# LARGE-SCALE DESALINATION: What can we learn from Australia?

Wikipedia

***Desalination is bound to take off on a large scale in South Africa in the near future as conventional water resources become increasingly scarce. But what can we learn from other countries where this has already happened, such as Australia? This report from Dawid Bosman, TCTA Senior Manager: Advisory Services.***

Seawater desalination is an immensely scalable and climate-independent water resource, and is being adopted on a global scale. Around 68 Gigalitres of desalinated water is already being produced each day by nearly 15 000 desalination plants (Imagine a cube of water standing as tall as the Empire State building in New York). This capacity is growing by about 12% each year, which suggests that global water scarcity is growing faster than both the economy and the population.

Large-scale desalination will take off in South Africa within the next few years; our surface water resources are already stretched to capacity in many catchment areas, and are vulnerable to changes in climate. But desalination will be only a part of a collective response to address water security, alongside conventional resources, and a multitude of water reuse, conservation and demand management initiatives. Whereas some dams will still be built or upgraded in years to come, a new breed of water infrastructure project will join the project pipeline: the large-scale desalination plant.

Desalination in South Africa is still in its infancy; the largest plant is a modest 25 Ml/day plant treating mine effluent at eMahlahleni. There are also a few smaller, seawater plants that were built by municipalities along the South Coast, often as an emergency response to prolonged drought conditions. Many of these projects have been characterised by technical design flaws, resulting in costly, premature refurbishments.

The next milestone will be desalination on a far greater scale, of 150 Mℓ/day per day and more, when the large metropolitan municipalities adopt the same technology. As one would expect, such a step-up in scale will bring a significant increase in cost and complexity.

The exact timeline to that milestone is not yet clear, but detailed feasibility studies have been undertaken on project options in Cape Town and Durban, and desalination now features prominently in their water resource planning portfolio. Desalination is also under consideration to treat acidic mine water to a potable standard on the Witwatersrand.

These projects will require a very different approach to project design, procurement and institutional framework, compared to what is the norm for conventional water infrastructure. Looking abroad at projects underway or recently completed, it is apparent that they are extremely complex, and can fail to deliver on early expectations. The question is whether our water sector, with its current resources and competencies, is ready to guide the implementation of a successful, large-scale desalination project?

At the TCTA, we are studying the complexities of the desalination challenge, and have set out to learn from the experiences of other countries that have gone on this path before us. Our aim is to gain insight that will help us avoid, as far as possible, the costly design and implementation mistakes made elsewhere.

After an initial desktop study, it became clear that Australia presented a very useful field of study. Between 2006 and 2013, they had built six very large sea water desalination plants, primarily as a response to the Millennium Drought, which lasted from 2003 to 2010. The fairly recent completion of the projects meant that the implementation teams and corporate memories were mostly still intact.

And since Australia has a similar energy mix as South Africa, their desalination technology choices would also be similar. Finally, amongst most of the water utilities in Australia, we encountered a willingness to share information.

Our initial enquiries were met by a positive response from three water utilities, who were also project owners. SEQWater in Brisbane invited us to visit their Gold Coast Desalination Plant, SAWater invited us to the Adelaide Desalination Project, then under construction at Port Stanvac, and Water Corporation in Perth invited us to visit their Kwinana Plant, and to attend a presentation on their Southern Desalination Project, then under construction near Binningup.

The lessons from the tour were documented in a TCTA journal, *Building Best Practice in Desalination: Part 2 – Lessons Learned from Large-Scale Projects in Australia.* What follows here are the key points, in a more concise format.

## CAPITAL EFFICIENCY IS NOT GUARANTEED

When comparing the capital efficiency of Australian desalination projects against other water-supply projects of similar technology, scale and timeframe, the Australian projects dominate the least capital efficient end of the spectrum, and in absolute terms, some of the Australian projects are 10 to 15 times more expensive than the best performing projects of the same capacity.

A number of factors contribute to this extraordinary capital expense. Firstly, environmental compliance is probably the main reason why the Australian desalination projects are so expensive. Australia has perhaps the toughest standards of environmental protection in the world, and a rather activist society.

Secondary reasons for the high cost would include the alliance procurement model, the unionised local labour force, and the risk premium that projects outside the Gulf market tend to attract, due to the absence of a track record of long-term successful projects.

