Desalination around the world in 2030

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Abstract
Many people still believe that seawater desalination is a recent development, unaware that the Caribbean island of Aruba will celebrate its 80th anniversary of seawater desalination next year. Meanwhile, the neighboring island of Curacao has been practicing desalination for 83 years. For most of those 80+ years, both islands – like the majority of the desal world – have relied on distillation technologies.
However, the desalination industry has undergone a remarkable transformation over the last 20 years. As someone who was involved in the development of a portion of Aruba’s thermal desalination capacity, it was impossible to predict that the island would begin to replace its MSF capacity with membrane systems as they have begun to do over the past few years.
Later, when I attended the 1999 IDS conference to present Veolia’s (then Vivendi) credentials in the hope of being prequalified to bid the Ashkelon project, I could not foresee that Israel would have five large-scale plants commissioned or under contract by now. Nor would I have predicted that the seawater RO market would grow by more than 700 percent to 22.4 million m$^3$/d of capacity over the next 11 years.
The combination of technological improvements, changing climactic conditions, aquifer overdraft and anthropogenic pollution have led to the rapid growth of seawater desalination as an alternate water supply source. Although the economic downturn and La Niña weather pattern have dampened the industry’s growth over the past two years, most agree that seawater desalination and the use of desalination technologies to reuse wastewater and treat polluted surface and groundwater will continue to grow.
The industry’s rapid, widespread growth has led to a considerable investment in the research of new desalination technologies and methods of improving performance, reducing energy consumption and mitigating environmental impacts.
This paper will consider what the desalination market is expected to look like 20 years from now, in 2030. It will take into account the research currently underway and how the various technologies could be used for point-of-use systems, small and mid-size systems and large-scale regional desalination and reuse systems.

1. Desalination in 2030
One of the most obvious recent trends in desalination has been the move to take advantage of economies of scale. Plants have grown larger and larger, and most large coastal cities in water stressed regions already have at least one large-scale seawater desalination plant in operation or planned. This is certain to continue until most major coastal cities have some portion - 20 to 50 percent of their potable water needs – supplied by local seawater desalination facilities.
In highly water stressed areas, use of desalinated seawater as the predominant potable water supply will likely extend to inland consumers at to elevations of up to 250 meters, or more.
However, there will also be a significant growth in inland plants desalinating brackish groundwater. The US State of Texas has embarked on a plan to characterize its immense brackish water reserves. It is hoped that a database containing information on brackish water quantities, salinities and hydrogeologic data will enhance the ability of small communities to more economically exploit this water supply resource.
By 2030, there will be no new large-scale seawater MSF or MED projects contemplated.
There may be a few units still in operation in the Gulf countries, but most will have been replaced by membrane plants. Reverse osmosis will be the dominant seawater desalination technology, although MED, and to a lesser extent MSF, may be used in conjunction with nuclear power plants that will be back in favor. However, small and mid-size MEDs will find applications at industrial facilities that employ exothermic processes.

One of the most likely trends that will occur over the next 20 years will be the way in which water is managed, particularly in densely populated urban areas. The use of potable quality water to flush our toilets, water our gardens or use for industrial purposes will become as rare as dial-up modems and slide rules. Although few cities are likely to follow Hong Kong’s lead, where 75 percent of the toilets are flushed with seawater, the use of grey water that has been produced and recycled on-site, will dominate non-potable water supplies in dense urban areas. In 20 years – except where it is required to maintain environmental stream flows - virtually all wastewater will be treated and reused. Indirect potable reuse will no longer be controversial. It will be commonly practiced and an important part of our water supply.

Meanwhile reliable monitoring and control systems will have been developed to the point that many communities will practice direct potable reuse.

While centralized water systems will continue to dominate in large cities, technological developments and the diverse needs of developing countries will mean that a significant portion of water will be consumed ‘off-grid’ in a decentralized manner. Remote, inland locations far from cities will have more smaller, local facilities to reduce pumping costs that facilitate reuse and redistribution, and further increase water supply security.

Industrial facilities will come to rely on their own, captive water and wastewater treatment systems. Practices that conserve, recycle and reuse will be the rule, rather than the exception. A larger portion of industrial facilities, as well as many remote communities, will also turn to mobile and or modular treatment units.

Wastewater treatment systems will also adapt to changes in the water supply picture and smaller footprint MBR plants that are able to produce a higher quality of effluent and increased flexibility will predominate.

The role of the private sector will increase in future water supply schemes. As the level of treatment complexity and capital costs both continue to rise, the private sector will assume more responsibility to finance, design, build and operate water systems. The number of water systems that involve some form of public-private partnerships will increase rapidly and soon represent the majority of plants.

There will be some sorting out of the many new technologies that have been developed over the last the years, and many that are still in development. However, it seems clear that based on the current installed capacity and the relative efficiency of the process, reverse osmosis will grow to dominate seawater desalination. And, to a large extent, the plants will look fairly similar to the way they look today.

For the most part, reliable and efficient pretreatment processes will combine with better membranes to virtually eliminate biofouling and scaling problems and greatly improve system reliabilities. New, sophisticated monitoring and control systems will enable the pretreatment and membrane portions of a plant to quickly react to changing water conditions, ensuring that a plant operate at its peak performance.
Dramatic developments are likely as carbon nanotubes, aquaporins and other new membranes are developed and perfected, although it is most likely that these new membranes will find use in specialized high purity or ultrapure applications.

Other technologies including membrane distillation and capacitive deionization will find high-value uses in niche markets. Forward osmosis holds a lot of promise for the future, but I am not sure if it will play a bigger role in concentrate management or in a hybridized scheme combining seawater desalination and wastewater reclamation.

By 2030 there will also be a variety of commercially available personal and point-of-use desalination systems available. Systems employing forward osmosis, nano-fluidics, and capacitive deionization will find use in households and for occasional or emergency use.

Stronger leadership may be the most important requirement to ensure water sustainability. This leadership will be required to make the tough regional decisions necessary to solve many ‘water rights’ issues, mediate riparian water rights cases and make sound decisions that benefit entire watersheds rather than a small group of stakeholders.

Seventy percent of the world’s fresh water is used for agricultural purposes. Growing water shortages will force some realignment of what crops are grown where to ensure that the local water supplies are best-suited to meet the requirements of the crops grown in the area. These changes will also be accompanied by more efficient irrigation methods.

In closing, you will note that I haven’t talked much about energy sources or the use of renewable energy. It goes without saying that new, sustainable energy sources will be required to treat wastewater and produce fresh water. But most of these new power generation technologies can be developed in parallel with the development of desalination and water treatment processes. In some cases, new energy sources will be able to be directly coupled to desalination and in many others, it will be available via a grid.