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Desalination: Technologies, Use, and Congressional Issues

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Summary

In the United States, desalination technologies are increasingly used for municipal and industrial water supplies and reclamation of contaminated supplies. At issue for Congress is the federal role in desalination research, demonstration and full-scale facilities, and regulatory requirements. Constraints on wider adoption include financial, environmental, regulatory issues and concerns.

Desalination processes generally treat seawater or brackish water to produce a stream of freshwater, and a separate, saltier stream of water that has to be disposed (often called waste concentrate). Its attractions include creation of a new freshwater source from otherwise unusable waters, and its independence from precipitation, runoff, storage, and recharge. Many states (most notably Florida, California, and Texas) and cities are actively researching and investigating the feasibility of large-scale desalination plants for municipal water supplies. Coastal communities are increasingly considering desalinating seawater or estuarine water, while interior communities are looking to brackish aquifers. Some communities and industries are opting to treat contaminated water supplies with desalination technologies (e.g., membrane separation) to meet disposal requirements or to reuse the water (e.g., saline waters from oil and gas development). Desalination also is used for obtaining high-quality water for industrial processes.

Desalination and its applications, however, come with risks and concerns. Although the costs of desalination dropped steadily in recent decades, making desalinated water more competitive with other supply augmentation options, the declining trend may not continue if energy costs rise. This creates a cost uncertainty for those contemplating desalination investments. Electricity expenses vary from one-third to one-half of the operating cost of many desalination facilities, and the energy intensity of desalination raises concerns about the greenhouse gas emissions emitted. Current desalination processes are already operating close to the theoretical minimum energy required. Therefore, significant improvements in facility-level energy efficiency are more likely to come from more energy efficient pretreatment of water before entering the desalination process and co-location with other facilities, such as power plants. Substantial uncertainty also remains about the technology's environmental impacts, in particular management of the saline waste concentrate and the effect of surface water intake facilities on aquatic organisms. Moreover, there are few federal health and environmental guidelines, regulations, and policies specific to desalination as a municipal water supply source. This creates uncertainty regarding the cost and time required for regulatory compliance. Research and public education may help to resolve some uncertainties, mitigate impacts, reduce the costs, and improve public understanding.

To date, the federal government has been involved primarily in desalination research and development (including for military applications), some demonstration projects, and select full-scale facilities. For the most part, local governments, sometimes with state-level involvement, are responsible for planning, testing, building, and operating desalination facilities, similar to their responsibility for freshwater treatment for municipal drinking water supplies. In the 112th Congress, H.R. 2664, Reauthorization of Water Desalination Act of 2011, would reauthorize a Department of the Interior program (expiring in 2011) carried out by the Bureau of Reclamation for desalination demonstration and outreach. Bills in the 111th Congress (e.g., H.R. 88, H.R. 469, H.R. 1145, S. 1462, S. 1731, S. 1733, and P.L. 111-11) represented a range of federal authorizations for desalination research and its coordination, demonstration and full-scale facilities, and planning and financing. While interest in desalination persists among some Members, efforts to expand federal activities and investment may face greater challenges in the near term due to the domestic fiscal climate and differing views on federal roles and priorities.

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Desalination Policy and Legislative Primer

Interest in desalination technologies for seawater, brackish water, and contaminated freshwater has increased in the United States as their costs have fallen and pressure to develop and reclaim new water supplies has grown. Adoption of desalination, however, remains constrained by financial, environmental, regulatory, and social factors. At issue is what role Congress establishes for the federal government in desalination research and development and in construction and operational costs of desalination demonstration projects and full-scale plants. Also at issue is the federal regulatory environment related to desalination.

Desalination processes generally treat seawater, brackish water,[1] or impaired waters to produce a stream of freshwater, and a separate, saltier stream of wastewater, often called *waste concentrate* or *brine*. The availability and regulation of disposal options for the waste concentrate can pose issues for desalination's adoption in some locations.

There are a number of desalination methods. Two processes, thermal (e.g., distillation) and membrane (e.g., reverse osmosis), are the most common, with reverse osmosis dominating in the United States. For more information on the technologies, see **Appendix A**. Desalination technology costs dropped steadily in recent decades, making it more competitive with other water supply augmentation and treatment options. A rise in electricity prices could reverse the trend. Electricity expenses vary from one-third to one-half of the cost of operating desalination facilities.[2] Costs and cost uncertainties remain among the most significant challenges to implementing large-scale desalination facilities, especially seawater desalination plants.[3]

Substantial uncertainty also remains about the environmental impacts of large-scale desalination facilities. Social acceptance and regulatory processes also affect the technologies' adoption and perceived risks. Research and additional full-scale facilities may resolve uncertainties and contribute to the development of methods to mitigate impacts and reduce costs.

