DESALINATION AS A WATER SOURCE FOR MUNICIPAL AND INDUSTRIAL WATER USERS: THE FUTURE IS NOW

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Abstract. Presented in this paper is an overview of technology, costs, and environmental issues associated with desalination. Use of desalination to produce fresh water is rapidly expanding. Key issues are cost and potential environmental effects. Technological innovations, creative planning, and cost reductions are providing new opportunities for significant advances in the use of desalination for fresh water production.

INTRODUCTION

The evolving status of desalination can be described with the following three statements:

Desalting of seawater is an ancient notion. Aristotle described an evaporation method used by Greek sailors of the 4th century BC. An Arab writer of the 8th century AD produced a treatise on distillation. In the 19th century, the development of steam navigation created a demand for non-corroding water for boilers; the first patent for a desalination process was granted in England in 1869. The same year, the first water-distillation plant was built by the British at Aden, to supply ships at the Red Sea port. The first still to provide water for commercial purposes was built in 1930 in Aruba. The first modern desalination plant was built in Saudi Arabia in 1938.[1]

If we ever competitively…get fresh water from salt water…[that] would dwarf any other scientific accomplishments. President John F. Kennedy (1961)

Jan. 6, 2003. TAMPA, Fla. …by the end of this month, water is expected to be flowing to faucets from …a seawater desalination plant. …by March, the plant will reach its full capacity of 25 million gallons a day. That's roughly 10 percent of what Tampa Bay Water, the region's water supplier, provides public utilities each day in…[area counties] and the cities of St. Petersburg, Tampa and New Port Richey.[2]

[1] Encyclopedia Britannica Online (keyword, "desalination")

[2] Tampa Tribune, January 6, 2003

WORLDWIDE STATUS

Desalination of seawater is a rapidly developing and evolving technology, and facilities operate in 126 nations. At the end of 2001, there were 15,223 completed or contracted plants, with fresh water production capacity of more than 6.8 billion gallons of water daily[3] ("Wangnick consulting," 2002). Nearly 60% of that capacity uses, or will use seawater, with the remaining using brackish or other feedwater.

Desalination is a major water source in some arid areas. A survey of capacity in 22 Middle East and North Africa countries indicated daily production capacity of 16.7 million cubic meters or 4.4 billion gallons a day (Wangnick consulting, 2002). Kuwait, Saudi Arabia, and the United Arab Emirates account for more than 70% of this capacity. One plant in Saudi Arabia produces 233 million gallons of fresh water a day (Simon, 1998). Saudi Arabia, with 23.5 million people gets 70% of the country's drinking water from desalination of seawater ("Saudi Arabia desalination," 1999). In Israel, the Ministerial Committee for Economic Affairs approved a plan to have an operating plant by 2004, with drinking water production of 37 million gallons a day (mgd) ("Israel to construct," 2000).

The market for desalination equipment in Asia is predicted to grow from $508.7 million in 2001 (US dollars) to $1.3 billion by 2010 because of increasingly scarce fresh water in the region. One contract in Singapore (scheduled to begin in 2005) is called the benchmark for future projects. Projected construction cost is about $400 million. The project will comprise three plants designed to produce more than 100 mgd of drinking water ("Asian desalination market," 2002).

[3] Note: The average U.S. household (four people) uses about 240 gallons per day. Thus, one million gallons will, in U.S standards, provide enough water for nearly 4200 families or 16,800 individuals. Household water use in most other countries would be well below that of the U.S.

A facility in Trinidad has a capacity of processing 29 mgd ("Business briefs: desalination," 2002).

In the two-year period 1999 to 2001, worldwide desalting capacity increased by 105%, with the capacity of seawater plants growing by 140% ("Wangnick Consulting," 2002). Notable proposed seawater projects are a Saudi Arabia 193 mgd plant and a 90 mgd plant in Point Comfort, TX, which will be the largest seawater desalting facility in the U.S.

U.S. STATUS

In the U.S., two existing facilities are of special interest: one in California (West Basin Municipal Water District in Los Angeles County-WBMWD) and the other in Florida (Tampa Bay Water).

WBMWD

This facility has been functioning since 1995, and uses desalination type technology to produce 20 mgd of recycled wastewater for non-potable uses such as groundwater injection to prevent saltwater intrusion and various industrial purposes including oil refinery cooling. The plant has the capacity to treat nearly 90 mgd for non-potable re-use. The WBMWD now plans to move into desalination of seawater for drinking water. The WBMWD has an operating pilot desalination facility in partnership with the US Bureau of Reclamation. Their first full-scale desalination plant will produce 20 mgd of drinking water. (West Basin Municipal Water District, 2002)

Tampa Bay

Of interest to many has been the construction of a desalination plant that will make Tampa the first city in the U.S. to use converted seawater as a primary source for drinking water. In the Tampa Bay Water desalination plant, for every 100 gallons of feedwater, about 43 gallons of concentrated saltwater will be sent back into a nearby lagoon. That is, about 57% of the input water is recovered as potable water, while about 43% is waste brine. The Tampa Bay facility currently has capacity of 25 mgd of drinking water. This facility is locating next to a large power plant, using that plant's cooling water as a feedwater source as well as a means of disposing waste brine. (Lindeman, 2002)

Other U.S. Locations

Numerous desalination plants are under development/review in Texas, California, and even North Dakota ("Freez-thaw water," 1999). Five proposed California seawater desalination plants would produce nearly 120 mgd of drinking water for cities along the Pacific Coast between San Diego and Los Angeles ("Agency to examine," 2002).

