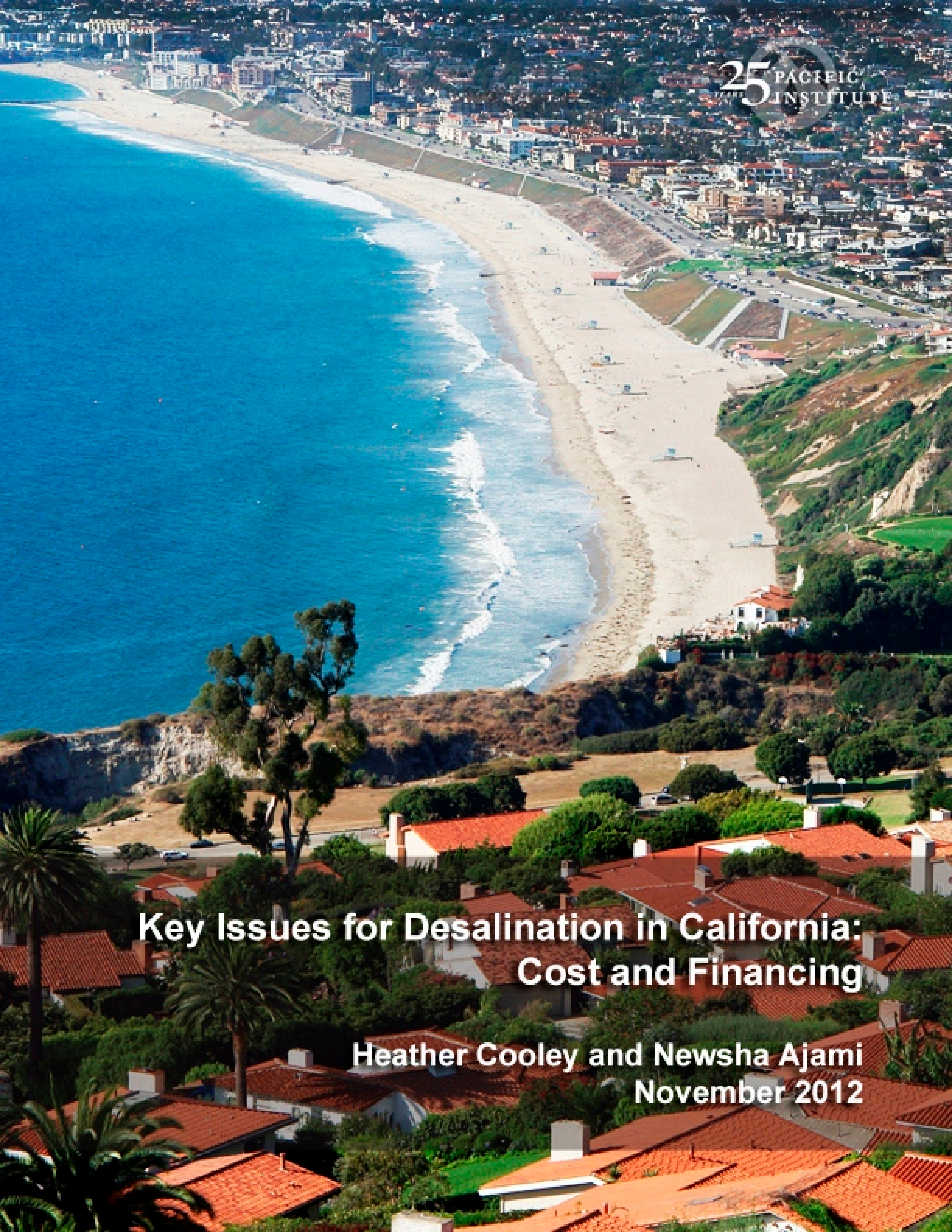

Pacific Institute

Key Issues for Desalination in California: Cost and Financing

Heather Cooley and Newsha Ajami

November 2012

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Heather Cooley
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Editors
Nancy Ross and Paula Luu, Pacific Institute

Pacific Institute
654 13th Street, Preservation Park
Oakland, California 94612
www.pacinst.org
Phone: 510.251.1600
Facsimile: 510.251.2203

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About the Pacific Institute

The Pacific Institute is one of the world's leading nonprofit research and policy organizations working to create a healthier planet and sustainable communities. Based in Oakland, California, we conduct interdisciplinary research and partner with stakeholders to produce solutions that advance environmental protection, economic development, and social equity – in California, nationally, and internationally. We work to change policy and find real-world solutions to problems like water shortages, habitat destruction, global warming, and environmental injustice. Since our founding in 1987, the Pacific Institute has become a locus for independent, innovative thinking that cuts across traditional areas of study, helping us make connections and bring opposing groups together. The result is effective, actionable solutions addressing issues in the fields of freshwater resources, climate change, environmental justice, and globalization. More information about the Institute and our staff, directors, funders, and programs can be found at www.pacinst.org.

About the Authors

Heather Cooley

Heather Cooley is the co-director of the Pacific Institute Water Program. She conducts and oversees research on an array of water issues, such as the connections between water and energy, sustainable water use and management, and the hydrologic impacts of climate change. Ms. Cooley has authored numerous scientific papers and co-authored five books, including *The World's Water, A 21st Century U.S. Water Policy,* and *The Water-Energy Nexus in the American West.* Ms. Cooley is a recipient of the Environmental Protection Agency's Award for Outstanding Achievement and serves on the Board of Directors of the California Urban Water Conservation Council. She also serves on the California Commercial, Industrial, and Institutional Task Force. Ms. Cooley received a B.S. in Molecular Environmental Biology and an M.S. in Energy and Resources from the University of California at Berkeley.

Newsha Ajami

Dr. Newsha Ajami is a senior research associate with the Pacific Institute Water Program. She is a hydrologist specializing in sustainable water resource management, hydrological modeling, flood and water supply forecasting, and advancing uncertainty assessment techniques impacting hydrological predictions. Dr. Ajami received her Ph.D. in Civil and Environmental Engineering from the University of California at Irvine, an M.S. in Hydrology and Water Resources from the University of Arizona, and a B.S. in Civil and Environmental Engineering from Tehran Polytechnic. She has published many highly cited peer-reviewed papers in predominant journals and was the recipient of 2010 William R. Gianelli Water Leaders scholarship, 2005 NSF funding for AMS Science and Policy Colloquium, and ICSC-World Laboratory Hydrologic Science and Water Resources Fellowship from 2000-2003.

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Executive Summary

In June 2006, the Pacific Institute released *Desalination, With a Grain of Salt*, an assessment of the advantages and disadvantages of seawater desalination for California. At that time, there were an estimated 21 active seawater desalination proposals along the California coast. Since then, only one project, a small plant in Sand City, has been permitted and built. A second plant, in Carlsbad, has had all of the necessary permits in place since 2009 but has not yet secured financing. Interest in seawater desalination, however, remains high in California and many agencies are conducting technical and environmental studies and pilot projects to determine whether to develop full-scale facilities.

Beginning in 2011, the Pacific Institute initiated a new research project on seawater desalination. As part of that effort, we conducted some 25 one-on-one interviews with industry experts, water agencies, community groups, and regulatory agencies to identify some of the key outstanding issues. Throughout 2012 and 2013, we are producing a series of research reports that evaluate key outstanding issues for seawater desalination projects in California. The first report, released in July 2012, provided an update of the proposed seawater desalination projects along the coast of California. In this report, the second in the series, we provide detailed information about the cost of seawater desalination projects, how they are financed, and some of the risks associated with these projects. Other issues that will be addressed in future reports include the marine impacts of seawater desalination, the energy requirements and associated greenhouse gas emissions of desalination, and an overview of the permitting process.

How Much Does Seawater Desalination Cost?

Economics – including both the cost of the water produced and the complex financial arrangements needed to develop a project – are key factors that will determine the ultimate success and extent of desalination in California. Our analysis finds that the cost to produce water from a desalination plant is highly variable. Recent estimates for plants proposed in California range from $1,900 to more than $3,000 per acre-foot, or $1.54 - $2.43 per cubic meter ($m^3$). While the cost of seawater desalination has declined considerably over the past 20 years, desalination costs remain high and there are unlikely to be any major cost breakthroughs in the near- to mid-term. Indeed, desalination costs may increase in response to rising energy prices.

The public and decision-makers must exercise caution when comparing cost estimates for different seawater desalination projects. In many cases, costs are reported in ways that are not directly comparable. For example, some report the cost of the desalination plant alone, while others include the additional infrastructure, e.g., conveyance pipelines, needed to integrate the desalination plant into the rest of the water system. Some estimates include the cost to finance the project, while others do not. Even when there is an apples-to-apples comparison, there are a number of site- and project-specific factors that make cost comparisons difficult, such as energy, land, and labor costs.

Furthermore, costs associated with wastewater conveyance and treatment are often excluded from desalination cost comparisons. The introduction of a new source of water increases the amount of wastewater that must be collected, treated, and disposed. Some communities may have adequate wastewater treatment capacity and the additional costs would simply be the variable O&M costs associated with that treatment. In other communities, however, wastewater treatment capacity may need to be expanded, which represents an additional, and in some cases significant, capital cost to the community. While these costs would apply to all of the water supply projects under consideration to meet demand, these costs would not be incurred if water demand was met through water conservation and efficiency improvements.

How Are Seawater Desalination Projects Financed?

The construction of a desalination plant is expensive and requires considerable up-front capital investment. To cover these costs, project developers often rely heavily on debt financing, which involves borrowing money from a lender with the intent of repaying the principal of that debt and interest. Although still relatively uncommon within the water sector, project developers are also turning to private equity financing – whereby an investor provides capital for the project in exchange for partial ownership of the desalination plant.

For most of the proposed projects in California, the financing mechanism has not yet been determined. Desalination projects that are being developed solely by public water agencies will likely use municipal revenue bonds or other conventional financing methods. Additional support may be provided through government grant and loan programs. Nine of the proposed plants in California, however, may be entirely or partially financed and owned by private companies, and these projects will likely use some combination of debt financing, especially tax-exempt private-activity bonds, and private equity. These public-private partnerships can allow for a mechanism to attract private investment and share some of the risks associated with a project. One of the possible drawbacks in private sector financing, however, is the high cost of private capital, which is reflected in the price of desalinated water. Proponents of this approach, however, argue that the higher costs are offset by lower risk for the water provider, higher efficiency of the contractor, and technology performance guarantees.

What Are Some of the Risks Associated with Seawater Desalination Projects?

There are several risks associated with seawater desalination projects that can affect the cost of the project, ability to attract financing, and overall viability of the project. Many of these risks are not unique to seawater desalination projects – rather they apply broadly to all major infrastructure projects. These include risks associated with permitting, construction, operations, and changes in law.

But as recent experience in the United States and Australia has shown, desalination projects entail risks specific to large water-supply projects, including demand risk. Demand risk is the risk that water demand will be insufficient to justify continued operation of the desalination plant due to the availability of less expensive water supply and demand management alternatives. In Australia, for example, four of the six desalination plants that have been developed since 2006 are being placed in stand-by mode. Likewise, the Tampa Bay Desalination Plant is operated considerably below full capacity because demand is lower than expected and less expensive water-supply options are available. Demand risk raises serious concerns about the size and timing of desalination projects, e.g., how big and when desalination plants should be built.

In some regions, seawater desalination can make an important contribution to the availability and reliability of water resources. However, it remains among the most expensive options available to meet water demands. Additionally, project developers may build large plants in an effort to capture economies of scale and reduce the unit cost of water. This can, however, lead to oversized projects that ultimately increase demand risk and threaten the long-term viability of a project.

How Are Desalination Projects Structured?