Questions that may confront the 112th Congress in its consideration of the federal role in desalination include:

- What is the appropriate level and nature of federal investment in desalination research and development? How should federal desalination research be prioritized?
- Should the federal government participate in and provide incentives for the construction and/or operation of desalination facilities separately from other federal programs supporting municipal water investments? If so, under what circumstances or using what criteria should federal participation be governed?

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[1] For more information on what is brackish groundwater, see National Ground Water Association, *Brackish Groundwater*, NGWA Information brief, Westerville, OH, July 21, 2010, http://www.ngwa.org/ASSETS/00F07610473C44B7862DCBFA43A2D84D/Brackish_water_info_brief_2010.pdf.

[2] S. Chaudry, "Unit cost of desalination," California Desalination Task Force, California Energy Commission, 2003.

[3] A survey of municipal desalination facilities in Texas found the cost for brackish desalination ranged from $410 to $847 per acre-foot, and for seawater desalination ranged from $1,168 to $1,881 per acre-foot. (J. Arroyo and S. Shirazi, *Cost of Water Desalination in Texas*, Texas Water Development Board, Austin, TX, October 2009, p. 6, http://www.twdb.state.tx.us/iwt/desal/docs/Cost_of_Desalination_in_Texas.pdf.)

To date, the federal government has been involved primarily in research and development, some demonstration projects, and select full-scale facilities, often through congressionally directed spending. For the most part, local governments, sometimes with state-level involvement, have been responsible for planning, testing, building, and operating desalination facilities to augment community water supplies, similar to their responsibility for treating freshwater drinking water supplies.

In the 112th Congress, H.R. 2664, Reauthorization of Water Desalination Act of 2011, would reauthorize a Department of the Interior program (expiring in 2011) carried out by the Bureau of Reclamation for desalination demonstration and outreach. The bill would reauthorize the program for $2 million annually for FY2012 to FY2016. During recent Congresses, legislative proposals have identified a range of different potential federal roles in desalination, including creation of a water research program within the national laboratories of the Department of Energy (to include numerous desalination-related research areas); authorization of desalination demonstration, research, and full-scale facilities; and authorization of payments to offset the energy costs of desalination operations. Discussions on the use of tax credit bonds, infrastructure banks, and innovative infrastructure financing techniques at times have also included desalination investments. Examples of the variety of desalination legislation proposed during the 111th Congress are available in **Appendix B**.

Desalination Adoption in the United States

Desalination technology is increasingly investigated and used as an option for meeting municipal and industrial water supply and water treatment demands. Globally, seawater desalination represents 60% of the installed desalination capacity.[4] In the United States, however, only 7% of the existing capacity uses seawater as its source. More than half of the water desalinated in the United States is brackish water. Another 25% is river water treated by desalination technologies for use in industrial facilities, power plants, and some commercial applications.

Desalination's attractions are that it can create a new source of freshwater from otherwise unusable waters, and that this source may be more dependable than freshwater sources that rely on annual or multi-year precipitation, runoff, and recharge rates. Many states—most notably Florida, California, and Texas—and cities are actively researching and investigating the feasibility of large-scale desalination plants for municipal water supplies. Desalination and its different applications, however, come with their own sets of risks and concerns. The growing use of desalination technologies in the United States and related concerns are discussed below.

Adoption Growing in States Searching for Municipal Water Supplies

The nation's installed desalination capacity has increased in recent years. As of 2005, approximately 2,000 desalination plants larger than 0.3 million gallons per day (MGD) were operating in the United States, with a total capacity of 1,600 MGD (less than 0.4% of total U.S.