An environmental study is underway to enable the construction of a desalination plant in Riverside County, CA that would reduce the salt content in the Colorado River flowing to the Metropolitan Water District of Southern California (Simon, 2002); and Tucson, AZ is addressing the issue of how to make salty Colorado River potable (Rosenbaum, 2000). Also, the U.S. Bureau of Reclamation operates a desalting plant at Yuma, AZ to remove excess salinity from Colorado River water before it discharges into Mexico (Mielke, 1999).

DESALINATION TECHNOLOGIES

A number of technologies exist for desalination, but distillation and reverse osmosis (RO) are the two most widely used desalination technologies.

Distillation

This is the oldest desalination method. Salt water is heated to a vapor, which in turn is condensed as freshwater. Common methods of distillation include multistage flash (MSF), multiple effect distillation (MED), and vapor compression (VC). In MSF, the feedwater is heated, usually by gas or electricity, and the pressure of the container is lowered so the water "flashes" into steam. In MED, the feedwater passes through a number of distillation chambers. The VC process involves evaporating the feedwater, compressing the vapor, and then using the heated compressed vapor as a heat source to evaporate additional feedwater. Distillation requires a great deal of energy, and typically is used where energy is relatively cheap, such as in the Middle East. (Buros, 2000; Mielke, 1999; and Pantell, 1993).

Reverse Osmosis and Electro-dialysis

The reverse osmosis and electro-dialysis processes involve separation through membranes rather than evaporation. Reverse osmosis (RO) involves forcing seawater through a semi-permeable membrane, which "strains out" salts and minerals. Electro-dialysis uses ion-specific membranes that are arrayed between anodes and cathodes to drive salt ions in controlled migrations to electrodes, leaving freshwater behind. These processes are relatively new, but their use is increasing steadily." (Suratt, Maimone, and Missimer, 2000) The Tampa Bay project described above uses the RO technology. Membranes used for RO have become cheaper, more durable, and more effective in recent years.

Rapid Spray Evaporation

AquaSonics International recently announced a new process referred to as Rapid Spray Evaporation™ (RSE) system. Saltwater or other feedwater is ejected at high velocities through specialized injector-nozzles. As the solution evaporates, solids are flashed out leaving water vapor, which is collected with 95% recovery. According to AquaSonics International, an added benefit of the RSE process is in waste recovery, because individual salt or other contaminant particles remain as isolated particles, which can be collected through a vacuum process for subsequent disposal or sale as a by-product. The company indicates that RSE does not use temperatures as high as MSF, nor the high maintenance and expensive membranes required for RO. ("The AquaSonics technology," n.d.)

Process Considerations

Each desalination process has advantages, and the key to a cost-effective and efficient system is to apply the appropriate technology based on the feedwater. The advantage of distillation is that pretreatment requirements are lower than those for reverse osmosis. On the other hand, membranes have lower energy requirements and remove more contaminants than distillation. Additionally, while distillation relies on thermal processes, membranes do not, meaning the feedwater does not need to be heated (Suratt, Maimone, and Missimer, 2000). The RSE process is currently under evaluation.

ENVIRONMENTAL ISSUES

The environmental implications of desalination of seawater and other feedwater are extensive, and clearly must be a major component of any project planning. Mickley (n.d.) suggests that at all stages, including collection of the feedwater, pretreatment, water recovery, post treatment, and waste disposal, there are potentials for physical and chemical alteration of the ecosystem. Pantell (1993) details the types of effects that should be considered as those that are related to: construction, energy use, air quality, ecosystem & environment, increased development, and others such as geologic hazards, navigation, and cumulative effects. See Schwabach (1999) for an extensive discussion of environmental implications and laws relative to desalination.

Positive environmental effects may occur under some conditions. Water from the Tampa Bay desalination project will replace some of the water now pumped from environmentally sensitive wetland areas. Reclaimed water from the WBMWD project discussed above is used to recharge coastal aquifers to prevent saltwater intrusion. Using desalination as an alternative to pumping from coastal aquifers may be a potential in the coastal areas of Georgia where saltwater intrusion is an issue.

U.S. TECHNOLOGY DEVELOPMENT

Congress, with the 1996 Water Desalination Act, provided funding for desalination research through the Bureau of Reclamation (BuRec). The goal of the program is to develop cost-effective, technologically efficient means to desalinate water. The two principal thrusts of the BuRec program are: research and studies on desalination technologies and related issues to push the state-of-the-art forward; and demonstration activities to evaluate new technology and economic feasibility. A description of the program, research grant funding, and other information regarding completed, current, and planned BuRec funded desalination projects can be found at:
http://www.usbr.gov/water/desal.html

DESALINATION COSTS

Costs for desalination of seawater have dropped substantially in recent years from $8 to $3 per 1000 gallons; and brackish water desalination costs have declined from $2 to $1 per 1000 gallons (Suratt, Maimone, & Missimer, 2000). [Note: for comparison, Albany, GA water rates are generally between $1.50 and $2.00 per 1000 gallons] In addition to salt concentration of feedwater, costs depend on factors such as plant size, type of technology, location, power source, and wastewater disposal alternatives. Tampa Bay Water gained cost efficiencies by locating the plant adjacent to Tampa Electric's Big Bend Power Station, bringing costs down to a projected $2.08 per 1,000 gallons. The facility will use the power plant's pretreated cooling water for feedwater, and use existing intake and discharge structures (Suratt, Maimone, and Missimer). Tampa Bay Water will blend water from their lower cost traditional sources with desalinated water. This will allow for keeping water prices lower, while eliminating some detrimental effects of pumping from wells in wetland areas (Lindeman, 2002).

Some argue that in instances where water from desalination facilities may substitute for new reservoirs, eliminate groundwater declines, restore wetlands, and/or prevent groundwater pumping where saltwater intrusion is occurring, public subsidies may be appropriate to make this desalination for fresh water competitive with current sources. Water management districts in California and Florida have followed this policy.

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