Issues around financing and how project costs and risks are allocated are tied to how the project is structured. Many project developers in California are using some form of public-private partnerships. The private sector's involvement in seawater desalination projects is not new. The private sector has developed several small plants to supply high-quality water for specific industrial purposes, such as for use on oil and gas platforms. Likewise, a desalination project in Santa Barbara, completed in 1992, was operated and partially owned by a private company. In some cases, the private sector's involvement is limited to conducting feasibility studies and preparing environmental documents as requested by the public project developer. In other cases, however, a private entity owns and operates the desalination plant and sells water directly to a public agency. Public-private partnerships provide a mechanism to access private capital and allocate risks among the project partners. They can, however, be highly contentious due to concerns about openness and transparency of data and financial information and the allocation of the risk among the project partners.

Additionally, utilities that are developing seawater desalination plants must be sure that there is a demand for that water, especially when establishing minimum commitments under take-or-pay contracts. A take-or-pay contract provides guaranteed revenue for the seller but commits the buyer to a purchase even if actual demand drops. This exposes the buyer to demand risk – and provides a disincentive for water agencies to pursue more cost effective water supply and water conservation and efficiency programs.

Key Issues for Seawater Desalination in California: Cost and Financing

Introduction

In June 2006, the Pacific Institute released *Desalination, With a Grain of Salt*, an assessment of the advantages and disadvantages of seawater desalination for California. At that time, there were 21 active seawater desalination proposals along the California coast. Since then, only one project, a small plant in Sand City, has been permitted and built. A second project, in Carlsbad, has all of the necessary permits but has not yet secured financing. Interest in seawater desalination, however, remains high in California, and many agencies are conducting technical and environmental studies and pilot projects to determine whether to develop full-scale facilities.

Beginning in 2011, the Pacific Institute initiated a new research project on seawater desalination. As part of that effort, we conducted some 25 one-on-one interviews with industry experts, water agencies, environmental and community groups, and regulatory agencies to identify some of the key outstanding issues for seawater desalination projects in California. We are now producing a series of research reports that evaluate these issues. The first report, released in July 2012, provided an update of the proposed projects along the California coast. In this report, the second in the series, we provide detailed information about the cost of seawater desalination projects, how they are financed, and some of the risks associated with these projects. Future reports will evaluate the marine impacts of seawater desalination, the energy requirements and associated greenhouse gas emissions, and the permitting process.

How Much Does Seawater Desalination Cost?

There are many components and definitions of the cost of a desalination project, and uncertainty about these terms can lead to confusion about cost comparisons, especially among those without a finance background. In this section, we provide a short introduction to some of the terms used to describe the financial costs of a desalination project. We also compare costs among proposed and recently constructed plants and describe some of the factors that contribute to the large variability among projects. We conclude with a comparison of the cost of seawater desalination with that of other water alternatives.

It is important to note that this report describes *financial* costs. There are other costs, however, that may not be captured in a financial analysis because they are not internalized in the project developer's cost stream or are not subject to market-like transactions (NRC 2008). For example, seawater intakes kill marine organisms on the intake screens. These impacts have a cost associated with them that some other group or individual bears, e.g., reductions in fish populations that affect local fishermen. These costs may be captured in an economic analysis. But unless they are internalized in the project through, for example, a requirement to restore or enhance wetlands, they will not be factored into the financial feasibility of a project and are not included in this report.

Cost Terminology

Capital and Operation and Maintenance Costs

The primary cost components of a seawater desalination plant are commonly divided into two major categories: capital costs and operation and maintenance (O&M) costs. Capital costs include those costs incurred during the construction of the project and include expenses associated with planning, permitting, designing, and constructing the project. Other capital costs include the expenses associated with buying or leasing equipment, purchasing the site, and mitigating environmental impacts.

Capital costs also include the cost to finance the project – referred to as the cost of capital. The capital required to develop desalination projects is not free, and the project developer must pay to access it. The cost of capital includes the cost of debt (for those projects financed with debt) and the cost of equity (for those projects financed with private equity). The cost of debt is based on the interest rate of the debt incurred for the project, i.e., the bond or loan, and reflects the compensation a lender demands for the risks involved in the project (Pemberton 2003). The cost of equity is the return paid to private equity investors to compensate for the risk they undertake by investing their capital. Generally, the greater the perceived risks of the project, the harder and costlier it is to secure capital.

In addition to capital costs, there are O&M costs associated with desalination plants. O&M costs represent the ongoing costs required to operate the plant, including expenses associated with replacement membranes, chemicals for pre- and post-treatment, energy to run the plant, environmental monitoring, and labor for plant operators. Some O&M costs, such as labor, are fixed, e.g., they do not vary with respect to the amount of water produced. Other O&M costs, such as for energy and chemicals, are variable and thus change in response to the amount of water produced.

Capital and O&M costs are often reported in different ways, which can complicate project cost comparisons. Capital costs are reported as one time, fixed costs. O&M costs, by contrast, are typically reported as annual costs. In order to determine the total annual cost of a desalination plant, the capital and O&M costs must be put on similar footing. The most common approach is to spread the capital costs, which include the cost to finance the project, over the life of the project, e.g., for 20 or 30 years, to produce an annualized capital cost. The annualized capital cost and the annual O&M cost are added together to produce a total annual cost.

Figure 1 shows an annual cost breakdown of a typical seawater desalination plant. Although variable from project to project, the annualized capital cost typically accounts for about one-third of the annual cost of a seawater desalination plant. O&M costs account for the remaining two-thirds. Generally, energy costs – at 36% of the annual cost – represent the single largest O&M cost and are of similar magnitude as the annualized capital cost. Depending on the desalination process and local site conditions, chemical costs can also be significant, accounting for about 12% of the total annual cost.

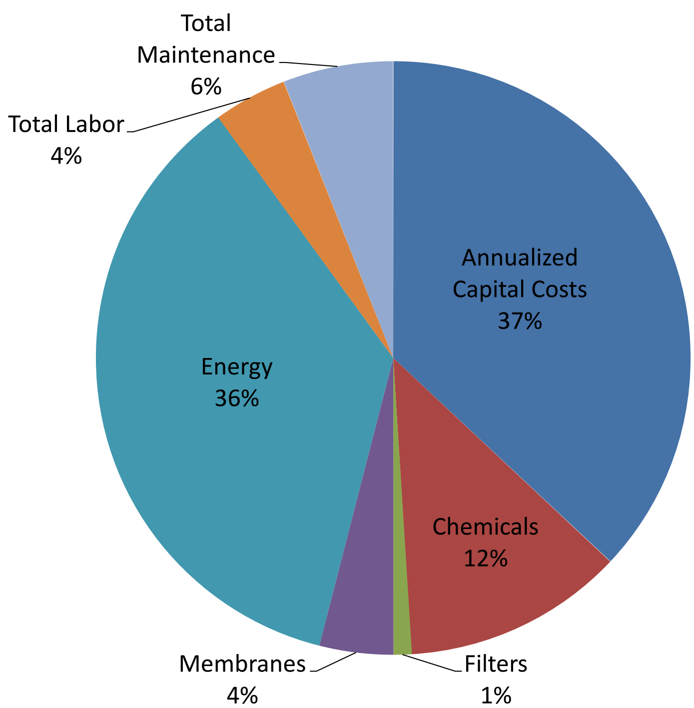

Figure 1. Annual Cost Breakdown of a Typical Seawater Desalination Plant

Note: Estimate for a reverse osmosis plant and based on the following assumptions: capacity of 50 million gallons per day (MGD), constant energy costs at $0.07 per kWh; membrane life of 5 years; nominal interest rate of 5%; and a depreciation period of 25 years.

Source: NRC 2008

Unit Cost

In addition to reporting capital and O&M costs, water managers often report the unit cost of water, i.e., the cost per acre foot (or cubic meter or thousand gallons) of water produced. The unit cost of water is derived from the annual cost (the annualized capital cost plus the O&M cost) and the annual production of water from the plant. Specifically, it is determined by the formula:

unit cost = (annualized capital cost + annual O&M cost)/annual amount of water produced

Given that the project cost is driven, in part, by the size of the plant, the unit cost effectively normalizes the cost of the project by the volume of water produced. It can also be useful for comparing projects of different sizes and for comparing various water supply and demand management alternatives.

Desalination Cost Estimates

Discussions about the actual costs of desalination plants have been muddled and muddied because estimates have been provided in a variety of units, years, and ways that are not directly comparable. Some report the cost of the desalination plant alone. Others include the costs for additional infrastructure needed to integrate the desalination plant into the rest of the water system, which can be significant. Some estimates include the cost to finance the project, while others do not. For example, the capital cost of the proposed Carlsbad Desalination Plant is currently estimated at $528 million. An additional $456 million is needed to build a pipeline to transport the water to customers, make other water-system improvements, and finance the project (SDCWA 2012a). Thus, the public, media, and analysts, must exercise caution when comparing costs.

Table 1 shows capital, O&M, and unit cost estimates for proposed plants in California and several recently constructed plants in Florida and Australia. O&M costs shown here are based on estimates the year the project was completed; these costs change over time and may not reflect current O&M costs (see page 13 for more about this topic). Costs for desalination plants in Australia were converted into U.S. dollars based on the conversion rates in the year that the plant was completed. We have not adjusted the apparent year of each reported cost for inflation since inflation varies from country to country. Even without adjustment to current year dollars, however, it is apparent from the table that costs vary far more widely than can be explained by inflation.

Table 1 shows that large plants tend to have higher capital and O&M costs than small plants but this is not always the case. For example, the Kwinana Desalination Plant in Perth, Australia has a capital cost of less than $330 million and an O&M cost of $17 million per year. The Gold Coast Desalination Plant, by contrast, is slightly smaller but has much higher capital and O&M costs of $890 million and $30 million per year, respectively. The Gold Coast plant was considerably more expensive than the Perth plant because steel and labor costs were dramatically higher when the plant was constructed. Additionally, the Gold Coast plant used a more complicated intake design and required the construction of a longer pipeline to distribute the water to customers (Crisp 2012).

Unit costs are also highly variable among projects. Variability among desalination projects is driven by a range of site- and project-specific factors. Land prices and labor costs, for example, can vary considerably among projects. Likewise, energy prices can have a major impact on the project cost. For example, the average electricity price of the Gold Coast Desalination Plant was $0.15 per kWh in 2009/2010 (Robertson 2010). Currently, electricity prices in California are about $0.10 per kWh (EIA 2012).[1] Other project- and site-specific factors that affect the cost include source-water temperature and salinity, intake and outfall design, environmental mitigation requirements, interest rates and loan period, project team experience, permitting requirements, and the presence of hidden and visible subsidies (Cooley et al. 2006, WateReuse Association 2012).

[1] Price in 2012 for industrial customers.

Table 1. Desalination Costs for Proposed and Recently Constructed Plants

Project	Capacity (MGD)	Capital Cost[a] ($ millions)	O&M Cost[b] ($ millions)	Unit Cost[c] ($/AF)	Dollars[d] are in…	Status	Data Source
Santa Cruz/ Soquel Creek Water District	2.5	$114	$3 - $4	N/A	2012 dollars	Proposed	Luckenbach 2012
California American Water[e]	4.9 – 8	$175 - $207	$7.77 - $11.0	$2,555 - $3,250	2012 dollars	Proposed	Separation Processes, Inc. 2012
Deep Water Desal[e]	4.9 - 8	$134 - $ 160	$9.38 - $12.3	$2,395 - $3,120	2012 dollars	Proposed	Separation Processes, Inc. 2012
The People's Moss Landing Water Desal Project[e]	4.9 - 8	$161 - $190	$7.06 - $10.1	$2,345 - $2,980	2012 dollars	Proposed	Separation Processes, Inc. 2012
Tampa Bay, Florida	25	$158	N/A	$1,100	2007 dollars	Complete	
Gold Coast Desalination Plant[f]	33	$888	$30	$1,982	2009 dollars	Complete	Pankratz 2012a
Kwinana Desalination Plant – Perth[f]	38	$330	$17	$1,221	2008 dollars	Complete	NWC 2008
Carlsbad Desalination Plant	50	$771	$50 - $54	$2,042 - $2,290	2012 dollars	Proposed	SDCWA 2012b
Camp Pendleton	50 - 100	$1,300 - $1,900	$45 - $105	$1,900 - $2,340	2009 dollars	Proposed	SDCWA 2012b
Kurnell Desalination Plant- Sydney[f]	55	$1,565	$47	$2,407	2008 dollars	Complete	NWC 2008
Southern Seawater Desalination Plant[f]	72	$1,466	N/A	$2,827	2012 dollars	Complete	Pankratz 2012a
Port Stanvac – Adelaide[f]	72	$1,878	$136	$2,389	2012 dollars	In progress	Pankratz 2012, Kemp 2012
Wonthaggi Desalination Plant – Melbourne[f]	109	$3,651	$63	$6,552	2012 dollars	In progress	Pankratz 2012a

Notes:
N/A: not available
(a) Capital costs here are based on capital expenditures (Cap Ex) and include the cost of the desalination plant plus any other infrastructure required to integrate the desalination plant into the rest of the water system. The cost to finance the project is not included.
(b) O&M costs include the operation and maintenance costs of the desalination plant and any other infrastructure required to integrate the desalination plant into the rest of the water system.
(c) The unit cost captures capital and O&M costs as well as the cost to finance the project.
(d) Costs have not been adjusted for inflation. Unless otherwise indicated, we assume that cost estimates are provided in the year in which the project was completed.
(e) The actual capacity of these projects may differ from what is stated here. The study these estimates were drawn from (Separation Processes, Inc. 2012) adjusted the plant capacities to make a more accurate comparison among projects in the region.
(f) Costs for plants in Australia were converted into U.S. dollars based on conversion rates for the year in which the cost estimates were made.