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[4] Data in this paragraph is from H. Cooley et al., *Desalination, With a Grain of Salt: A California Perspective*, Pacific Institute (June 2006).

water use).[5] Florida, California, Texas, and Arizona have the greatest installed desalination capacity. Florida dominates the U.S. capacity, with the facility in Tampa being a prime example (see box); however, Texas and California are bringing plants online or are in advanced planning stages. Several other efforts also are preliminarily investigating desalination for particular communities, such as Albuquerque. Two-thirds of the U.S. desalination capacity is used for municipal water supply; industry uses about 18% of the total capacity.[6]

While interest in obtaining municipal water from desalination is rising in the United States, desalination is expanding most rapidly in other world regions, often in places where other supply augmentation options are limited by geopolitical as well as natural conditions. The Middle East, Algeria, Spain, and Australia are leading in the installation of new desalination capacity.[7]

Tampa's Desalination Experience and Lessons

Tampa's planning of the first large-scale (25 MGD) desalination plant in the late 1990s ignited interest in large-scale desalination as a municipal water supply source elsewhere in the United States. The facility was thought of as a signal of desalination becoming a cost-effective supply option, However, the Tampa plant, a facility to desalinate heavily brackish estuarine water, encountered technical and economic problems (e.g., less freshwater produced than anticipated, fouling of reverse osmosis membranes, financing issues) during construction and start-up, driving up the cost of the freshwater produced. For some observers, a lesson from the Tampa plant experience is one of caution; before proceeding to full-scale implementation, large-scale desalination requires careful investigation. In the view of industry observers, the lessons to be learned from Tampa are that (1) good design suited to the local conditions and (2) a thorough pilot-study are critical for a desalination facility to function properly. For other observers, the Tampa project illustrates some of the risks of working with private water developers and lowest-bid contracts without sufficient external review and accountability mechanisms. Private developers, however, remain attractive for some communities because of their role in financing the capital cost of constructing a large-scale desalination facility.

Energy Intensity Creates Cost Uncertainties

The cost of desalination remains a barrier to adoption. Like nearly all new freshwater sources, desalinated water comes at substantially higher costs than existing sources. Much of the cost for seawater desalination is for the energy required for operation of the desalination technologies; in particular, the competitiveness of reverse osmosis seawater desalination is highly dependent on the price of electricity. Additionally, the electricity consumed in desalination has greenhouse and other emissions associated with it. Price and emissions have driven many desalination proponents to investigate renewable energy supplies and co-location with power plants.[8] As electricity becomes more expensive, less electricity-intensive options (such as conservation, water purchases, and changes in water pricing) increase in competitiveness relative to desalination.

Reverse osmosis pushes water through a membrane to separate the freshwater from the salts; this requires considerable energy input. Currently the typical energy intensity for seawater desalination with energy recovery devices is 3-7 kilowatt-hours of electricity per cubic meter of

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[5] Ibid.

[6] Ibid.

[7] J. Hughes, "Seawater Desalination Leads Response to Global Water Crisis," *AWWA Streamlines*, November 10, 2009.

[8] A major benefit of co-location is using the cooling water from the power plant for desalination; this water has been warmed by the power plant which reduces the energy requirements for desalinating it. Also, the desalination facility may avoid construction costs by sharing intake and discharge facilities.

water (kWh/m^3).[9] The typical energy intensity of brackish desalination is less than seawater desalination, at 0.5-3 kWh/m^3. This range exists and is lower than seawater requirements because the energy required for desalination is proportional to the salinity of the source water.[10] Uncertainty in electricity prices, therefore, creates significant uncertainty in the operating costs of desalination facilities, which influences the technology's attractiveness as a water supply. Reducing the technology's energy requirements would decrease its cost uncertainties. The energy used in the reserve osmosis portion of new desalination facilities is close to the theoretical minimum energy required for separation of the salts from the water.[11] Energy efficiency improvements, therefore, may be more likely to come from other components of desalination facilities, such as the pretreatment of the water before it enters reverse osmosis. Pretreatment is necessary in order to avoid fouling and harm to the reverse osmosis membranes.

Substantial further cost savings are unlikely to be achieved through incremental advances in the commonly used technologies, like reverse osmosis. The National Research Council (NRC) in a 2008 report, *Desalination: A National Perspective,* recommended that federal desalination research funding be targeted at long-term, high-risk research not likely to be attempted by the private sector that could significantly reduce desalination costs.

