DESALINATION

Has desalination entered a new era?

Dawid Bosman of the Trans-Caledon Tunnel Authority explores the latest global trends in desalination as South Africa increasingly explores this alternative water-supply option to strengthen water security.

The desalination of seawater in South Africa has traditionally been associated with situations of extreme drought, and all municipal installations I can think of have come about as emergency projects in times when conventional water resources were failing. This perception and resultant practice are being overturned, as freshwater scarcity increases, and the effects of climate change becomes more prominent. This change in paradigm is evident in the National Water and Sanitation Master Plan, where large-scale desalination features prominently, to be relied upon as a base load supply within the next eight years.

With desalination firmly in the national medium-term planning framework, it is important for water managers in South Africa to be informed of the dynamics within the global desalination industry; we need to be cognisant of developments in this sphere, as we will need to source technology and services from that market soon, to implement such projects locally.
A number of developments have come about in the global desalination industry since the later years of the previous decade, which now, in hindsight, may well have ushered in a new era for the practice. The new era is characterised by three trends as described elsewhere.

Almost simultaneously, around 2018, the six countries of the Gulf Cooperation Council (GCC, which includes United Arab Emirates, Saudi Arabia, Qatar, Oman, Kuwait and Bahrain) started replacing their vast fleet of thermal desalination plants with seawater reverse osmosis (SWRO) plants. This resulted in at least fifteen

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Figure 1: Fifteen mega-projects (>300Ml/d) installing SWRO technology in the GCC region during 2019-23.

mega-projects, all more than 300 Ml/d in capacity, entering the market between 2019 and 2023 (See Figure 1). This caused a step-change in global contracted capacity, which Global Water Intelligence regards as largely sustainable (See Figure 2), and effectively signalled the end of significant new investment in thermal desalination technologies such as multi-stage flash distillation (MSF) and multiple effect distillation (MED).

The tender request for these projects were mostly for independent water producer (IWP) contracts, whereby private developers design, finance (and hence own), build and operate the plant for a protracted period of 25 to 35 years, backed up by a firm offtake agreement. This indicates that there had been a policy shift in the GCC away from public ownership of large desalination plants.

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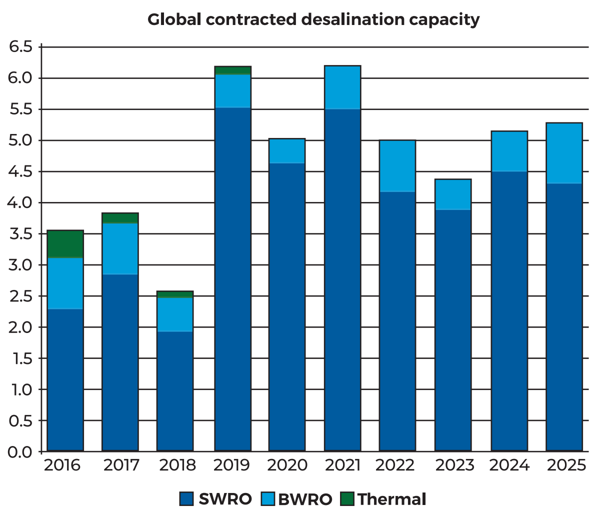


Figure 2: Global contracted desalination capacity (non-cumulative), actual and forecast, 2016–2025.

The long-standing cost benchmarks for both capital expenditure and water exit price saw a decline as these bids reached financial close; this was immediately visible due to the transparency of the IWP contracts. The benchmark capital outlay, or EPC costs, of a 600 Ml/d seawater reverse osmosis (SWRO) plant declined from $1000 per kl/d capacity in the mid-2010s to $750 – $900 per kl/d capacity in 2021. Similarly, the all-inclusive water cost declined from the $0.60 – $1.20/kl range, to the $0.40 – $1.00/kl range over the same period. In the GCC, given its market maturity, scale and risk profile, the expectation currently would be for bid prices well below $0.50/kl. It should however be noted that these cost benchmark have not yet been achieved outside of the MENA region (GCC plus Israel and North Africa).