Desalination Costs Can Vary Over Time

It is important to note that desalination costs are not static but can vary over time. Many of the estimates shown in Table 1 are engineering estimates based on the initial project design. Actual production costs can be higher due to increases in the capital and O&M costs or a reduction in the amount of water produced. Capital costs may change if the price of materials, such as cement or steel, or the cost of borrowing money changes. Major project delays are also likely to increase capital costs.

O&M costs can also change over the life of the desalination plant due to changes in input costs or in the lifetime of major equipment. Energy, for example, represents a major cost component (Figure 1), and short-term and long-term increases in energy prices can increase production costs. If energy accounts for 36% of the annual production cost, a 25% increase in energy costs would increase the cost of produced water by 9%. Similarly, membranes typically last between 5 and 7 years, although in some cases, 10 years is possible. If the actual lifetime of the membranes exceeds 5-to-7 years, the production cost may be lower than the initial estimate. Conversely, if the membranes foul more quickly, than production costs may be higher.

The cost of produced water from a desalination plant is especially sensitive to changes in the amount of water produced. As described previously, the unit cost of water is determined by dividing the annual costs by the amount of water of produced. Typically, unit cost estimates during the design and planning of the project are based on the assumption that the desalination plant will operate at or near full capacity. By producing less water, however, the unit cost increases (Table 2). For example, a 50 MGD plant produces water at cost of $2,700 per acre-foot ($2.17 per m^3) at full capacity; an estimated 1/3 of the cost is fixed, and the remaining 2/3 of the cost is variable. If the operator reduces water production to 40 MGD, on average, then the unit cost of water increases to $3,100 per acre-foot ($2.53 per m^3). If the operator further reduces water production to 10 MGD, then the unit cost increases to more than $9,800 per acre-foot ($7.96 per m^3).

Table 2. An Example of the Relationship between Desalination Plant Production and Unit Cost

Plant Capacity (MGD)	Actual Production (MGD)	Annual Fixed Cost ($ millions)	Annual Variable Cost ($ millions)	Unit Cost ($/AF)	Unit Cost ($/$m^3$)
50	50	$100	$50	$2,678	$2.17
50	40	$100	$40	$3,125	$2.53
50	30	$100	$30	$3,869	$3.14
50	20	$100	$20	$5,356	$4.34
50	10	$100	$10	$9,820	$7.96

Cost Comparisons

Seawater desalination is considerably more expensive than most other water supply and demand management options, but cost comparisons made on the basis of the cost of existing water supplies can be misleading. The costs of existing supplies are often far below the investment needed to construct and maintain these systems because of heavy subsidies from state and federal investments. Additionally, current water prices often fail to include costs for adequately maintaining and improving water systems. As a result, the public often has a somewhat distorted perception of the cost of reliable, high-quality water, making it difficult for water utilities to justify their investment in more expensive water-supply options, such as desalination.

Consequently, a comparison of the cost of new seawater desalination systems should be based on the marginal cost of water: the cost of providing, or saving, the next increment of water. The marginal cost of water varies considerably among communities and can change over time. As a result, these costs should be evaluated periodically on a case-by-case basis. A recent analysis of water alternatives for San Diego County, California – a region considering building multiple desalination plants – finds that seawater desalination has the highest marginal cost of all plausible alternatives (Table 3). The marginal cost of recycled water is also relatively high, although treating the water to potable levels and using the existing distribution system can reduce this cost considerably. Surface and groundwater are less expensive than recycled water or seawater desalination, although these supplies are limited. In many cases, conservation and efficiency improvements have the lowest marginal cost.

Table 3. Example of the Marginal Cost of Water in San Diego County

Water Alternative	Cost Per Acre-Foot	Cost Per Cubic Meter
Imported Water	$875 - $975	$0.71 - $0.79
Surface Water	$400 - $800	$0.32 - $0.65
Groundwater	$375 - $1,100	$0.30 - $0.89
Seawater Desalination	$1,800 - $2,800	$1.46 - $2.27
Recycled Water (Non-Potable)	$1,600 - $2,600	$1.30 - $2.11
Recycled Water (Potable Water)	$1,200 - $1,800	$0.97 - $1.46
Water Conservation and Efficiency	$150 - $1,000	$0.12 - $0.81

Note: All costs are in year 2010 dollars. Cost estimates for water conservation and efficiency are based on costs to the water agency, e.g., estimated expenditures on educational initiatives or incentives for conservation measures divided by the cumulative water savings and do not include costs or savings to the customer. One acre-foot equals 1,233 cubic meters.
Source: Equinox Center 2010

The cost associated with wastewater conveyance and treatment is another factor that is often excluded from cost comparisons. The introduction of a new source of water increases the amount of wastewater that must be collected, treated, and disposed. Some communities may have adequate wastewater treatment capacity and the additional costs would simply be the variable O&M costs associated with that treatment. In other communities, however, wastewater treatment capacity may need to be expanded, which represents an additional, and in some cases significant, capital cost to the community.

While these costs would apply to all of the water supply projects under consideration to meet demand, these costs would not be incurred if water demand was met through water conservation and efficiency improvements.

How Are Seawater Desalination Projects Financed?

The construction of a desalination plant requires considerable up-front investment to cover the capital costs, and project financing is a key challenge for any capital-intensive project. As a result, project developers often rely heavily on debt financing. Debt financing involves borrowing money from an outside source with the intent of repaying the money borrowed plus interest. Some projects may also qualify for state or federal grants. Although still relatively uncommon within the water sector, project developers are also turning to equity financing – which involves obtaining money from an investor in exchange for partial ownership of the desalination plant. In the following section, we provide additional detail on the financing mechanisms available for desalination projects.

Overview of Financing Mechanisms

Grants

A grant is an award of financial assistance in the form of money with no expectation that the funds will be repaid. Some amount of funding for desalination plants may be available through state or federal grant programs, although these grants rarely cover the entire cost of the project. In 2002, for example, California voters approved Proposition 50, the Water Security, Clean Drinking Water, Coastal and Beach Protection Act, providing $50 million in grants to support the development of brackish and seawater desalination. In total, this funding supported three construction projects, nine pilots and demonstrations, and five feasibility studies for seawater desalination projects (Table 4).[2] The estimated financial cost for these projects was $139 million, about 16% of which was provided by state grants. While grants for desalination projects typically represent a relatively small fraction of the total investment required for these projects, they can make the investment far more cost-effective from the grantee's perspective.

Limited federal grant programs for seawater desalination plants are also available. Federal investment in seawater desalination has largely been through the support of research and development (R&D), although some funding has been directed toward demonstration projects and select full-scale facilities (Carter 2011). For example, the Desalination and Water Purification Research & Development (DWPR) Program, authorized by Congress under the Water Desalination Act of 1996, provides grant funding for R&D and some demonstration projects. In 2002 and in 2003, the Long Beach Water Department received a total of $2 million of federal support for the design and construction of a $5.4 million prototype desalination R&D facility (LBWD 2003).

[2] Additional funding was directed toward R&D. We do not include this here, as the focus of this section is on project funding.

Table 4. Proposition 50 Grant Awards for Seawater Desalination Projects in California

Project Sponsor	Description	Project Type	Grant Amount	Total Project Cost
Marin Municipal Water District	Construction of a 10 MGD facility	Construction	$3,330,744	$77,171,043
East Bay Municipal Utility District	Low-energy application of desalination to produce 1.5 MGD	Construction	$2,900,000	$14,640,000
Sand City	Construction of a 300 AFY RO desalination facility	Construction	$2,900,000	$8,375,000
City of Long Beach	Under ocean floor seawater intake and discharge demonstration project	Pilot Project	$2,000,000	$5,180,000
City of Long Beach	Mitigating water quality effects of desalination seawater	Pilot Project	$1,000,000	$2,270,000
West Basin Municipal Water District	Demonstration of integrated membrane seawater desalination using single-pass RO for the Los Angeles region	Pilot Project	$1,500,000	$10,213,435
City of Santa Cruz	Test technology innovations and optimize operation of the Santa Cruz desalination facility	Pilot Project	$1,982,601	$3,971,007
Los Angeles Department of Water and Power	Assess feasibility of a seawater desalination facility at Scattergood Generating Station	Pilot Project	$1,224,300	$2,877,780
Affordable Desalination Collaboration	Test new technologies and membranes to optimize and reduce energy costs associated with reverse osmosis	Pilot Project	$1,000,000	$2,368,437
East Bay Municipal Utility District	Pilot project to test the operation and maintenance of a joint desalination facility in San Francisco Bay	Pilot Project	$949,300	$1,898,600
Municipal Water District of Orange County	Test slant "beach wells" for an extended period to assess cost and pretreatment effectiveness	Pilot Project	$1,500,000	$4,171,226
City of Avalon	Test a skid-mounted seawater reverse osmosis system with reduced energy consumption	Pilot Project	$1,000,000	$3,637,500
Bay Area Regional Desalination Partnership	Assess processes to support regional collaboration on desalination projects	Feasibility Study	$249,756	$499,512
Association of Monterey Bay Governments	Devise regional framework for desalination planning in the Monterey Bay area	Feasibility Study	$100,000	$211,970
West Basin Municipal Water District	Research the feasibility of a 40 MGD desalination facility in Santa Monica Bay	Feasibility Study	$246,005	$590,820
San Diego County Water Authority	Feasibility of seawater desalination at the San Onofre Nuclear Generating Station and a regional brine conveyance facility in southern San Diego County	Feasibility Study	$250,000	$800,000
City of Arroyo Grande	Feasibility of a desalination facility for the southern portion of San Luis Obispo County	Feasibility Study	$45,000	$90,000
Total			$22,177,706	$138,966,330

Note: Additional funding was directed toward research and development (R&D). Some of the projects listed here were cancelled for a variety of project-specific reasons. The money granted to those projects was retained by the state to be spent on other projects. MGD: million gallons per day. AFY: acre-feet per year

Bonds

A bond is a form of debt financing. Bonds are essentially "IOUs" issued by public authorities, companies, and credit institutions. By issuing a bond, the borrower agrees to repay the money (the principal) on a specified date (maturity). Interest on the bond is typically repaid every six months and is based on prevailing market rates and the risk profile of the bond, which includes the credit quality of the bond issuer and the project-related risk. There are three general bond categories in the United States: municipal, corporate, and U.S. Government (and Government Agency) bonds.

