/m3 compared to 3.3 to 3.6 kWh/m3 for land-based desalination.

Note: The desalination system combines existing RO membrane technology from DuPont Water Solutions with existing Norwegian subsea technology used in oil and gas applications over the last two decades.