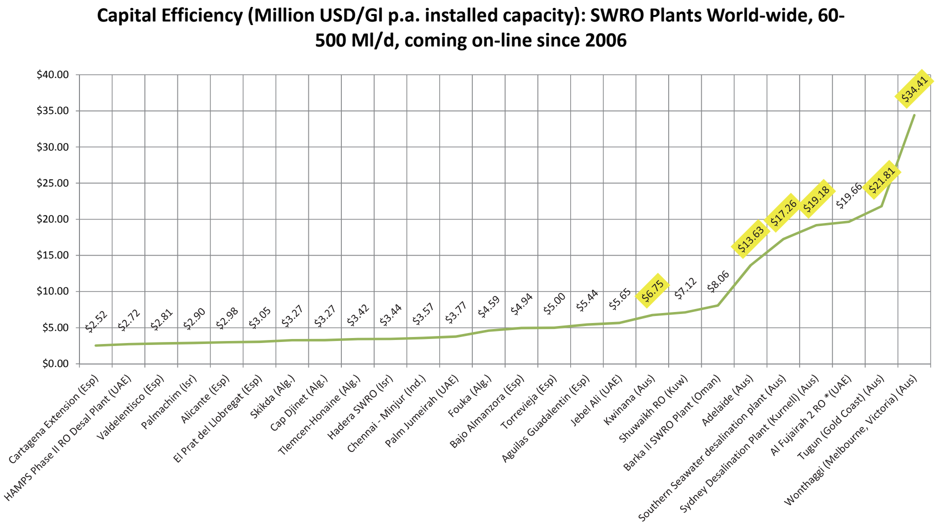


***Figure 1***
*Comparison of Capital Efficiency, XL SWRO Plants, coming on-line since 2006 (DesalData, 2012)*

## GETTING PROCUREMENT RIGHT: THE ALLIANCE MODEL

Large-scale desalination projects are extremely complex to design, build and operate, and this poses a tough challenge to conventional procurement methods. In the Australian public infrastructure sector, the alliance model of procurement and contracting is widely used. In 2012, alliance contracts represented one third of the total value of public sector infrastructure projects delivered.

The desalination projects we reviewed also went this route, before

Courtesy Dawis Bosman

*The TCTA team during their visit to Australia.*

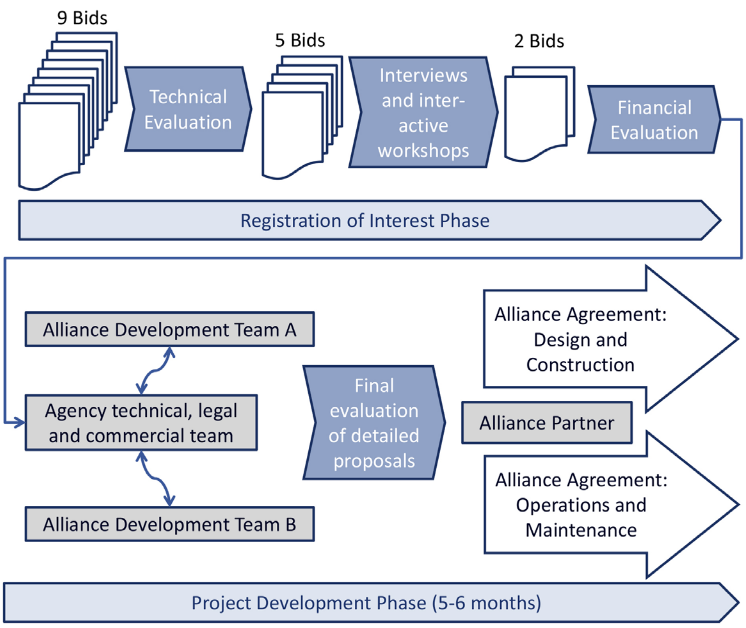


***Figure 2***
*The Alliance Development Process*

entering into long-term design-build-operate-maintain (DBOM) contracts. The idea of the alliance approach is to create a project environment where the interests of both the agency and the consortium are aligned, through smart incentives and risk-sharing arrangements, where the risk of avoidable cost overruns are minimised by design. And because the alliance is such an intimate business venture, it is extremely important to select the right partner – not unlike a marriage. Hence a very thorough process of evaluation and elimination is followed.

The alliance-forming process happens in two phases: The registration of interest (ROI) and the project development phase (PDP). During the ROI phase, consortia are invited to submit their qualifications, proposed personnel and cost estimate for the project development phase (PDP). The bids would contain separate technical and financial envelopes.

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After a technical evaluation, the field of bidders would be narrowed down. Then follows interviews and interactive workshops, after which only two bidders would be selected for the PDP-phase. The financial bids are then opened to ensure that cost estimates are within a predetermined range.

The PDP phase extends over a period of five to six months, during which time the agency will second key personnel to each of the bidding teams, and conduct a continuous evaluation through weekly progress meetings and workshops. This produces two detailed, competing proposals, in whose accuracy the agency will have a high degree of confidence, containing the following:

- Designs completed to about 30-40%;
- All technical and financial risks identified;
- Detailed capital and operating cost estimates;
- Risk and reward mechanisms negotiated.

In the final evaluation, the two proposals are evaluated using criteria that include life-cycle cost, culture, capability and commitment. Then follows a thorough commercial, technical and qualitative evaluation, after which one consortium is appointed as the alliance partner, and thereby chosen to design, construct, operate and maintain the plant in an alliance with the agency.

The alliance model is a fundamental departure from conventional methods of procurement and contracting. Competition for the bid extends quite far into project design. This is costly and time-consuming, and hence the agency reimburses the losing bidder for expenses incurred. This makes it a very expensive procurement process. Yet the advantage is that a long-term partnership on a very complex, strategic and expensive undertaking, is entered into on a well-informed basis.