Major water infrastructure projects in the U.S. are commonly financed using municipal bonds. A municipal bond is a bond issued by a municipal government (state, city, or county) or its agency and purchased by individual and institutional investors. For investors, municipal bond income, i.e., the interest payment, is typically exempt from federal tax and may also be exempt from state and local taxes. As a result, the investor will often accept lower interest payments relative to other types of comparable bonds. The bond issuer then benefits from tax-exempt bonds by paying lower interest rates on its debt than would a comparable corporate issuer, reducing the financing costs.

The two broad categories of municipal bonds are revenue bonds and general obligation bonds. Revenue bonds are issued for a specific project and are repaid from a specific revenue source (often the project itself). Large utilities may also be able to issue debt that is repaid from revenues for the entire system (rather than just the project), which is referred to as system debt (NRC 2008). General obligation bonds are backed by the full-faith, credit, and taxing power of the issuer, so payments to investors are not dependent on the success of a specific project. General obligation bonds were used by the state of California to finance desalination projects through Proposition 50, but are not commonly used by local governments to finance water infrastructure projects.

Private-activity bonds are a subset of municipal bonds that can also be used to finance a desalination plant. Generally, the interest on private-activity bonds can be taxed whereas other municipal bond interest is tax-exempt. Certain "qualified" private-activity bonds are afforded special status in the tax code and are tax-exempt if the projects they support meet certain public-interest criteria (IRS 2005).[3] Tax-exempt private-activity bonds typically have a lower interest rate than the market rate for comparable taxable bonds, and therefore reduce financing costs. These bonds are issued by a state or local government on behalf of a private entity. Unlike with a traditional municipal bond, however, payment of the principal and interest on these bonds is the responsibility of the private entity, not the government agency that issued the bond. For example, the Carlsbad

[3] In each state, there is a cap on the volume of tax-exempt private-activity bonds that can be issued in any given year. This volume cap sets the maximum amount of tax-exempt bonds that can be issued in a calendar year and is determined based on the state's population. Some qualified activities, such as facility bonds for airports, docks and wharves, and qualified public educational facilities, are not subject to a volume cap.

desalination project, described in more detail on page 33, proposes to use tax-exempt private-activity bonds to finance 82% of the project's capital cost (SDCWA 2012a).

Desalination projects may also be financed using corporate bonds. A corporate bond can be issued by a publicly or privately owned corporation to raise money for a variety of purposes, such as building a new plant, purchasing equipment, or growing the business. As is the case with municipal bonds, the corporation agrees to repay the amount borrowed (the principal) on some pre-determined date and repay interest on the principal periodically. Unlike with stock (equity), however, the bond holder retains no ownership interest in the issuing company.

Loans

A loan is a type of debt financing in which the lender gives money to a borrower, who then agrees to repay the money (the principal), usually with interest, at some future point(s) in time. Interest rates for loans are based on prevailing market rates, the terms and conditions of the loan, and the risk of default on that loan.

The federal and state government provides a variety of low-interest loan programs that can be used to finance a desalination plant. In 1988, for example, California voters passed Proposition 82, the Water Conservation Bond Law, making local public agencies eligible for loans of up to $500,000 for a feasibility study and up to $5 million for construction of local water supplies, including desalination. Interest rates for these loans, which are administered by Department of Water Resources, are equal to the rate that the State pays on the general obligation bonds sold to finance the program. Low-interest loans may also be available for desalination plants from the federal government through the Environmental Protection Agency's Drinking Water State Revolving Fund.

A desalination project developer may also secure a loan from a commercial lending institution. These loans are generally non-recourse or limited recourse loans. Non-recourse loans are structured such that if the borrower defaults, then the lender can seize the borrower's collateral but not its other assets. With limited recourse loans, the lender retains some ability to seize assets, although these loans often revert to non-recourse loans once a specific project milestone is achieved. The federal government may set aside funds to guarantee the repayment of these loans, which reduces the risk to the lender and encourages the lender to provide lower interest rates and longer repayment periods (Dornbirer n.d.). For example, the United States Department of Agriculture Rural Development provides loan guarantees for water system projects in some rural areas.

Private Equity

Some project developers for desalination plants are also turning to equity financing, which involves obtaining money from an investor in exchange for partial ownership of the desalination plant. These equity investments are generally made by a private equity firm, a venture capital firm, or an angel investor. Private equity investments in infrastructure have grown considerably since the late 1990s. In the case of the Carlsbad project, for example, Stonepeak Infrastructure Partners is providing approximately $164 million in equity for the project, which is about 18% of the project's capital cost (SDCWA 2012a).

Financing of Desalination Projects in California

For most of the proposed projects in California, the financing mechanisms have not yet been identified. Desalination projects that are being developed solely by public water agencies will likely use municipal revenue bonds or other conventional financing methods. Additional support may be provided through government grant and loan programs. Nine of the proposed plants in California, however, may be entirely or partially financed and owned by private companies, and these projects will likely use some combination of debt financing, especially tax-exempt private-activity bonds, and private equity. These public-private partnerships can allow for a mechanism to attract private investment and share some of the risks associated with a project. In the following sections, we describe the project-related risks, various forms of public-private partnerships, and how these partnerships have been or are likely to be used for seawater desalination projects in California.

What Are Some of the Risks Associated with Seawater Desalination Projects?

Large-scale projects, such as desalination plants, include a variety of risks which affect the ability to attract financing, the rate of return, and the overall viability of a project. Each project will have a unique set of risks that will vary in their relative importance. Some of the risks that have been identified for seawater desalination projects include the following (Pemberton 2003, Wilcox and Whitney 2005, Wolfs and Woodroofe 2002, Schiller n.d.):

> ***Permitting risks*** are risks that government permits and approvals required to construct or operate the project will not be issued or will only be issued subject to onerous conditions.
>
> ***Design and technology risks*** are those risks that can be attributed to the use of a design or technology that fails to deliver at expected service levels.
>
> ***Construction risks*** are those risks that arise during the construction period. Construction risks can be attributed to poor project design, ineffective project management, inexperienced contractors, and lack of effective communication among the various contractors working on a project.
>
> ***Operational/performance risks*** are those risks that arise during the operation and maintenance period and can be attributed to inexperienced operators, higher operating costs than anticipated, product water that fails to meet required standards, and underperformance of equipment.

Financial risks are influenced by the financial status of the borrower, changes in interest rates, fluctuation in foreign exchange rates (if the project relies on foreign investment), and changes to pricing of construction and/or operational phase insurance.

Market risks can be caused by unrealistic demand assessments and water production assumptions, reluctance of customers to buy the produced water, and reluctance of those with ratemaking authority to approve rate increases to cover new costs.

Political risks are those risks associated with political decisions that affect the cost and/or viability of the project and can relate to laws, tax rates, government permissions, and other factors. These risks may be associated with decisions made by elected or appointed officials or by the public through, for example, a referendum.[4]

Force majeure risks are the risks of events which render the construction or operation of the project impossible, either temporarily or permanently. A force majeure event includes an extraordinary event or circumstance that prevents one or both parties from fulfilling their obligations under the contract and is beyond the control of the parties, such as an earthquake, flood, hurricane, war, strike, or riot.

Recent experience suggests that a key risk associated with seawater desalination plants is overly optimistic assumptions about future demand for the product water and/or under appreciation of the availability of less expensive alternatives. This is a type of market risk that is also often referred to as demand risk. Water managers often have multiple sources of water to choose from to meet water demand. Desalination is among the most expensive options, and water managers may reduce the output of a desalination plant when demand drops or when less expensive options are available. Because of the fixed costs of the plant, reducing the output can increase the overall cost of the produced water considerably, which can further reduce demand or make other supply options more economically attractive. In response, water managers may temporarily or permanently shut down the desalination plant. This can reduce the variable operating costs associated with the plant, especially energy and chemical costs, but ultimately leave ratepayers to pay off a plant while receiving little to no benefit from it. Additionally, desalination expert Tom Pankratz notes that “frequent stopping and starting, or long-term mothballing, may not only affect the short-term performance of a plant, it may actually be detrimental to the system itself” (Pankratz 2011).

Recent experience in Australia highlights demand risk (Table 5). The Australian government made a massive investment in seawater desalination plants in response to a severe and persistent drought, developing six major plants since 2006. The first plant, a 37 MGD plant was built in Perth, became operational in late 2006, and continues to operate at or near full capacity. A second plant (the “Southern Desalination Plant”) is being developed in the same region and should be completed in late 2012. Other plants

[4] For example, in November 2012, Santa Cruz residents passed Measure P, which guarantees residents the right to vote on whether to pursue a seawater desalination project in the future.

were built in New South Wales, Victoria, and South Australia. While many consider the Perth plant to be a success, the four other plants built in recent years have been or will be put into stand-by mode due to reductions in demand and the availability of less expensive alternatives.

Table 5. Operational Status of Recently Constructed Desalination Plants

Facility Name	Location	Date Operational	Plant Capacity (MGD)	Status
Tampa Bay Desalination Plant	Tampa Bay, Florida	2007	25	intermittent use
Tugun Desalination Plant[a]	Gold Coast, Australia	Feb 2009	33	in stand-by mode since December 2010 due to high operating cost and operational issues
Kurnell Desalination Plant[b]	Sydney, Australia	Jan 2010	66	in stand-by mode since July 2012 because reservoirs full
Kwinana Desalination Plant	Perth, Australia	Nov 2006	38	operational
Southern Desalination Plant	Binningup, Australia	Sept 2011 (Phase 1); late 2012 (Phase 2)	72	Phase 1 is operational and Phase 2 is under construction
Wonthaggi Desalination Plant[c]	Victoria, Australia	end of 2012	109	Undergoing performance tests but will be put in stand-by mode in January 2013
Port Stanvac Desalination Plant[d]	Adelaide, Australia	2013	72	will be put in stand-by mode 2015

Source:
a) Marschke 2012
b) AAP News 2012
c) Hosking 2012
d) Kemp 2012

For example, the Kurnell Plant in Sydney was completed in January 2010 but was mothballed in July 2012 because less expensive surface water sources are available.[5] Likewise, the Wonthaggi Desalination Plant in Victoria is undergoing performance tests that should be complete by the end of 2012. While the plant is performing as designed, officials announced that the plant would be put in stand-by mode in January 2013. Similarly, the Port Stanvic Plant, south of Adelaide, Australia, is expected to be completed in 2013, but in an October 2012 statement, SA Water Chief Executive John Ringham announced that "to keep costs down for our customers, SA Water is planning to use our lower-cost water sources first, which will mean placing the desalination plant in

[5] If reservoir levels fall below 80% capacity, the desalination plant will be restarted.

stand-by mode when these cheaper sources are available" (Kemp 2012). The desalination plant, which cost nearly $1.9 billion, is slated to go on stand-by mode in 2015.

Experience in Santa Barbara, California and in Tampa Bay, Florida provides further evidence of demand risk. During the 1987-1992 drought, the City of Santa Barbara partnered with several local water agencies to build a seawater desalination plant. The plant was completed in March 1992, and shortly thereafter, the drought ended. The plant was eventually decommissioned as the cost to produce the water was too high to warrant use during non-drought periods. In addition, the high cost of building the plant and connecting to the State Water Project raised local water prices high enough to encourage substantial additional conservation, further decreasing need for the plant. Similarly, the Tampa Bay desalination plant in Florida was completed in 2008 in an effort to reduce groundwater pumping. Since it was built, that plant has operated far below its full capacity due to periodic operational issues with the plant, regional water demand reductions, and the availability of less expensive alternatives (see page 29 for more about the Tampa Bay plant).

In some regions, seawater desalination can make an important contribution to the availability and reliability of water resources. However, it remains among the most expensive options available to meet water demands. Additionally, project proponents tend to develop large plants in an effort to capture economies of scale and reduce the unit cost of water. This tendency, however, can lead to oversized projects that ultimately increase demand risk and threaten the long-term viability of a project.

How Are Seawater Desalination Projects Structured?