What this comes down to is that over the past four years, there has been a significant shift towards very large SWRO plants being financed, built and operated by private developers, at lower costs than what had been seen before. All of this happened in the largest and most mature market for desalination, the Middle East.

To make sense of the trends, we need to explore what may have been the underlying, causal factors. Arguably the most prominent factor would be the transition from fossil-based energy to renewable energy, commonly referred to as the energy transition. Since the energy component comprises typically 45% of operational expenditure in desalination, any shift in energy cost will be keenly followed by the de-salters.

Ramez Naam

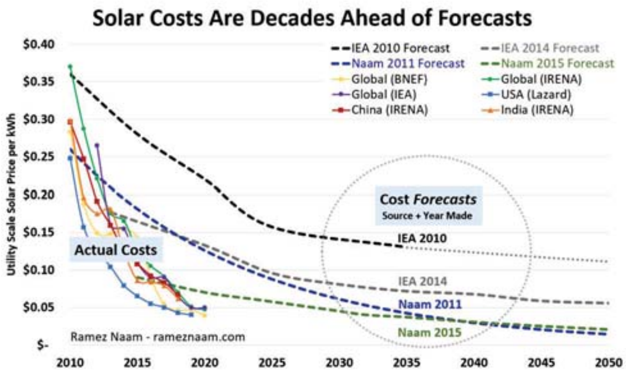


Figure 3: Solar photo-voltaic (PV) costs have breached the $0.05/kWh level some 17 years earlier than expected.

Figure 3 relates how the cost of solar PV declined much faster than even the most optimistic forecasters could anticipate. The cost threshold of $0.05/kWh, achieved some seventeen years earlier than expected, is comparable with the prices received through South Africa's REIPPP Bid Window 5 during October 2021, of R0.50/kWh for wind and R0.43/kWh for solar PV.

Wind and solar energy projects became cost-effective around 2014 globally, and thus no longer reliant upon subsidies; today, solar PV and wind are the least-cost new supply options in most markets, according to the IEA. The energy transition has now gained economic momentum, along with the imperative to reach net zero emissions by 2050.

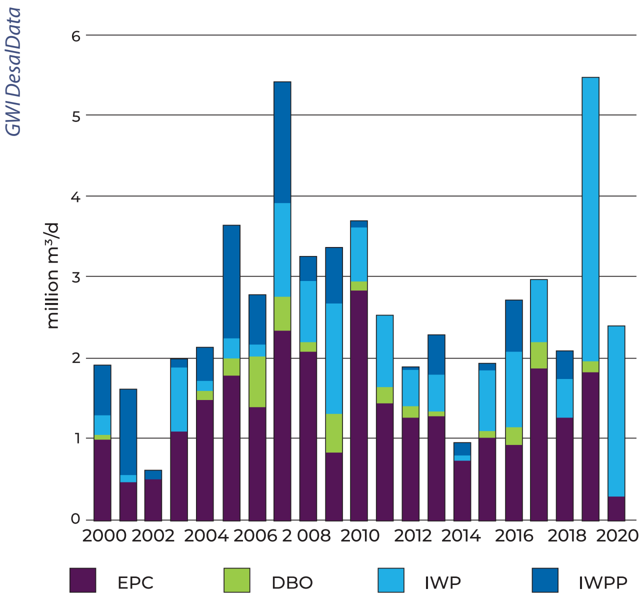
This shift in energy costs, along with ever tighter emissions commitments, tipped the scales in favour of SWRO for the planners and policymakers in the GCC region. Herewith the view expressed by Bruce Smith, planning chief of the Emirates Water and Electricity Company (EWEC) in July 2021: "In practice, reverse osmosis becomes the lynchpin of the whole sector decarbonisation, and it comes at such a cost and efficiency advantage that the all-in cost of building and operating RO is less than a third of the all-in price of water from thermal desal. Between 2020 and 2024, EWEC will cut the carbon intensity of power and water production in Abu Dhabi by 50%." In essence, the combination of renewable energy and reverse osmosis now presents a very compelling case, both from an economic and climate perspective, to replace thermal desalination.

