Sustainable water supply from desalination and reuse

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Five years ago, the concept of sustainable water supply produced using desalination and reuse technologies was considered only a topic of academic debate, rather than a practical target. Solar power generation took a similar route, but with even more widescale adoption and remarkable success in the past 20 years.

Both desalination and renewable energy industries have come a long way in terms of lower production costs. Together, solar-powered desalination could achieve sustainability in the production of both potable water and energy. To realize this goal, two steps are important: a shift towards smaller, decentralized desalination plants and the opportunistic use of wastewater treatment facilities to recover not only water and energy, but also nutrients. This paradigm change could fundamentally transform the financing of desalination and reuse projects by creating profitable resources from what is considered waste.

In Gulf Cooperation Council (GCC) countries – Saudi Arabia, Kuwait, the United Arab Emirates, Qatar, Bahrain, and Oman – solar farms are sprouting up and their power generation has priority to feed into the grid. For at least six hours a day, power tariffs as low as US$0.02 per kilowatt hour (kWhr) are available to utilities from photovoltaic (PV) plants as the amount of electricity being generated by PV plants will shortly outstrip grid demand during certain hours of the day. For this reason, the power sector is now heavily investing in research for energy storage – both with pumped hydro storage and batteries.

Yet, what is a desalination plant if not a device that converts electric power into stored chemical energy by separating seawater into water and salts? From this perspective, a desalination facility could be looked at as a device for both water generation and indirect energy storage. Clearly this approach would require provisions for more storage and generation capacity, but it would also allow for opportunities to relax pre-treatment criteria and overprescribed plant design conditions. Currently, plants are overdesigned to ensure operations in extreme conditions, which occur once every 5 to 6 years for a few hours.

PV power offers great opportunities to reduce fossil fuel consumption and overall energy costs as well as improve operational efficiency in the desalination sector. According to the International Renewable Energy Agency's (IRENA) report, *GCC 2019 Market Analysis,* solar PV electricity costs have plummeted 73 percent since 2010. This positive trend has contributed significantly to a surge in new solar projects in the GCC region and worldwide.

If the industry could move beyond the traditional concept of steady water generation mainly dictated by the lack of storage, it would be possible to develop a more cost-effective approach to seawater reverse osmosis (SWRO) to generate drinking water. In effect, solar-powered SWRO desalination facilities equipped with energy storage capacity would be able to produce more water when excess power is available in the grid from PV system, and less when the grid is in peak mode.

Mini PV farms installed on top of SWRO facilities have helped reduce overall power demand. The specific energy consumption of 3.5 kilowatt hours per cubic meter (kwh/m^3) – considered a threshold destined to be unbeatable for at least a decade – has now decreased specific energy consumption to 2.9 to 3 kwh/m^3 in the new plants that guarantee production of potable water in the harsh Arabian Gulf region.

Meanwhile, the desalination sector has also been experiencing a revolution in terms of energy use in the last five years. In GCC countries, energy-intensive thermal technologies have been abandoned, and SWRO projects have reached record low tariffs of $0.5 per cubic meter ($m^3$) in recent large independent water and power (IWP) project tenders in Saudi Arabia and United Arab Emirates.

Decentralized versus megaton

The decentralization of SWRO desalination is the next logical step towards sustainable water generation. Smaller SWRO plants installed in an urban district and architecturally harmonized with the surrounding neighborhoods could reduce the transmission and distribution footprint, which is often as large as the SWRO facility. Smaller SWRO facilities provides an alternative to large, centralized, megaton plants, which are installed sometimes hundreds of kilometers away from the utility point and often destroy large portions of valued natural habitats and beaches.

Shift to nutrient factory

Currently, wastewater treatment processes in GCC countries are based primarily on oxidation. The more the wastewater is oxidized, the more carbon dioxide is emitted in the atmosphere and the potential for energy recovery from the wastewater stream is lost. Unfortunately, this approach dissipates an incredibly high amount of carbon dioxide in the process of "killing" the residual energy in wastewater treatment streams.

Conventional wastewater treatment facilities have been designed to treat industrial and municipal wastewater for disposal. However, we need to envision the next generation as "cradle to cradle" water processing and energy generation facilities in which wastewater is upcycled to freshwater and energy from the wastewater stream is recovered rather than dissipated.

One way to achieve this is to move to anaerobic and membrane processes, which leaves more carbon in the sludge, making it ideal as fuel for waste-to-energy thermal plants or biogas generation. Along with the inherent energy, nutrients and resources in the wastewater stream can also be upcycled – recovering elements precious to the biosphere for beneficial use, such as nitrogen, organic carbon, and phosphorus.

The value of struvite as a biological phosphorus-rich fertilizer is gaining commercial momentum versus chemical fertilizers, but the possibilities offered by nutrient recovery are endless and within reach using technology available today.

Future outlook

Sustainable solutions implemented in the industry are often criticized as financially unsustainable. However, this may be true if the liabilities of unsustainable practices (high CO_2 emissions) are pushed outside of a specific project liability envelope. For example, the public and social costs for increased healthcare and emergency crises arising from increasing such natural events as droughts, typhoons, and floods – which are ultimately climate change effects from unsustainable practices – are left to be paid by future generations.

Looking ahead, we can see there will be an economy in which unsustainable practices will be penalized by taxes (carbon tax) and society will not be accepting of companies that gain financially from enterprises that create environmental liabilities to future generations. This change in attitude will generate a new momentum towards achieving sustainability.

Sustainable Water and Power Consultants is based in Abu Dhabi, United Arab Emirates.