Planning, designing, financing, constructing, and operating major water projects, such as desalination plants, can be challenging. Such projects are often accomplished by public agencies or through various types of public-private partnerships. The delivery of large-scale water projects may involve different parties and stakeholders, including the owner, designers and engineers, construction contractors, operation contractors, external financiers, and consumers. The project delivery method determines how these multiple groups relate to one another. There is a range of project delivery methods; among the most common are:

Design-Bid-Build (DBB) – traditional project delivery approach for municipal infrastructure projects by which the owner, i.e., the public water provider, determines that a project is needed and secures financing for the project; the owner works with an engineer to define the project and develop plans with detailed specifications; the owner then solicits bids from multiple contractors to construct the project; the contractor that provides the lowest bid that meets all of the criteria is selected; operations are performed by the owner or by a contract operator.

Design-Build (DB) – the owner develops the project concept and secures financing; the owner then hires a design-build team to construct the project for a lump sum fixed price or guaranteed maximum price; operations are performed by the owner or by a contract operator.

Design-Build-Operate (DBO) – the owner develops the project concept and secures financing; the owner hires a single team responsible for the development, design, construction, and long-term operation of the project.

Design-Build-Own-Operate-Transfer (DBOOT) – the contractor is responsible for the design, construction, and long-term operation of the project; unlike with the more traditional project delivery methods, the contractor must secure financing for the project and initially owns the facility; the water agency agrees to purchase the water at an agreed-upon price over a certain period (these purchase agreements allow the contractor to secure the necessary financing); the contract contains provisions for the transfer of ownership of the facility to the water provider on an agreed-upon date.

Design-Build-Own-Operate (DBOO) – variation of the DBOOT delivery method; the contractor is responsible for the design, financing, construction, and long-term operation of the project; the water agency agrees to purchase the water at an agreed upon price over a certain period; unlike with a DBOOT, however, there is no asset transfer at the end of the project.

Each project delivery method has advantages and disadvantages with respect to how risk is shared among parties, the length of the process, etc. Some of these advantages and disadvantages are described in Table 6. A key difference among the project delivery methods is the degree to which innovation is integrated into the project. The water sector has traditionally employed the DBB delivery model. With DBB, the public utility or agency (owner of the project) plays a central role, selecting different groups to design, construct, and possibly operate the project. DBB contracts are generally awarded based on the lowest cost (NRC 2008). Thus, there is often little incentive to implement innovative designs and technologies that may have a higher capital cost but reduce operating costs and result in a less expensive project overall. With a DBO delivery method, by contrast, the DBO contractor is responsible for operation of the project. Thus, the contractor has an incentive to promote innovative designs and technologies that can optimize and improve the operability of the project.

Another key difference among the various project delivery methods is the party required to secure financing. Under the DBB, DB, and DBO delivery methods, the water provider secures project financing, largely by issuing debt (bonds or loans). Under the DBOO and DBOOT delivery methods, by contrast, the contractor secures financing by issuing debt and/or obtaining private equity. One of the possible drawbacks in using this approach, however, is the high cost of private capital, which may be reflected in the price of desalinated water. For example, the Carlsbad desalination project will be financed using private equity (18%) and private-activity bonds (82%); the cost to finance the project is estimated to be $213 million, or more than 20% of the project's capital cost (SDCWA 2012a). Proponents of this delivery method, however, argue that the higher costs (which are borne by the consumer) are offset by lower risk for the water provider, higher efficiency of the contractor, and technology performance guarantees (Texas Water Development Board 2002).

Table 6. Advantages and Disadvantages of Various Project Delivery Methods

	Advantages	Disadvantages	Works best when…
Design-Bid-Build (DBB)	• Well understood by all involved parties • Potential for high degree of owner control and involvement • Independent oversight of construction contractor	• Segments design, construction, and operation and reduces collaboration • Linear process increases schedule duration • Prone to disputes and creates opportunities for risk avoidance by the designer and construction contractor • Low-bid contractor selection reduces creativity and increases risks of performance problems • Risks are mostly borne by the owner • May not allow for economies of scale in operations • For new technologies, operability may not be the primary design concern	• Operation of facility is minimal or well understood by owner • Project requires high degree of public oversight • Owner wants to be extensively involved in the design • Schedule is not a priority
Design-Build (DB)	• Collaboration between designer and contractor • Parallel processes reduce duration • Reduces design costs • Reduces potential for disputes between designer and construction contractor • Single point of accountability • Can promote design innovation • Provides more certainty about costs at an earlier stage • Allows owner to assign certain risks to DB team	• Owner may not be as familiar with DB process or contract terms • Reduces owner control and oversight • Design and "as-built" drawings not as detailed • Eliminates "independent oversight" role of the designer • Does not inherently include incentives for operability and construction quality as does DBO or DBOOT approach • Higher cost to compete	• Time is critical but existing conditions and desired outcomes well defined • Project uses conventional, well-understood technology • Owner willing to relinquish control over design details • Operational or aesthetic issues easily defined • Early contractor input will likely save time or money
Design-Build-Operate (DBO)	• Allows collaboration among designer, construction, contractor, and operator • Parallel processes reduce duration • Operator input on new technologies and design • DBO contractor has built-in incentive to assure quality since they will be long-term operator • Single point of accountability • Allows owner to assign certain risks to DBO contractor • Economies of scale for operations • Collaboration, long-term contract, and appropriate risk allocation can cut costs • Defines long-term expenses for rate setting	• Reduces owner involvement • Owner may not be familiar with DBO contracting • High cost to compete may limit competition • Depending on contract terms, may give operator incentives to overcharge for ongoing renewals and replacements or to neglect maintenance near the end of the contract term • Operations contract may limit long-term flexibility • Requires multiphase contract	• Owner's staff does not have experience operating the type of facility • Input conditions to the facility can be well defined and the number of external influences affect plant operations are limited • Owner is comfortable with less direct control during design, construction, and operation
Design-Build-Own-Operate-Transfer (DBOOT)	• Same as DBO and: • Can be used where project expenditures exceed public borrowing capacity • Beneficial when preserving public credit for other projects is important • Can isolate owner from project risk	• Same as DBO but lack of public financing increases the cost of money	• Public financing cannot be contained • Transfer of technology risk is important

Source: Adapted from Texas Water Development Board (2002) and NRC (2008)

Risk Allocation Among Project Partners

A key element of any public-private partnership is the allocation of risk among the project partners. With DBB contracts, the owner – typically the public – carries most of the risks associated with the project. By contrast, with a DBO and DBOOT, the contractor bears more of the risk (Figure 2). By assuming a specific risk, the project partner is responsible for any additional cost (or savings) associated with that risk and cannot pass that cost along to the other project partner. For example, if Partner A assumes the construction risk for the project, and the cost of construction is higher than anticipated, Partner A must pay the additional cost of construction and cannot pass those costs along to Partner B. Likewise, if construction costs are lower than anticipated, Partner A would capture that savings and would not pass the savings on to Partner B.

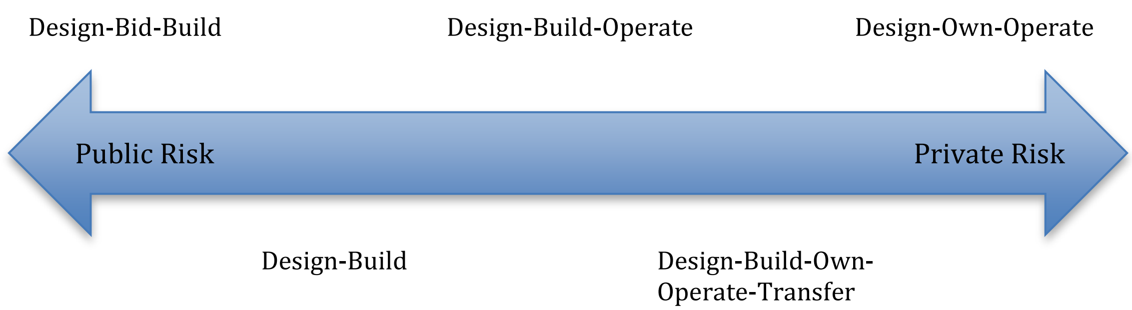

Figure 2. Risk Allocation Under Various Project Delivery Methods

The project sponsor is expected to identify the risks associated with the project and determine the appropriate risk and responsibility allocation prior to the procurement process and contract development. This allows the interested parties to understand the underlying risks and responsibilities and price their proposal accordingly, since the contractual risk structure is directly related to pricing (Wilcox and Whitney 2005). In theory, a particular risk should be allocated among parties such that the party with the greatest ability to control the outcome takes on that risk. There are some risks, however, that are outside the control of both parties.

As described above, demand risk is one of the key risks associated with desalination projects. The quantity of water that will be purchased is set forth in a long-term water purchase agreement – also referred to as an off-take agreement. This agreement is negotiated prior to the construction of the project and is often needed to secure financing. Among the most common form of off-take agreement is a "take-or-pay" contract. Under a take-or-pay contract, the buyer agrees to pay for a minimum amount of water from the seller on a certain date even if the buyer does not need the water. This type of contract provides guaranteed revenue for the seller but commits the buyer to a purchase even if actual demand drops. A minimum commitment to a large volume of water, however, provides a disincentive for water agencies to pursue more cost-effective water supply and water conservation and efficiency programs. Thus take-or-pay contracts, if structured poorly, can result in significant exposure to demand risk and higher costs for the buyer.[6]

Structure of Desalination Projects in California

A limited number of seawater desalination plants have been constructed in California and many of the proposed plants have not yet identified the project delivery method, making it difficult to make broad generalizations about past and current trends. From the limited information available, however, it appears that DBB projects are fairly uncommon for seawater desalination projects in California (Table 7). Seawater desalination projects constructed in the 1990s used DBO and DBOOT delivery methods. The Santa Barbara plant, for example, was the first major DBOOT desalination project in the United States. Ionics, Inc. (now GE) designed, financed, built, operated, and owned the desalination plant. After five years, the local water agencies paid off the construction costs and acquired the plant.[7] In a more recent example, the Sand City plant, which opened in May 2010, used a DB approach, hiring CDM Smith for the design-build component of the project while retaining California American Water (Cal Am) to operate the plant (CDM Smith 2012).

For proposed plants, the delivery method and the structure of that relationship will depend on a variety of factors, including whether public financing is available and public sentiment about private sector involvement. Project developers in California are considering a range of project delivery methods. DBB projects, however, will likely be fairly uncommon because California water agencies do not have significant experience in developing seawater desalination projects and there are opportunities to shift risks to the private sector. The Bay Area Regional Desalination Plant, for example, will likely use a DB delivery method. The South Orange Coastal Ocean Desalination Project is considering either a DB or DBO approach. The City of Santa Cruz/Soquel Creek Water District is considering a DBB or DB approach and will likely discuss a DBO approach, although this is not currently considered viable. DBOOT is also being considered for two major projects in southern California.

[6] See the Carlsbad case study on page 33 for some of the issues that can arise with a take-or-pay contract.
[7] The plant has been in stand-by model since it was completed. Two of the local water agencies stepped away from the project. Membranes from the plant were sold for use in the Middle East in the 1990s.

Table 7. Project Delivery Methods for Select Existing and Proposed Seawater Desalination Plants in California

Plant Name	Public Entity	Private Entity	Capacity (MGD)	Status	Date of Operation	Project Delivery Method
Morro Bay Desalination Plant	City of Morro Bay	Ionics, Inc.	0.83	Intermittent use	1992	DBO
The Charles Meyer Desalination Facility[a]	City of Santa Barbara	Ionics, Inc.	2.8	Idle	1992	DBOOT
MCWD Seawater Desalination Facility[b]	Marina Coast Water District	Ionics, Inc.	0.3	Idle	1997	DBB
Sand City Coastal Desalination Facility[c]	City of Sand City	CDM Smith (Design-Build) Cal Am (Operation)	0.3	Operational	2010	DB
Carlsbad Desalination Project	San Diego County Water Authority	Poseidon Resources	50	Permitted	Proposed	DBOOT
Huntington Beach Seawater Desalination Project	City of Huntington Beach	Poseidon Resources	50	Permitting	Proposed	DBOOT
scwd[2] Regional Seawater Desalination Project[d]	City of Santa Cruz and Soquel Creek Water District	Undetermined	2.5	EIR	Proposed	DB/DBB
The South Orange Coastal Ocean Desalination Project	5 southern California water agencies	Undetermined	15	Feasibility Study	Proposed	DB/DBO
Bay Area Regional Desalination Project	7 San Francisco Bay area water agencies	Undetermined	20	Design	Proposed	DB

Source:

a) WDR 1996
b) Sterbenz 2012
c) CDM Smith 2012
d) Luckenbach 2012

Case Studies

In the following section, we provide two case studies that emphasize several elements of seawater desalination projects, including their cost, how they are financed, the structure of the public-private partnership, and the risks associated with the projects. The first case study looks in detail at the Tampa Bay Seawater Desalination Project, which is the largest plant built in North America to date, and has been the subject of several case studies. The second case study focuses on the proposed desalination project in Carlsbad, California, which has been in development for more than a decade, received all of the necessary permits, but has not yet secured financing.