Health and Environmental Concerns

From a regulatory, oversight, and monitoring standpoint, desalination as a significant source of water supply is new in the United States, which means the health and environmental regulations, guidelines, and policies regarding its use are still being developed. Existing laws and policies often do not address unique issues raised by desalinated water as a drinking water supply. Similarly, the implications of integrating desalination into existing water distribution infrastructure have not been tested in a wide range of applications (e.g., corrosion of distribution facilities by desalinated water). This creates uncertainty for those considering investing millions in constructing a full-scale facility. Addressing these concerns will reduce potential risks and improve the information available for decision-making.

Evolving Drinking Water Guidelines

While the quality of desalinated water is typically very high, some health concerns remain regarding its use as a drinking water supply. For example, the source water used in desalination may introduce biological and chemical contaminants to drinking water supplies that are hazardous to human health, or desalination may remove minerals essential for human health. For example, a health concern about boron has been raised in relation to seawater desalination; this is an uncommon concern for traditional water sources. Boron is know to cause reproductive and developmental toxicity in animals and irritation of the digestive tract, and it accumulates in plants, which may be a concern for agricultural applications. There are concerns about boron in the freshwater produced from seawater desalination because the boron levels after basic reverse osmosis commonly exceed current World Health Organization health guidelines and the U.S.

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[9] National Research Council, *Desalination: A National Perspective*, 2008, pp. 74-75, and 77. Hereafter referred to as NRC *Desalination: A National Perspective*, 2008.

[10] NRC *Desalination: A National Perspective*, 2008, p. 77.

[11] M. Elimelech and W.A. Phillip, "The Future of Seawater Desalination: Energy, Technology, and the Environment," *Science*, vol. 333 (August 5, 2011), pp. 712-717.

Environmental Protection Agency (EPA) health reference level. Boron can be removed through treatment optimization, but that treatment could increase the cost of desalted seawater. Boron is one of a number of potential health concerns requiring further attention and investigation as seawater desalination is used in large-scale application for water supply; for example, microorganisms unique to seawater and algal toxins may also pass through reverse osmosis membranes and enter the water supply.

EPA sets federal standards and treatment requirements for public water supplies, and controls disposal of wastes, including concentrate disposal, which is discussed later.[12] In 2008, EPA determined that it would not develop a maximum contaminant level for boron because of its rare occurrence in most groundwater and surface water drinking water sources; EPA has encouraged affected states to issue guidance or regulations as appropriate.[13] Most states have not issued such guidance. Therefore, most U.S. utilities lack clear guidance on boron levels in drinking water suitable for protecting public health. The National Research Council recommended development of boron drinking water guidance to support desalination regulatory and operating decisions; it recommended that the guidance be based on an analysis of the human health effects of boron in drinking water and other sources of exposure.

Environmental Effects of Intake Structures and Concentrate Disposal

The environmental concerns that arise in relation to desalination facilities include the effect of intake structures and the disposal of waste concentrate, as well as the potential to open up new coastal areas to development. These concerns are often raised in the context of obtaining the permits required to site, construct, and operate the facility and dispose of the waste concentrate. According to the Pacific Institute's report *Desalination, With a Grain of Salt*, as many as 26 federal, state, and local agencies may be involved in the review or approval of a desalination plant in California. A draft environmental scoping study for a facility in Brownsville, TX, identified 26 permits, approvals, and documentation requirements for construction and operation of a seawater desalination facility.[14] Some stakeholders view these permit requirements as a barrier to adoption of desalination.

The application of desalination in the United States is also challenged by the use of estuarine water in many of the facilities being contemplated. Estuarine water, which is a brackish mixture of seawater and surface water, has the advantage of lower salinity than seawater. Application of desalination to estuarine water is uncommon, with the facility in Tampa being the largest of its kind in the United States. The presence of surface water (which tends to be more contaminated than seawater) in estuarine water may complicate compliance of desalinated estuarine water with federal drinking water standards. For inland brackish desalination, significant constraints on adoption are the uncertainties and the cost of the waste concentrate disposal.[15]

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[12] For more information on EPA's role in protecting drinking water, see CRS Report RL31243, *Safe Drinking Water Act (SDWA): A Summary of the Act and Its Major Requirements*, by Mary Tiemann.

[13] EPA, *Regulatory Determinations for Priority Contaminant s on the Second Drinking Water Contaminant Candidate List*, available at http://www.epa.gov/OGWDW/ccl/reg_determine2.html.

