Desalination
Offers Drought-Proof New Supply of Drinking Water

Summary

Background

Desalination of the ocean or brackish groundwater is rapidly becoming a reality in California. The largest ocean desalination plant in North America went online in Carlsbad, California in December 2015. Several other coastal communities are investigating ocean desalination to add to their water supply portfolio. Major industries in California, such as agriculture, aerospace, bio-tech, and computer manufacturing, require reliable supplies of high-quality water. California residents also expect a reliable water supply at affordable rates for home uses.

Desalination has the potential of being a very reliable supply of high-quality drinking water for local and regional systems because it does not depend on variable weather and hydrologic cycles. Desalination will not typically replace traditional water supplies, but augment them to accommodate growth or shore up reliability. As traditional water supply options become strained and unreliable, desalination helps by providing a "drought-proof" reliable drinking water supply. Developing more desalination plants is one of the strategies Australians used during their Millennium Drought. Although not all plants are operating at the moment, Australians are much better prepared to meet the next drought cycle or population expansion through diversification of their water assets.

About 97% of all water on Earth is saltwater. Water that can be desalinated includes seawater and brackish groundwater. Desalination generates less than 0.4% of the water used in the United States, but desalination capacity nationwide increased by 40% between 2000 and 2005. Desalination plants (mostly for brackish groundwater) now exist in every state.

The Process of Desalination—Innovative New Materials and Processes

Reverse osmosis, widely used in the United States, is the process in which saltwater is forced through a membrane with holes too tiny for salt molecules to pass. These membranes are rolled like rugs and placed into meter-long tubes with additional layers that direct water flow and provide structural support.

For years, most membranes have been made out of **polyamide**, a synthetic polymer used because of its low manufacturing costs, around $1 per square foot. Polyamide has additional costs associated with its use, however. It degrades rapidly when exposed to chlorine, so if the source water has chlorine, it must be removed before desalination, and then added back as a disinfectant. Without chlorine, the polyamide membranes are susceptible to growing biological matter that can clog up the tiny holes.

One new technology is the use of **graphene oxide**. These membranes are made by graphene flakes peeled from pieces of graphite, the form of carbon found in pencil lead. Researchers have suspended the graphene flakes in liquid and then the liquid is removed, forming the sheet. The graphene oxide membranes are resilient to important cleaning chemicals like chlorine, they hold up in harsh chemical environments, can withstand high temperatures, and due to their thinness, allow water molecules to pass through more easily, requiring less energy to produce desalinated water. Researchers estimate that the cost of desalination of groundwater would require 46% less energy and processing of saltier seawater would use 15% less energy than the current process.

Distillation is another desalination process that involves turning water into steam and then condensing the steam back into water. While most of the developed world uses reverse osmosis to remove salt from water, researchers at Nanjing University in China are hoping to bring drinkable water to unpowered parched places by using a system that does not require boiling water. Their system would use tiny particles of aluminum that line the surface of a special material that can absorb a wide range of wavelengths—generated by the sun. The absorbed light excites electrons in the material, which can pass on the energy to nearby water molecules, causing evaporation without boiling. This process is not capable of handling large-scale desalination such as reverse osmosis does, but still would be useful.

Researchers also are exploring the use of **carbon nanotubes**, tiny cylindrical carbon structures, as a desalination membrane. These newer techniques, however, must be cost competitive with the current systems.

Environmental Concerns

Seawater desalination affects the environment in two main ways: entraining fish and other sea life through the intakes of water into the desalination plant; and the discharge of brine back into the ocean after desalination. These environmental effects must be taken into account in the design of a desalination plant to

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reduce and mitigate impacts. Every plant location is unique, with a different combination of factors, including resident species and currents. Environmental protection and mitigation must be evaluated on a site-specific basis, taking into account the features of the particular site.

Developments in fish screens and intake designs have helped to lessen the impact of intakes on sea life. Different outfall designs help to diffuse the brine as it is discharged, preventing concentrations of salts and other minerals that could be detrimental to sea life.

Economics of Desalination

When California began developing its water supply in the late 19th and early 20th centuries, little thought was given to environmental impacts. Infrastructure such as dams and canals was built with the sole intent of producing the greatest yield of water. In the 1970s, however, environmental concerns began to take prominence in the Legislature. In addition, the state's rapid population growth was outstripping supplies even as they were being developed.

Water supply development impacts on fisheries and on water quality required an adjustment in the way water supplies were viewed. Dedicating water resources to the environment and to water quality caused shortages that increased the cost of water to agricultural, urban and industrial users. The 1987–1992 droughts created additional shortages that forced water suppliers to consider diversifying supplies. Water use efficiency, conjunctive use of groundwater, and integrated regional water management flourished in the 1990s and 2000s as water suppliers sought innovative solutions to supply problems.

Throughout this period, desalination generally was regarded as too expensive to be of much economic benefit. The rising cost of traditional supplies, however, has changed this perception in recent years. Compared with other "new" water supply options, desalination is indeed cost competitive. For example, West Basin Municipal Water District is investigating high-quality water through both ocean desalination and recycling. In 2009 dollars, the district calculates that desalinated water, assuming a 20 million gallons-a-day project, would cost $1,700 per acre-foot. The average cost for similar high-quality recycled water would be $1,638 per acre-foot.