Tampa Bay Seawater Desalination Project

Like many communities around the United States, the Tampa Bay, Florida region has been experiencing significant growth combined with increasing constraints on water availability. Over-pumping of local groundwater resources in the region has forced communities to think about alternative water solutions. In the late 1990s, some water managers and planners thought seawater desalination might be a key element of the region's long-term water future. The Tampa Bay Seawater Desalination Project faced several major delays but was completed in 2007. It is the first large-scale seawater desalination project constructed in the United States.

Since its completion in 2007, the plant has operated far below its design capacity of 25 MGD. Figure 3 shows the average monthly water production between 2003 and October 2012. During some periods, the plant operates at or near capacity. In others, the plant operates at reduced capacity or is in stand-by mode. In 2013, Tampa Bay Water plans to operate the plant at a higher capacity (averaging 11 MGD) because a local water reservoir is undergoing repair. Once this is complete, however, production from the desalination plant will likely be reduced because cheaper water supply alternatives are available. For example, a recent analysis by Tampa Bay Water found that implementing cost-effective conservation and efficiency programs in the region would reduce water demand by 2035 by 40 MGD (Tampa Bay Water 2012), significantly more water than is produced by the seawater desalination plant and at a lower cost.

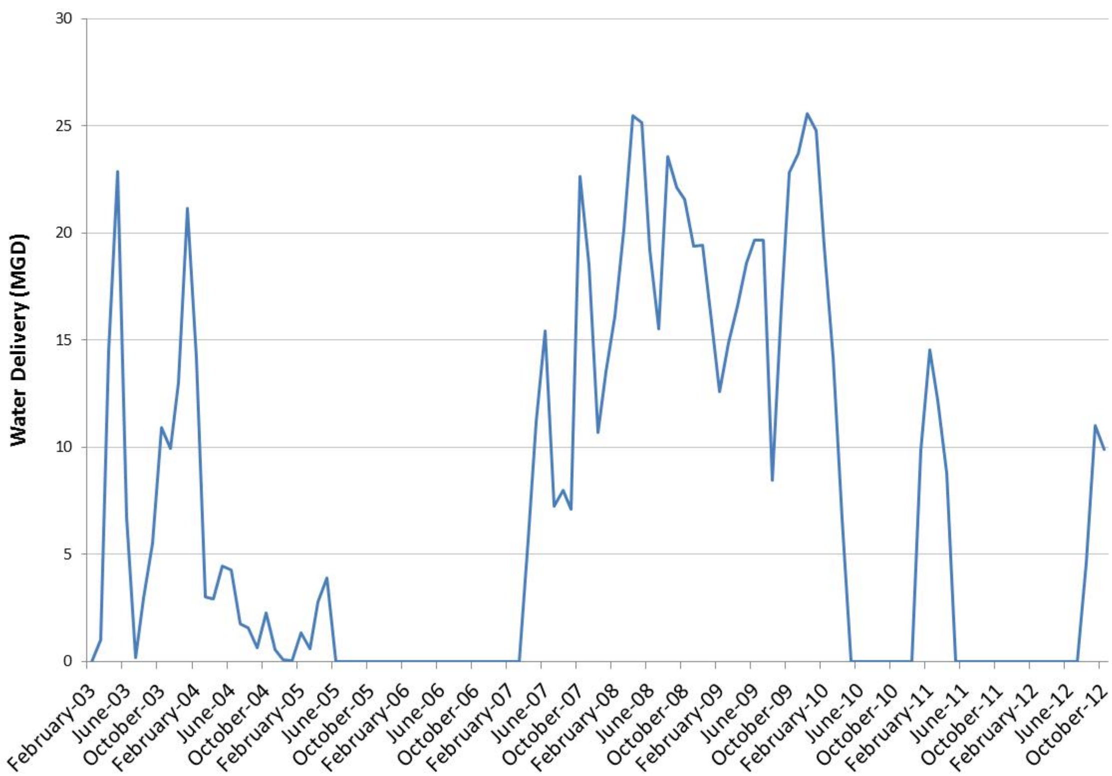

Figure 3. Average Monthly Water Production from Tampa Bay Desalination Plant, 2003-2012.
Note: The design capacity of the plant is 25 MGD.

Project Delivery Method

Due to ongoing water-supply concerns, the West Coast Regional Water Supply Authority – later to become Tampa Bay Water – issued a Request for Proposals (RFP) to design, build, operate, and own a desalination plant in 1996. The RFP allowed the project developer to select the size and location of the plant as well as the operations and method of seawater desalination. In July 1999, after a two-and-a-half-year solicitation process, Tampa Bay Water entered into a water purchase agreement with S&W Water, LLC – a partnership between Stone & Webster and Poseidon Resources Corp. Under the initial agreement S&W Water would develop a desalination plant capable of supplying 25 MGD to Tampa Bay Water and would sell that water at a fixed price. The agreement was structured as a BOOT arrangement that would allow Tampa Bay Water to buy the plant after 30 years or earlier, if necessary.

Soon after the water purchase agreement was signed, the project began encountering problems. In June 2000, Stone and Webster declared bankruptcy, leaving Poseidon without an engineering and construction partner. Poseidon Water Resources then hired Covanta Energy to construct the plant, and a new partnership emerged: Tampa Bay Desal. Obtaining financing for the project, however, proved to be difficult. Covanta Energy had a poor bond rating and was unable to secure financing for the construction bonds. Tampa Bay Water, however, had a more favorable AA bond rating, which would allow them to obtain financing at a lower interest rate and thereby reduce the financing cost. In early 2002, Tampa Bay Water bought Poseidon's interests in the project while retaining the engineering and construction company (Covanta Construction) to complete the project. At the time, the plant's design and permitting were complete while construction was only 30% complete (Smith 2010). Tampa Bay Water signed a 30-year O&M contract with Covanta Tampa Bay, Inc. (a subsidiary of Covanta Energy) to operate the facility.[8] This move effectively restructured the DBOOT procurement into a DBO contract, whereby Tampa Bay Water assumed ownership and many of the risks associated with the plant.

Before Covanta Tampa Bay could commence the separate 30-year O&M contract, the plant was required to meet certain performance standards. Covanta Construction was unable to meet the test standards after repeated attempts and finally declared bankruptcy in 2003. In 2004, the parties agreed to a settlement whereby Tampa Bay Water paid Covanta nearly $5 million to end its contract. In return, Tampa Bay Water retained full control of the facilities and the operating contract. In late 2004, Tampa Bay Water signed a DBO contract with American Water-Pridesa, a joint venture between American Water and Acciona Agua, to repair deficiencies and operate the plant long-term.

Under the current operating contract, Tampa Bay Water must pay American Water-Pridesa about $7 million per year, regardless of whether water is produced by the plant. This base contract covers the fixed O&M costs for the plant plus some return to the operator. Tampa Bay Water pays variable operating costs (chemicals and electric) separately. This contract allows Tampa Bay Water to reduce production of the plant if cheaper alternatives are available.

Project Cost

The initial capital cost for the desalination plant and the 15-mile pipeline to connect it to the water system was estimated to be $110 million. Initial performance tests in 2003, however, revealed 31 deficiencies in the plant. To fix the plant, Tampa Bay Water signed a $29 million, two-year contract with American Water-Pridesa. Major improvements were made to the pre-treatment, reverse osmosis, and post-treatment system, and the final capital cost of the project was $158 million, more than 40% above the original cost.

Initially, desalination proponents were excited by the Tampa Bay project and by the apparent price breakthrough. In the initial water purchase agreement, S&W Water made a binding commitment to <u>deliver</u> desalinated water in the first year of operation at an unprecedented wholesale cost of $557 per acre-foot ($0.45 per m^3), with a 30-year average cost of $678 per acre-foot ($0.55 per m^3) (Heller 1999). This was well below the cost of water from other recent desalination plants. By comparison, the same year, the Singapore Public Utility Board announced plans to build a 36 MGD desalination plant to <u>produce</u> water at an estimated cost of between $2,440 and $2,850 per acre-foot ($1.98

[8] The O&M contract was worth $300 - $360 million and was Covanta Tampa Bay's only asset (Wright 2003).

and \$2.31 per m^3) with an additional cost to deliver water to customers (U.S. Water News 1999).

The project developers were unable to deliver on the initial cost estimates, and the cost estimates have increased. Additionally, the production of water from the plant has varied dramatically since the project was completed in 2007, further affecting the unit cost (Figure 4). According to recent estimates from Tampa Bay Water, the unit cost of water from the desalination plant is \$1,300 per acre-foot (\$1.05 per m^3) if the plant is operating at full capacity (Vatter 2012).[9] Officials at Tampa Bay Water, however, indicate that the plant will operate at an average production of 11 MGD from October 2012 through October 2013, which is considerably less than full capacity. At this reduced capacity, the unit cost of water is estimated at \$1,600 per acre-foot (\$1.30 per m^3), more than double the original cost estimate (Vatter 2012).

Project Financing

The Tampa Bay desalination project was originally structured as a BOOT agreement, which usually employs some combination of debt and equity financing. Tax-exempt private-activity bonds provided 90% of the project's capital cost (Lokiec and Kronenberg 2001), and the remaining 10% was provided as an equity stake by the project developer. In 2007, however, Tampa Bay Water bought out Poseidon's interest in the project using short-term, variable interest rate bonds and became the sole owner of the plant. Tampa Bay Water selected this financing strategy because interest rates were low at the time. Furthermore, the bonds would be repaid shortly after the project was completed because the Southwest Florida Water Management District (SWFWMD), a regional agency that regulates and permits water resources for west-central Florida, agreed to provide \$85 million of the project's eligible capital costs over an 18-month period upon completion. SWFWMD obtained these funds through voter-approved, locally collected ad valorem property taxes designated for water supply creation.

Summary

When the Tampa Bay desalination plant was announced, it was hailed as a breakthrough for desalination in the United States and sparked enormous interest and excitement. But the project encountered several technical and managerial challenges. The experiences of Tampa Bay Water can help to inform the development of projects under consideration in California and in other regions. Some of the lessons can be learned about cost, financing, and risk include the following:

- Anticipate the transfer of ownership at any point of the project and consider what actions will be taken if that transfer occurs.
- Exercise caution when transferring ownership under a DBOOT contract. The new owner must recognize that they are assuming many of the risks associated with the project.

[9] This estimate includes O&M plus the annual debt service cost assuming that the full capital cost of project was financed at Tampa Bay Water's average bond rate over 30 years.

- Ensure that those submitting proposals have relevant desalination project experience.
- Minimize demand risk by implementing cost-effective water supply alternatives prior to the development of the project.
- Consider establishing a minimum operating contract, rather than a take-or-pay contract, to allow the water supplier to adjust production of the plant if cheaper alternatives are available.