[14] Texas Water Development Board, *The Future of Desalination in Texas: 2010 Biennial Report*, Austin, TX, December 2010, p. 8, http://www.twdb.state.tx.us/iwt/desal/docs/2010_thefutureofdesalinationintexas.pdf. The report includes a table listing the permits, approvals, and environmental documentation compliance requirements, and estimates of the cost for obtaining each.

[15] The Texas Water Development Board undertook a study with the intent of showing that oil and gas fields can (continued...)

The National Research Council in 2008 called for further research and development on mitigating environmental impacts of desalination and reducing potential risks relative to other water supply alternatives.[16] It identified the following priority research areas to address environmental concerns:

- assess environmental impacts of desalination intake and concentrate management approaches, and synthesize results in a national assessment;
- improve intake methods at coastal facilities to minimize harm to organisms;
- develop cost-effective approaches for concentrate management that minimizes environmental impacts; and
- develop monitoring and assessment protocols for evaluating the potential ecological impacts of surface water concentrate discharge.

Federal Desalination Research

Desalination research represents less than 0.1% of the approximately $130 billion annual federal research and development investment. The optimal level of federal investment in desalination research is inherently a public policy question shaped by factors such as fiscal priorities and views on the appropriate role of federal government in research, industry development, and water supply. Increasing federal funding for desalination research raises questions, such as what should be the respective roles of federal agencies, academic institutions, and the private sector in conducting research and commercializing the results, and should federal research be focused on basic research or promoting the use of available technologies?

Desalination Research Agenda

Several reports in the last decade have aimed to inform the path forward for U.S. desalination research. The first was the *Desalination and Water Purification Technology Roadmap* produced by the Bureau of Reclamation and Sandia National Laboratories at the request of Congress. The National Research Council reviewed the roadmap in a 2004 report, *Review of the Desalination and Water Purification Technology Roadmap*, which called for a strategic national research agenda. To this end, the National Research Council convened a Committee on Advancing Desalination Technology. That NRC committee published a report in 2008, *Desalination: A National Perspective*, recommending that the strategic agenda focus on research on environmental impacts of desalination and lowering the cost of desalination. In 2010, the Water Research Foundation, WateReuse Foundation, and Sandia National Laboratories published a report on how to implement the 2003 roadmap.[17] The report identifies research agendas for a

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physically and chemically accept desalination waste concentrate and to recommend changes to statutes and rules to facilitate waste concentrate disposal in oil and gas fields. R. E. Mace et al., *Please Pass the Salt: Using Oil Fields for the Disposal of Concentrate from Desalination Plants*, Texas Water Development Board, Austin, TX, April 2006, http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/Report366.pdf.

[16] NRC, *Desalination: A National Perspective*, 2008.

[17] Water Research Foundation, WateReuse Foundation, Sandia National Laboratories, *Implementation of the National Desalination and Water Purification Technology Roadmap*, January 2010, http://www.sandia.gov/water/docs/DesalImplementRoadmap1-26-2010_c_web.pdf.

range of topics—membrane technologies, alternative technologies, concentrate management, and institutional issues such as energy cost reduction and regulatory compliance.

Federal Desalination Funding

Most federally supported desalination spending is on research to improve existing technologies, fostering innovations in alternative technologies, and applications in the military. Much federal desalination research is managed by the Bureau of Reclamation through its Desalination and Water Purification Research & Development Program. Congress authorized the program in the Water Desalination Act of 1996 (P.L. 104-298) and has extended its authorization for appropriations of $5 million annually through FY2011.

The National Research Council in 2008 recommended a level of funding consistent with the levels in FY2005 and FY2006, roughly $25 million, but recommended that the research be targeted strategically, including being directed at the research activities described above.[18] The level of funding fell after FY2006, when the appropriations process has included less congressionally directed spending. The NRC drew the following conclusion:

> There is no integrated and strategic direction to the federal desalination research and development efforts. Continuation of a federal program of research dominated by congressional earmarks and beset by competition between funding for research and funding for construction will not serve the nation well and will require the expenditure of more funds than necessary to achieve specified goals.[19]

Although not directly addressing desalination research, H.R. 1145, the National Water Research and Development Initiative Act of 2009, would require greater coordination of federal water research and funding, which would include technologies such as desalination. Research cannot address all barriers to adoption of desalination. Efforts to overcome other constraints (e.g., public education and regulatory processes) also are often recommended as part of an overall strategy for reducing adoption barriers.