Clearly, the alliance approach requires a very mature professional environment.

## SITE SELECTION

Site selection is an extremely important decision-point in the design of the project, as the choice will determine the efficiencies and risks that will characterise the plant over its entire lifespan. As a result, site selection is typically preceded by an in-depth investigation into the project requirements, and the degree to which alternative sites will address those needs. Costs and benefits of each site parameter are quantified, as well as the timeframe in which it will occur, and the Net Present Value (NPV) calculated. Allowing for key considerations that could not be quantified, the site with the lowest NPV would usually be selected.

A previously disturbed site can be attractive, as it often presents a lower environmental hurdle. The Binningup site had been used as a stone quarry before, and this eased some environmental concerns. However, the prior use of the site may also be a negative; at the Tugun site (Gold Coast), the site had been previously been used as a landfill, which aggravated the ill effects of sub-standard civil works, resulting in contaminated groundwater ingress into the intake and outlet shafts, and unwanted Methane releases on-site.

A potential site may not have clear access to the beach (the Tugun site has an airport and residential area between itself and the beach), or disturbance of the beach may be restricted due to environmental or social sensitivity. In these instances, the designers may have no choice but to select a tunnel design for the marine intake and outlet. This would add hugely to the cost of the entire project.

The rapid dispersal of brine (the highly saline waste from the desalination process) in sea water, as well as a slow flow-rate of feed water at the intake, are both key design objectives of the marine structures, due to environmental concerns. Whereas the intake flow-rate could largely be achieved through clever design, brine dispersal is very much reliant upon the sustained flow of off-shore currents, which is of course site-specific.

Some plants are more susceptible to brine dispersal problems than others; the Kwinana plant is perhaps the most intensely monitored plant in the world, due to its location within the environmentally sensitive and relatively still Cockburn Sound. During 2008, the desalination plant had to be shut down twice due to insufficient brine dispersal. A site with restricted or inconsistent ocean currents could lead to permitting delays, onerous monitoring requirements and the enforcement of periodic plant shut-downs, all resulting in reduced operational efficiency.

## ACHIEVING VALUE FOR MONEY

Despite the Australian projects being probably the most expensive in the world as a group, it became clear that, amongst themselves, they achieved varying degrees of success, in terms of value for money. The term 'value for money' in this instance, refers to the best economic outcome over the project lifespan, and has two key components:

- Capital Efficiency: The ratio of capital outlay over yield, measured in $ million per gigalitre of water produced per annum.
- Operational Efficiency: The ratio of operating cost over yield, measured in $ million per gigalitre of water produced per annum.

Within the Australian cohort, a range of capital and operational efficiencies were achieved, which indicates that some projects had achieved better economic results than others – Figure 3 illustrates the benchmarks.

Whereas there are a multitude of factors that would contribute to a project's performance in this comparison, the following observations may explain some of the differences:

- The Victorian project is located on a site with very high levels of environmental sensitivity, which required extensive landscaping to cover the entire plant, even on the roofs, to mitigate the impact and obtain approval.
- The Gold Coast project was beset with engineering and site-related challenges, probably more so than any of the other projects.
- The later projects (Southern and Adelaide, completed in 2012) appear to perform better than the earlier projects, which suggests that some learning had transferred between projects, which resulted in greater efficiency in procurement, site selection and technology choice.


Lani van Vuuren

*The Emalahleni Water Reclamation plant, which treats polluted mine-water to potable quality, has one of the largest desalination installations in South Africa.*

The above spread of benchmarking values again underlines the importance of carefully considered project design, site selection, alliance partner selection and efficient execution. These broad areas of risk are significant determinants of the capital and operational efficiencies of a project, over the long term. Furthermore, it should be an on-going aim to draw on the learning experiences of projects that had gone before, and in doing so reduce the probability of repeating mistakes.

Finally, it is worth noting that even in the relatively robust institutional environment of Australia's federal and state governments, not all the challenges of the desalination build programme were anticipated, and some expensive lessons were learned, despite efforts to pre-empt them. ❑

***Figure 3***
*Benchmarking Capital and Operational Efficiency.*

| | Installed Daily Capacity | Installed Annual Capacity | Capital Cost | Capital Efficiency | Operating cost per annum | Operating Efficiency |
|---|---|---|---|---|---|---|
| Desalination project: | MLD (Mega-litre per day) | GLA (Giga-litre per annum) | AUD million | AUD million / GLA | AUD million | AUD million / GLA |
| Victorian | 435 | 146 | 5500 | 37.74 | 600 | 4.11 |
| Gold Coast | 125 | 42 | 1200 | 28.66 | | |
| Sydney | 250 | 84 | 1900 | 22.69 | 258 | 3.07 |
| Southern | 140 | 47 | 955 | 20.36 | | |
| Adelaide | 300 | 101 | 1824 | 18.15 | 129.9 | 1.29 |