Carlsbad Desalination Project

Poseidon Resources (Poseidon) is proposing to build a 50 MGD desalination facility at the Encina Power Station in the City of Carlsbad. The project would utilize the Encina Power Station's existing surface intake and outfall structures. Poseidon began working on the project in 1998 and in 2003 constructed a demonstration facility at the site (Poseidon Resources n.d.). The project has been highly contested, with local and environmental groups filing more than a dozen legal challenges, including lawsuits and permit appeals, against the project. By November 2009, Poseidon had received all of the permits required to build and operate the plant and announced it would begin to secure financing (Fikes 2010). As of November 2012, however, financing for the project has not yet been secured. Here, we provide a detailed case study on the cost, financing, and partnerships associated with the project.

Project Cost

Numerous and contradictory cost estimates for the Carlsbad desalination project have been put forth since the project was initiated in the late 1990s. In May 2002, initial capital cost estimates for the desalination plant were $260 million (Green 2002), dramatically less than other similar sized plants at the time. Estimates for the desalination plant and distribution pipeline were quoted at $270 million in 2002 (Jimenez 2002) and $320 million in 2009 (Schwartz 2009). By October 2011, however, projected costs increased to $950 million, more than 3.5 times the original cost. It is difficult to determine why these costs have grown so dramatically over the past 10 years because there has been a lack of transparency regarding assumptions about financing, inflation rates, energy costs, interest repayment, related facilities, and other factors.

The water purchase agreement, released for public review in September 2012, provided detailed cost estimates for the project. According to these figures, the total capital cost of the project is $984 million (Figure 4) (SDCWA 2012a). Of that amount:

- $528 million, or 54% of the capital cost, is needed for the planning, permitting, design, construction, mitigation, and legal costs associated with the desalination plant;
- $163 million, or 16% of the capital cost, is needed to build a 10-mile pipeline to transport the desalinated water from the coast to the regional water distribution system;
- $80 million, 8% of the capital cost, is needed for indirect costs associated with

water system improvements, including relining and rehabilitating a 5.5-mile section of the distribution pipeline and modifying the Twin Oaks Valley Water Treatment Plant to accommodate desalinated water flows; and
- $213 million, 22% of the capital cost, is needed to finance the project.

In addition to the capital costs, operating and maintaining these facilities would cost an additional $49 - $53 million each year (SDCWA 2012a).[10] These costs, with the exception of the cost to finance the project, will be finalized in the water purchase agreement that must be approved by the Water Authority's Board of Directors. Financing will be secured after the water purchase agreement is signed, and once this is secured, the cost to finance the project will be determined.[11]

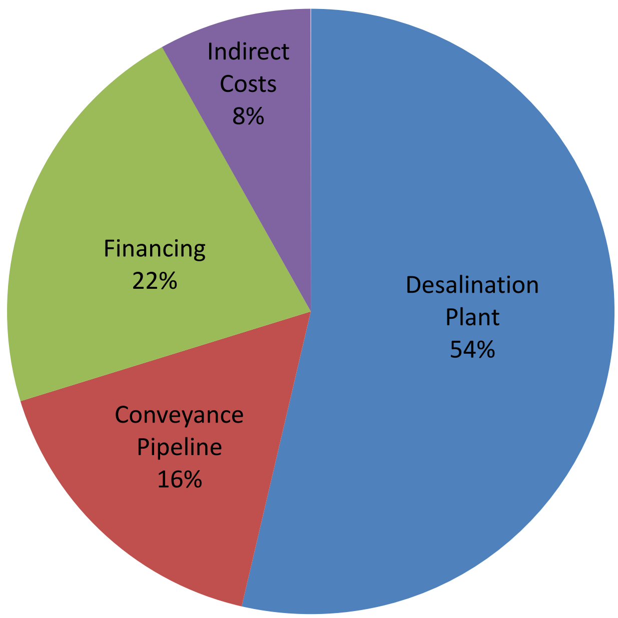

Figure 4. Capital Cost Breakdown for Carlsbad Desalination Project
Note: Based on breakdown from SDCWA 2012a. Capital costs include those costs associated with the planning, permitting, design, construction, mitigation, and legal costs.

[10] This includes O&M costs for the entire project, i.e., the desalination plant, conveyance pipeline, and the efficiency losses at the Twin Oaks Water Treatment Plant.
[11] Note that the water purchase agreement stipulates that the Water Authority takes on the risk of financing once the water purchase agreement is signed. If the financing costs are higher than anticipated, then those costs will be passed on to the SDCWA and its ratepayers.

As described previously, the unit cost of water is determined by dividing the annual capital and O&M costs by the amount of water of produced. In 2002, Poseidon estimated that the unit cost of water would be $800 per acre-foot ($0.65 per m^3) (Green 2002). In the initial contracts with local water agencies, Poseidon agreed to sell desalinated water at the same price that the agencies paid for imported water. Poseidon was willing to take a loss on the project in the short term, with the belief that imported water supplies would eventually be more expensive than the desalinated water and that they would recover these costs over the long term. Today, water agencies pay less than $1,000 per acre-foot ($0.81 per m^3) for treated water from the Metropolitan Water District of Southern California (MWD), which is more expensive than Poseidon's original cost estimate but considerably less than the most recent estimates for the project.

Like the total cost, the unit price of water has also grown tremendously as the project has developed. By July 2010, the unit cost for water had increased to $1,100 per acre-foot ($0.89 per m^3) plus an additional $500 per acre-foot ($0.41 per m^3) (in 2010 dollars) for delivery charges (SDCWA 2010). Since that time, the unit cost has changed several times in response to changes in the plant design, inflation rates, etc. The most recent figures from the Water Authority estimate that the cost to produce desalinated water and to integrate it into the existing distribution system is about $2,000 - $2,300 per acre-foot ($1.66 - $1.86 per m^3) (in 2012 dollars) (SDCWA 2012a).[12] This estimate does not include any grants or subsidies for which the project may qualify and which would reduce the unit cost for the Water Authority.[13] Note that the cost estimates – both the total cost and the unit cost – will likely change as the project advances. The interest rate on the bond, for example, is not yet known. A variety of other factors, including electricity prices and changes in regulations, will also affect the future cost.

A key question is how the cost of desalination compares with other water supply alternatives. A recent analysis by the Water Authority finds that the marginal cost of new supply within the San Diego area ranges from $1,500 - $2,400 per acre-foot ($1.20 - $1.93 per m^3) (in 2011 dollars) (Figure 5). The cost of water from the proposed seawater desalination plants – Carlsbad and Camp Pendleton – are at the high end of the range. Brackish groundwater desalination and recycled water are considerably less. This analysis, however, does not include an evaluation of the cost of water conservation and efficiency measures, many of which provide water for considerably less than $1,500 per acre-foot ($1.22 per m^3) (Gleick et al. 2003).

[12] The range in the unit price reflects a purchase of 48,000 to 54,000 acre-feet per year.

[13] In particular, it does not include the $250 per acre-foot subsidy from MWD because the Water Authority is suing MWD for their rate setting practices and as a result, is ineligible to collect this subsidy.

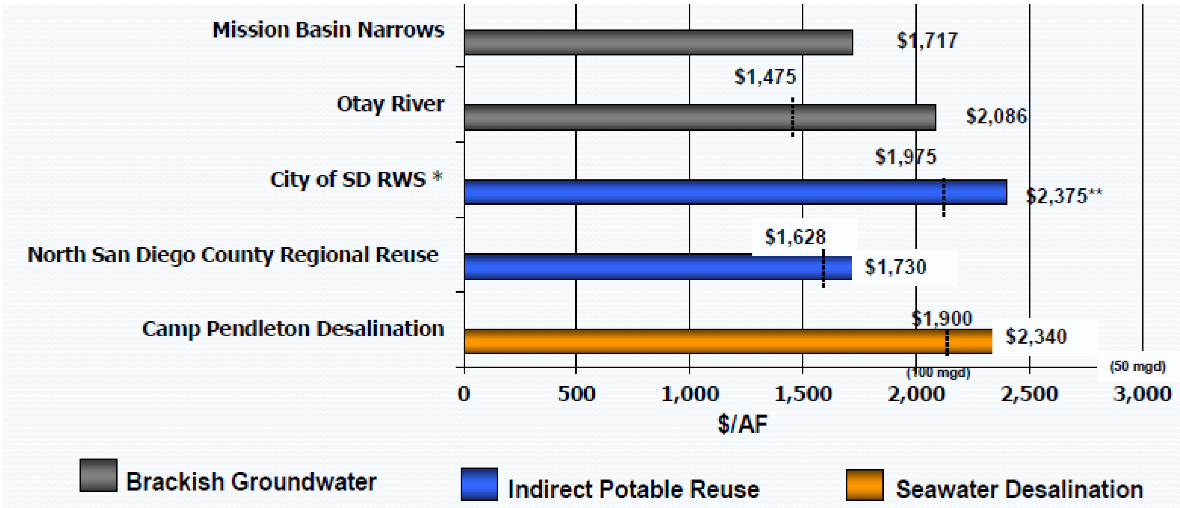

Figure 5. Marginal Unit Cost of Water, Dollars per Acre-Foot
Note: All costs are in year 2011 dollars and exclude any grants or incentives. The cost listed for the City of San Diego Recycled Water Study includes wastewater-related costs that could reduce the unit cost by up to $600 per acre-foot. This figure also excludes the costs of conservation and efficiency, water transfers from agriculture, or additional water from regional providers.
Source: SDCWA 2012b

Project Delivery Method

The Carlsbad desalination project has been in development since 1998 as a public-private partnership. The project partners – and the relationship between those partners – have changed considerably over the past 14 years. In December 2001, Poseidon completed an initial study for the City of Carlsbad and proposed to build a desalination plant at the Encina Power Plant. The original proposal was structured as a DBOO agreement, whereby Poseidon would retain ownership of the facility and regional water agencies, including the City of Carlsbad and the Water Authority, would be asked to sign a 30-year contract to purchase water directly from Poseidon (La Rue 2001).

By 2002, the partnership shifted to a DBOOT arrangement. In November 2002, the Water Authority approved the outline of a partnership with Poseidon to build a desalination plant in Carlsbad. Under the proposed agreement, Poseidon would obtain the permits, secure the financing, and supervise the construction. The power plant's owner, Cabrillo Power, would operate and maintain the facility. The Water Authority would be the sole purchaser of water and would be responsible for building the pipelines that distribute the water. Poseidon would initially own the plant but would sell it to the Water Authority after five years of operation (Jimenez 2002).

Negotiations between Poseidon and the Water Authority were on-again, off-again between 2003 and 2005. Unable to reach an agreement, the two sides resolved to pursue separate, competing projects at the Encina Power Plant: one by the Water Authority and the other by Poseidon. In mid-2006, however, the Water Authority announced it would no longer pursue a desalination plant in Carlsbad (Rodgers 2006). Poseidon continued to pursue water purchase agreements with local agencies. By late 2009, Poseidon had received all of the permits it needed to build the plant and had signed water purchase agreements with a number of local agencies (Burge 2009). With these agreements in place and with the withdrawal of the Water Authority, the Carlsbad desalination project in effect shifted to a DBOO arrangement.

In mid-2010, the structure of the project abruptly shifted back to a DBOOT arrangement. In July 2010, the Water Authority approved key terms to be the sole purchaser of water from Poseidon. The Water Authority staff began negotiating specific elements of the agreement, including the water purchase price, allocation of risk, and options to eventually purchase the project's pipeline and the entire desalination plant (SDCWA 2010). After more than two years of negotiation, the Water Authority released the water purchase agreement in September 2012 for a public review period prior to a vote by the Board of Directors. Under this agreement, Poseidon would be responsible for designing, permitting, financing, constructing, and operating the desalination plant and would be the owner of the desalination plant during the contract term.[14] The Water Authority would have the right to purchase the plant after ten years of commercial operation under pre-specified terms and conditions or take over the ownership of the plant after 30 years for $1. The Water Authority may also purchase the plant if Poseidon is unable to secure financing or if the venture goes bankrupt (SDCWA 2012a). It is of note that in Tampa Bay, the project contractors were unable to secure financing, prompting Tampa Bay Water to purchase Poseidon's interest in the project and assume many of the project-related risks.