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[18] According to the 2004 NRC report, *Confronting the Nation's Water Problems: The Role of Research*, "water supply augmentation and conservation" including desalination research by federal agencies totaled $14.5 million in FY2000. In the past the federal government invested more in this area; in the late 1960s, federal research in desalination and other saline water conversion activities exceeded $100 million annually. Research alone does not represent all federal spending on and support of desalination. The EPA also may support construction of municipal desalination facilities through loans provided to these facilities through the EPA's Drinking Water State Revolving Loan Funds.

[19] NRC *Desalination: A National Perspective*, 2008, p. 228.

Appendix A. Desalination Technologies

There are a number of methods for removing salts from seawater or brackish groundwater to provide water for municipal and agricultural purposes. The two most common processes, thermal (e.g., distillation) and membrane processes (e.g., reverse osmosis), are described below; their descriptions are followed by descriptions of some of the more innovative and alternative desalination technologies. The earliest commercial plants used thermal techniques. Improvements in membrane technology have reduced costs, and membrane technology is less energy-intense than thermal desalination (although it is more energy-intense than most other water supply options). Reverse osmosis and other membrane systems account for nearly 96% of the total U.S. desalination capacity and 100% of the municipal desalination capacity.

Distillation and Reverse Osmosis

In distillation, saline water is heated, separating out dissolved minerals, and the purified vapor is condensed. Reverse osmosis forces salty water through a semipermeable membrane that traps salt on one side and lets purified water through. Reverse osmosis plants have fewer problems with corrosion and usually have lower energy requirements than thermal processes. Distillation plants, however, require less maintenance and pretreatment before the desalination process.

Innovative and Alternative Desalination Processes

Forward Osmosis

Forward osmosis is a relatively new membrane-based separation process that uses an osmotic pressure difference between a concentrated "draw" solution and the saline source water; the osmotic pressure drives the water to be treated across a semipermeable membrane into the draw solution. The level of salt removal can be competitive with reverse osmosis. A main challenge is in the selection of a draw solute; the solute needs to either be desirable in the water supply, or be easily and economically removed. Research is being conducted on whether a combination of ammonia and carbon dioxide gases can be used as the draw solution. The attractiveness of forward osmosis is that its energy costs can be significantly less than for reverse osmosis when combined with industrial or power production processes.[20]

Electrodialysis[21]

Electrodialysis depends on the ability of electrically charged ions in saline water to migrate to positive or negative poles in an electrolytic cell. Two different types of ion-selective membranes are used—one that allows passage of positive ions and one that allows negative ions to pass between the electrodes of the cell. When an electric current is applied to drive the ions, fresh water is left between the membranes. The amount of electricity required for electrodialysis, and

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[20] R. L. McGinnis, and M. Elimelech. "Energy requirements of ammonia carbon dioxide forward osmosis desalination," *Desalination* (2007) 207, pp. 370-382.

[21] The description of the remaining technologies was written by Peter Folger, Specialist in Energy and Natural Resources Policy.

therefore its cost, increase with increasing salinity of feed water. Thus, electrodialysis is less economically competitive for desalting seawater compared to less saline, brackish water.

Ion Exchange

In ion exchange, resins substitute hydrogen and hydroxide ions for salt ions. For example, cation exchange resins are commonly used in home water softeners to remove calcium and magnesium from "hard" water. A number of municipalities use ion exchange for water softening, and industries requiring extremely pure water commonly use ion exchange resins as a final treatment following reverse osmosis or electrodialysis. The primary cost associated with ion exchange is in regenerating or replacing the resins. The higher the concentration of dissolved salts in the water, the more often the resins need to be renewed. In general, ion exchange is rarely used for salt removal on a large scale.

Freezing Processes

Freezing processes involve three basic steps: (1) partial freezing of the feed water in which ice crystals of fresh water form an ice-brine slurry; (2) separating the ice crystals from the brine; and (3) melting the ice. Freezing has some inherent advantages over distillation in that less energy is required and there is a minimum of corrosion and scale formation problems because of the low temperatures involved. Freezing processes have the potential to concentrate waste streams to higher concentration than other processes, and the energy requirements are comparable to reverse osmosis. While the feasibility of freeze desalination has been demonstrated, further research and development remains before the technology will be widely available.