The cost of desalination will be blended into the overall costs of the water supply. Overall costs to water users will rise, but only in proportion to the share of the supply from desalination. When this share is relatively small, costs will not increase significantly. For example, San Diego County Water Authority ratepayers are currently paying only $5 a month for the water supplied by the Carlsbad Desalination Plant.

Desalination in California

According to the California Water Plan Update 2013, 26 desalination plants were operating in California in 2013—23 brackish groundwater plants and three ocean plants. Four more are in the design and construction phase (four brackish groundwater plants, one ocean plant), and 33 facilities are in the proposal stage (17 brackish groundwater plants, one brackish surface water plant, 15 ocean plants). If all were to come on line, that would amount to 684,069 acre-feet per year more water supply for the state.

In 1991, Santa Catalina Island established a desalination facility that provides 200,000 gallons of potable water per day. Santa Barbara built a desalination plant in the early 1990s to ensure against drought shortages. The plant was operated only between March and June 1992. Due to above-average rainfall in the winter of 1992, the plant was placed in standby mode. In 2015, California's ongoing drought caused the plant to be evaluated for reactivation. Technology had advanced so much, however, it was determined that the facility should be demolished and rebuilt. The new plant will use 40% less energy by using high-efficiency pumps, motors and improved filter technology, as well as using newer model intake pipes to minimize marine life entrainment and impingement.

In 2012, the San Diego County Water Authority signed a water purchase agreement with Poseidon Resources for a 50 million gallon-per-day facility in Carlsbad. The plant went on line in December 2015. The City of San Diego is looking at a $3.5 billion plan to recycle treated sewage into drinking water to further bolster its local supplies. The project is currently in Phase I, which is the North City phase, comprised of four projects that will deliver 30 million gallons per day of purified water to the Miramar Reservoir. Once in the reservoir, the purified water will blend with the city's imported and local water sources before it is treated again at the Miramar Drinking Water Treatment Plant and distributed to the public. The four projects include the Morena Pump Station and Pipeline, the North City Water Reclamation Plant Expansion, the North City Pure Water Facility, and the North City Pure Water Pump Station and Pipeline.

Up the coast in Huntington Beach, Poseidon Resources in October 2016 announced the approval of an agreement among the staffs of the California Coastal Commission, California State Lands Commission, and the Santa Ana Regional Water Control Board to streamline the permitting process for the desalination plant. This proposed ocean desalination facility serving South Orange County would utilize state-of-the art "subsurface slant" wells off Doheny State Beach to draw in seawater, yielding up to 50 million gallons a day of local potable water. Poseidon Resources anticipates the permitting process to be completed in 2017, moving then to the construction phase of the project.

In Northern California, there had been discussion of a 65 million gallon-per-day plant in Marin County to supply water to the Bay Area, but it was sidelined by local opposition. As of May 2016, there were nine active proposals for desalination plants along California's coast. This is down from an estimated 21 proposed projects in 2006 and 19 in 2012. Since 2006, only two projects have been built: a small plant in Sand City with a capacity of 300,000 gallons a day and the much larger Carlsbad Project discussed above.

Desalination Hurdles

Under current California policy, siting a desalination plant is challenging. It requires many permits, such as a local land use permit, water discharge permit, drinking water permit, Energy Commission permit, State Lands Commission permit and, if in the coastal zone, a Coastal Development Permit, just to mention a few. Of course, an environmental impact report also has to be completed. Current federal law requires permits under the Clean Water Act and, given the locale, permits under the River and Harbors Act, at a minimum. This is best demonstrated by the permitting process for the Huntington Beach Desalination Plant. In 2006, the City of Huntington Beach certified the initial environmental impact study for the plant. A decade later, the permitting process is still ongoing.

Desalination faces hurdles that traditional water supplies have not confronted, although that may change. Desalination has to meet 21st century environmental standards for intake of the ocean water and discharging the brine back into the ocean. The State Water Resources Control Board amended its California Ocean Plan to set new rules for ocean water desalination intakes, mitigation and brine discharge early in 2015. The amendments provide for a uniform permitting process.

Naturally, there will be land use-related issues depending on the location of an ocean desalination facility. Many project proponents have investigated co-locating their facility near a power plant that uses the ocean to cool the plant. The power plants' existing intake and brine disposal outfall would be used to also make drinking water. However, most power plants that currently use the ocean for cooling will need to upgrade facilities or stop using the ocean for cooling due to the State Water Board's recently adopted once-through cooling policy.

CalChamber Position

The California Chamber of Commerce supports a balanced approach to securing a safe and reliable supply and conveyance of water for all businesses and residents of California. Desalination, like recycling, water reuse, potable water reuse, water use efficiency, conservation, conveyance and new storage, should be pursued to help increase water supply. Permit streamlining amongst the various agencies should be undertaken to expedite the approval process.

Desalination is a viable option for the state's future water supply picture. In order to meet its water supply challenges, California needs to pursue desalination where appropriate and feasible. Desalination will provide an invaluable addition to a well-balanced local or regional water portfolio with a reliable drought-proof component.

The CalChamber will support legislation streamlining the permit process for siting desalination projects.

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