The pipeline needed to convey the desalinated water from the coast to the distribution system would be developed under a separate DB agreement between the Water Authority and Poseidon. The Water Authority would own and maintain the pipeline and would finance the project using municipal bonds. Poseidon, however, would assume the responsibility for payment on the bonds in the event that Poseidon is unable to complete the desalination project. The Water Authority would also assume responsibility for completing and financing the other water system improvements, i.e., relining the conveyance pipeline and improving the Twin Oaks Water Treatment Plant.

The process for selecting Poseidon as the project partner was different than is typical in a DBOOT arrangement. Typically, the public agency solicits proposals for a project. Interested parties would then submit their qualifications, and if accepted, submit a proposal that would include some cost estimate. The public agency would then select among the proposals based on a variety of factors, including the cost. The Water Authority, however, did not allow other parties to submit proposals and determine which one offered the best alternative. Without this process, it is difficult to determine if the best project was selected.

[14] The contractor for the project would be a joint venture of Kiewit Infrastructure West and J.F. Shea Construction. IDE Technologies would be the process technology provider, e.g., the pumps and membranes, and would also operate and maintain the desalination plant.

Risk Allocation

One of the key elements of the water purchase agreement between Poseidon and the Water Authority is the allocation of risk among the project partners. As shown in Table 8, project-related risks are split between Poseidon and the Water Authority. Poseidon, for example, assumes the risks associated with the construction of the plant, which includes ensuring that the project is completed on time, on cost, and according to design standards. Poseidon also assumes certain operational risks, including those associated with amount of energy consumed, membrane performance and replacement costs, and chemical costs. Additionally, if Poseidon fails to produce water, then Poseidon must cover the debt service cost for the desalination plant and the Water Authority's conveyance pipeline.

The Water Authority also assumes several project-related risks that could further increase the price of water. For example, the Water Authority assumes the risk associated with changes in law or regulations that generally apply to water treatment facilities and wastewater dischargers. Thus, any additional costs associated with complying with these laws or regulations would allow Poseidon to increase the price of water. The State Water Resources Control Board, for example, is considering amendments to the Ocean Plan that could increase the costs associated with brine discharge. Under the purchase agreement, capital costs of up to $20 million (in 2010 dollars) could be passed along to the Water Authority. The Water Authority also assumes the risk associated with inflation and electricity prices, and thus Poseidon can increase the price of water due to costs associated these factors.

Table 8. Project Risk Allocation

Risk Description	Poseidon	San Diego County Water Authority
Construction Risk – facility is not completed on time, on cost, and according to design standards	X	
Permitting Risk – current permit and environmental mitigation requirements increase	X	
Change in Law Risk – future unanticipated laws or regulations increase operating costs	X	X
Technology Risk – plant technology does not perform as expected	X	
Output Risk – plant produces less than the projected volume of water	X	
Operating Margin Risk – the price of water is not adequate to generate enough revenue to pay expenditures or may increase more than projected	X (Budget Cap)	X (Subject to CPI)
Pipeline Operating Risk – the pipeline connecting the plant to the regional aqueduct system and associated facilities transport acceptable water to Water Authority wholesale customers	X	X
Electricity – the cost of electricity is accounted for in the water price	X (Electricity Consumption)	X (Electricity Price)
Force Majeure Events	X (Insurable)	X (Uninsurable)

Note: SDCWA assumes those risks, and costs, that affect all water treatment plant operators and wastewater discharges and the cost of power plant improvements (with a cap of up to $20 million in capital and $2.5 million annual operating costs; these estimates are in 2010 dollars).
Source: SDCWA 2012c

The Water Authority also assumes the risk associated with sustaining demand for the water produced by the desalination plant. The water purchase agreement is structured as a take-or-pay contract, and under these terms, the Water Authority must pay for the water regardless of whether that water is needed. In a July 2012 meeting, SDCWA staff indicated that current regional water demands do not justify a fixed commitment to purchase the entire output of the plant, which is equivalent to 56,000 acre-feet. Rather, staff suggested that the agreement be based on a lower contract minimum of 48,000 acre-feet and that fixed costs be allocated based on that purchase amount.

Based on staff's recommendation, the 2012 water purchase agreement establishes a take-or-pay contract with a minimum demand commitment of 48,000 acre-feet per year. Thus, the Water Authority must purchase at least 48,000 acre-feet of the most expensive water available each year, even if demand declines or if cheaper alternative supplies are available. This exposes the Water Authority to significant demand risk and could have major cost implications for the Water Authority and its ratepayers. The Water Authority should consider a contract that establishes a lower minimum commitment. While this may increase the unit cost of water, it would allow the Water Authority to reduce some operating costs, especially energy and chemical costs.

Project Financing

Efforts to finance the project began in late 2009. At that time, the cost estimate for the project was $300 million. Steve Howard, head of the infrastructure group at Barclay's Capital, which was seriously considering the plant at the time, was quoted as saying that a $300 million project was feasible but "if this project was north of $800 million to $1 billion, it would probably be very challenging" (Schwartz 2009). Today, costs are squarely within this range.

Financing for the project has not yet been secured. An approved purchase agreement is needed to secure financing but is not expected prior to November 2012. It is anticipated that 82% of the cost of the project would be financed through tax-exempt private-activity bonds. The remaining 18% would be provided through cash equity from Stonepeak Infrastructure Partners (SDCWA 2012a).[15] Standard & Poor's assigned a preliminary "BBB-" credit rating to the project in 2010 because of how the debt was structured (Pankratz 2010b). This is considered a low credit rating and would have increased the cost to finance the project. Under the new agreement, Water Authority staff anticipates that the bonds will receive a slightly higher "BBB" credit rating; with this rating, staff expects 5.6% and 5.1% yield on the bonds for the desalination plant and conveyance pipeline, respectively (Pankratz 2012b). Higher rates of return are expected for the equity providers. The Water Authority estimates that the cost to finance the project would be $213 million.

[15] Stonepeak Infrastructure Project, formerly the infrastructure division of Blackstone, is an equity investment firm that focuses on traditional infrastructure assets, especially in North America.

Summary

It is not yet clear whether the Carlsbad desalination project will proceed and what lessons can be drawn from the project. However, the project raises several issues that should be addressed before the project is approved, in particular:

- The project was negotiated in a non-competitive environment, which raises concerns about whether the best project was selected, especially as it relates to the cost, design, and operation of the plant.
- Demand risk is a major concern for the project. Alternative supplies and conservation and efficiency improvements are available at lower cost than the desalination project.
- The take-or-pay contract establishes a high minimum commitment to purchase water. This would prevent the Water Authority from pursuing cheaper water alternatives, as they become available.
- The Water Authority should consider a lower minimum commitment, which would allow them the flexibility to reduce plant output and capture potentially significant financial savings from lower O&M expenses.

Conclusions

Economics – including both the cost of the water produced and the complex financial arrangements needed to develop a project – are important factors that will determine the ultimate success and extent of desalination in California. In this report, the second in a series on key issues for seawater desalination in the state, we provide detailed information on the cost of seawater desalination projects, how they are financed, and some of the risks associated with these projects.

How Much Does Desalination Cost?

Our analysis finds that the cost to produce water from a desalination plant is highly variable. Recent estimates for plants proposed in California range from $1,900 to more than $3,000 per acre-foot ($1.54 - $2.43 per m^3). While the cost of seawater desalination has declined considerably over the past 20 years, desalination costs remain high and there are unlikely to be any major cost breakthroughs in the near- to mid-term. Indeed, desalination costs may increase in response to rising energy prices.

The public and decision-makers must exercise caution when comparing cost estimates for different seawater desalination projects. In many cases, costs are reported in ways that are not directly comparable. For example, some report the cost of the desalination plant alone, while others include the additional infrastructure, e.g., conveyance pipelines, needed to integrate the desalination plant into the rest of the water system. Some estimates include the cost to finance the project, while others do not. Even when there is an apples-to-apples comparison, there are a number of site- and project-specific factors that make cost comparisons difficult, such as energy, land, and labor costs.

Furthermore, costs associated with wastewater conveyance and treatment are often excluded from desalination cost comparisons. The introduction of a new source of water increases the amount of wastewater that must be collected, treated, and disposed. Some communities may have adequate wastewater treatment capacity and the additional costs would simply be the variable O&M costs associated with that treatment. In other communities, however, wastewater treatment capacity may need to be expanded, which represents an additional, and in some cases significant, capital cost to the community. While these costs would apply to all of the water supply projects under consideration to meet demand, these costs would not be incurred if water demand was met through water conservation and efficiency improvements.

How Are Seawater Desalination Projects Financed?

The construction of a desalination plant is expensive and requires considerable up-front capital investment. To cover these costs, project developers often rely heavily on debt financing, which involves borrowing money from a lender with the intent of repaying the principal of that debt and interest. Although still relatively uncommon within the water sector, project developers are also turning to private equity financing – whereby an investor provides capital for the project in exchange for partial ownership of the desalination plant.

For most of the proposed projects in California, the finance mechanism has not yet been determined. Desalination projects that are being developed solely by public water agencies will likely use municipal revenue bonds or other conventional financing methods. Additional support may be provided through government grant and loan programs. Nine of the proposed plants in California, however, may be entirely or partially financed and owned by private companies, and these projects will likely use some combination of debt financing, especially tax-exempt private-activity bonds, and private equity. These public-private partnerships can allow for a mechanism to attract private investment and share some of the risks associated with a project. One of the possible drawbacks in private sector financing, however, is the high cost of private capital, which is reflected in the price of desalinated water. Proponents of this approach, however, argue that the higher costs are offset by lower risk for the water provider, higher efficiency of the contractor, and technology performance guarantees.

What Are Some of the Risks Associated with Seawater Desalination Projects?

There are several risks associated with seawater desalination projects that can affect the cost of the project, ability to attract financing, and overall viability of the project. Many of these risks are not unique to seawater desalination projects; rather they apply broadly to all major infrastructure projects. These include risks associated with permitting, construction, operations, and changes in law.

But as recent experience in the United States and Australia has shown, desalination projects entail risks specific to large water-supply projects, including demand risk. Demand risk is the risk that water demand will be insufficient to justify continued operation of the desalination plant due to the availability of less expensive water supply and demand management alternatives. In Australia, for example, four of the six desalination plants that have been developed since 2006 are being placed in stand-by mode. Likewise, the Tampa Bay Desalination Plant is operated considerably below full capacity because demand is lower than expected and less expensive water-supply options are available. Demand risk raises serious concerns about the size and timing of desalination projects, e.g., how big and when desalination plants should be built.

In some regions, seawater desalination can make an important contribution to the availability and reliability of water resources. However, it remains among the most expensive options available to meet water demands. Additionally, project developers may pursue large plants in an effort to capture economies of scale and reduce the unit cost of water. This can, however, lead to oversized projects that ultimately increase demand risk and threaten the long-term viability of a project.

How Are Desalination Projects Structured?

Issues around financing and how project costs and risks are allocated are tied to how the project is structured. Many project developers in California are using some form of public-private partnerships. The private sector's involvement in seawater desalination projects is not new. The private sector has developed several small plants to supply high-quality water for specific industrial purposes, such as for use on oil and gas platforms. Likewise, a desalination project in Santa Barbara, completed in 1992, was operated and partially owned by a private company. In some cases, the private sector's involvement is limited to conducting feasibility studies and preparing environmental documents as requested by the public project developer. In other cases, however, a private entity owns and operates the desalination plant and sells water directly to a public agency. Public-private partnerships provide a mechanism to access private capital and allocate risks among the project partners. They can, however, be highly contentious due to concerns about openness and transparency of data and financial information and the allocation of the risk among the project partners.

Additionally, utilities that are developing seawater desalination plants must be sure that there is a demand for that water, especially when establishing minimum commitments under take-or-pay contracts. A take-or-pay contract provides guaranteed revenue for the seller but commits the buyer to a purchase even if actual demand drops. This exposes the buyer to demand risk, and provides a disincentive for water agencies to pursue more cost effective water supply and water conservation and efficiency programs.

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