Appendix B. Desalination Legislation of the 111th Congress

Examples of Research Legislation from the 111th Congress

H.R. 469, the Produced Water Utilization Act of 2009, would have authorized a Department of Energy program for research, development, and demonstration of technologies (including desalination) for environmentally sustainable utilization of groundwater produced during energy development (i.e., groundwater brought to the surface as part of exploration or development of coalbed methane, oil, natural gas, or any other substance to be used as an energy source) for agricultural, irrigational, municipal, and industrial uses, or other environmentally sustainable purposes.

H.R. 1145, the National Water Research and Development Initiative Act of 2009, would have formally established a federal interagency committee to coordinate federal water research, including desalination research. The committee, with input from an advisory committee, was to develop a four-year plan for priority federal research topics and annually report on progress on the plan. Among the proposed outcomes of the plan was the promotion of technology for enhancing reliable water supply (e.g., desalination). The bill also would have established a National Water Initiative Coordination Office to function as a clearinghouse for technical and programmatic information, support the interagency committee, and disseminate the findings and recommendations of the interagency committee. A version of the committee, the Subcommittee on Water Availability and Quality (SWAQ), which was not created by statute, has been operating since 2003 within the Office of Science and Technology Policy (OSTP) as part of the National Science and Technology Council (NSTC).

S. 1462, the American Clean Energy Leadership Act of 2009, included a provision directing the Secretary of the Interior to operate, maintain, and manage the Brackish Groundwater National Desalination Research Facility.[22] The bill would have directed the facility to conduct research, development, and demonstration activities to promote brackish groundwater desalination, including the integration of desalination and renewable energy technologies, and outreach programs with public and private entities and for public education. The facility's mission also includes managing the waste concentrated from desalination, desalinating waters produced during oil and gas production, and small-scale desalination systems.

S. 1733, Clean Energy Jobs and American Power Act, included a provision requiring the U.S. Environmental Protection Agency (EPA) to establish a research program on the effects of climate change on drinking water utilities, and authorizing $25 million annually for program funding for FY2010 through FY2020. The research program would have addressed alternative water supply

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[22] The Brackish Groundwater National Desalination Research Facility is a federally constructed research facility focused on developing desalination technologies for brackish and impaired groundwater found in the inland states. It is located in Alamogordo, Otero County, NM. The facility opened in August 2007 and is integrated into Department of the Interior's existing desalination research and development program at the Bureau of Reclamation. It brings together researchers from other federal agencies, universities, the private sector, research organizations, and state and local agencies.

technology issues, including desalination, brine management, and environmental impacts of intakes for seawater desalination.

Examples of Planning, Construction, and Financing Legislation from the 111th Congress

P.L. 111-11, the Omnibus Public Land Management Act of 2009, includes provisions authorizing federal funding to be used for design, planning, and construction costs for facilities with desalination and brine disposal components—$20 million for the Rancho California Water District (CA)[23] and $46 million in the Santa Ana watershed (CA)[24]—as part of the Bureau of Reclamation's Title XVI water reuse program. The act also authorizes the Secretary of the Interior to financially assist the California Water Institute to conduct a study coordinating and integrating subregional water management plans, including desalinated water supplies, for the San Joaquin and Tulare Lake regions.

H.R. 88, the City of Oxnard Water Recycling and Desalination Act of 2009, would have authorized federal funding to be used for up to 25% of the design, planning, and construction costs ($15 million of a total $60 million) of the Groundwater Recovery Enhancement and Treatment (GREAT) project in Ventura County (CA). The bill would have authorized the project as part of the Bureau of Reclamation's Title XVI water reuse program. The project combines wastewater recycling and reuse and groundwater management and desalination to provide regional water supply solutions to the Oxnard Plain.

H.R. 4132, the Clean Renewable Water Supply Act of 2009, and S. 1731, the Clean Renewable Water Supply Bond Act of 2009, would have made facilities desalinating seawater, groundwater, or surface water among the types of projects eligible for accessing the federal bonds mechanism created by the bill.

In addition to the research provision previously described, S. 1733, the Clean Energy Jobs and American Power Act, would have included investigating, designing, or constructing desalination facilities among the eligible uses of grants provided to states as part of the bill's climate change adaptation provisions.

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[23] The project also was the subject of H.R. 371, Rancho California Water District Recycled Water Reclamation Facility Act of 2009.

[24] These activities and additional regional conveyance infrastructure for the waste brine were also the subject of H.R. 530, Santa Ana River Water Supply Enhancement Act of 2009.