The trend towards IWP contracting seems plausible when one compares it with the other common contracting method for such projects, the design-build-operate-maintain (DBOM) contract, in terms of efficiency and risk allocation.

Some ten years ago we encountered the DBOM-based alliance contracting method, much favoured during the Australian build programme, and today still popular in Asia. This approach required the client to adjudicate and short-list DBOM proposals from a technical and financial perspective, before embarking on a 40% design phase with the two short-listed candidates. This required the client to assign resources to work with the two bidders for several months, while the designs were developed and assessed. Upon conclusion of this final evaluation phase, the losing bidder would be reimbursed in full for all expenses incurred. This resulted in a very expensive, albeit very thorough process to select the optimal technical partner for implementation of the client's plant. One implication was that the client had to maintain a high level of technical and financial involvement throughout the procurement process, and build operational capacity to take back its plant when the DBOM contract came to an end, usually after about ten years.

IWP contracts stand in contrast to the alliance contracting described above and has now become the preferred procurement method for new desalination plants in the GCC, Israel and the Caribbean. Figure 4 illustrates the growing popularity of the IWP method.

In the IWP process, the client approaches the market with a long-term concession on a well-vetted site, and bids are called from developers to fund, design, build and operate their plants on that site over a prolonged period, with assurance given of sustained off-take at an agreed price. The delivery and



Seawater desalination procurement models 2000 to 2020.

technology risks are transferred to the winning developer, which means that if the plant does not perform as expected, it falls to the developer to remedy the problem.

The developer retains the latitude to innovate where it deems appropriate, and to follow proprietary and best practice design codes without any constraints. IWP contracting works well in a mature desalination market such as the GCC, where very long-term off-take agreements are possible. This allows for capital to be amortised over a protracted period, resulting in a smaller capital cost component in the overall water cost.

Other factors have also contributed to the decline in cost benchmarks. The very low cost of capital in recent years helped to reduce the capital outlay, although this gain would now be under threat from rising inflation. Also, one should recognise that the latest mega-projects in the GCC are much larger than previous SWRO projects, which were mostly outside the GCC, and hence the new projects are benefitting from an element of economics of scale.

Returning to the contention that a new era has dawned for desalination, it is clear that the energy transition and the shift to IWP contracting are changing the dynamics within the industry, resulting in a lowering of costs, implementation hurdles and climate impact, to the extent that the combination of renewable energy and reverse osmosis could now be seen as one of the pivots for decarbonising the water sector.

In practical terms, the to-market strategy for the procurement of a large desalination plant would be quite different in 2022 than what it would have been even five years ago. The erstwhile onerous approach required by DBOM procurement, of "know what can be had, know what you want and find the optimal implementation partner" is now only relevant if asset ownership is required by the client. If not, as many water and power utilities in the GCC have now chosen, one can go to the market with a long-term concession on a qualified site, along with carefully considered water supply specifications, and invite a competitive price auction from desalination plant developers.

Even in a new era where the hurdles to desalination are lower, several intractable challenges to the industry remain, and will need to be focus of attention in the coming years. For seawater desalination, it is minimising the marine impact, and achieving the \$0.40/m^3 price points outside of the mature market of the MENA region. For inland desalination of brackish or mine-impacted water, the challenge remains to be brine disposal.

Perhaps the most impactful challenge to resolve would be to regularly achieve the GCC cost benchmark in emerging desalination markets such as Chile, Egypt, the USA, South Africa and Australia. Common obstacles in these markets are high financing costs in the low or middle-income countries, onerous environmental compliance in wealthy countries, and failure to address demand-side risk, i.e., the flawed practice of implementing desalination as a drought mitigation measure.