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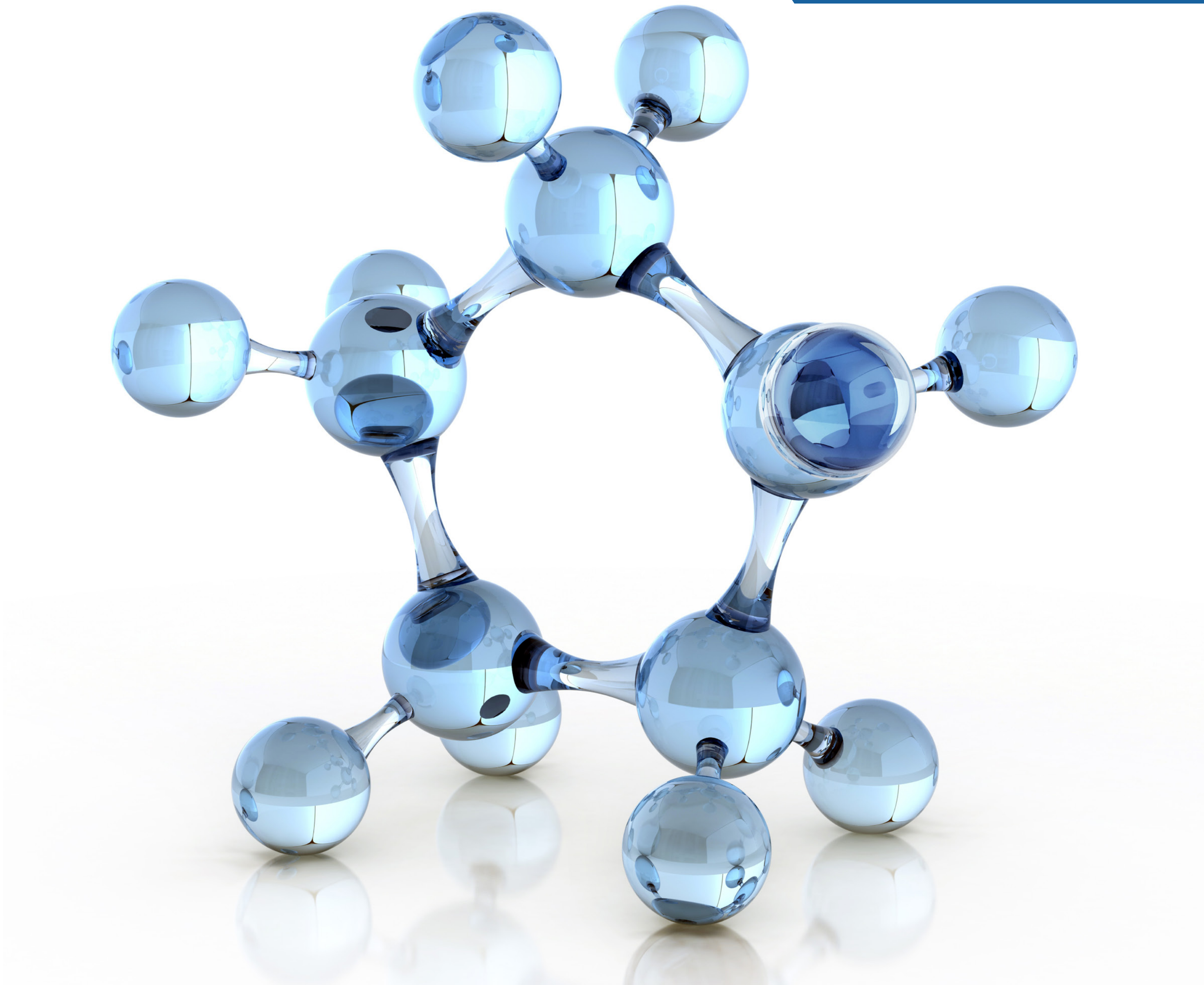

Financial Models for Water Sustainability

Financial Innovations Lab® Report

A project of the California-Israel Global Innovation Partnership

Jerusalem Institute
Milken Innovation Center

Acknowledgments

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Financial Innovations Labs bring together researchers, policymakers, and business, financial, and professional practitioners to create market-based solutions to the challenges facing emerging economies. Using real and simulated case studies, participants consider and design alternative capital structures, and apply appropriate financial technologies to address hurdles to growth, in the areas of energy, water, food and health.

About the Milken Innovation Center

The Milken Innovation Center at the Jerusalem Institute focuses on developing market-based solutions to Israel's greatest challenges as it transitions from a startup nation to a global nation. The Milken Institute Fellows program, trains some of Israel's best and brightest young professionals in creating pragmatic financing and economic policy solutions, and then deploys them as resources to government ministries, nonprofits, and other key organizations. Applied research and Financial Innovations Labs serve as a launching pad for transformative change, using innovative financing mechanisms, programs, and policies to bridge social, regional, economic, technological, and productivity gaps within Israel and between Israel and the world. The goal of the Milken Innovation Center is to accelerate economic growth, build human capital, and cement Israel's role as a pioneer in addressing global challenges in water, food, education, health, and energy with solutions that are broadly scalable for other nations.

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EXECUTIVE SUMMARY

Reports on water scarcity have been discouraging. For 40 percent of the global population, demand for water exceeds supply. Within a decade, water scarcity may spread to regions holding 60 percent of the world's people.[1] Nearly one-third of the world's 37 largest aquifers are being drained faster than they are being replenished, meaning "groundwater recharge is negative" in eleven of the aquifers.[2] NASA data shows that in California there is only about one year of water supply left in reservoirs, and that total water storage has been in decline since at least 2002.[3] California is in a drought. Yes, but more importantly, California's water situation is unsustainable.

According to the US Intelligence Community Assessment of Global Water Security, by 2030, the world's water needs will exceed current sustainable water supplies by 40 percent, which could generate widespread instability and contribute to state failure in certain regions, including in the Middle East.[4]

In Israel, this particular existential threat was recognized long before the modern state took form,[5] but the threat materialized into a national emergency in 2005, in the form of a seven-year drought that threatened to exhaust what was left of the country's natural water supplies. Through usage taxes, water rationing, creation of the centralized Water Authority in 2007, and government partnerships with private-sector firms and new water technology providers, Israel opened many fronts in the drive to end chronic water shortages.[6] The result? Israel leads the world in cutting-edge water technologies with a $4 billion high-tech industry focused on one of the most basic needs for survival on this planet: water conservation and reclamation.

Like Israel, much of California has a dry Mediterranean climate that is slowly warming. Both Israel and California devote about 60 percent of their water to agricultural uses. In January 2015, California recorded the lowest rainfall since 1895, and Israeli rainfall was the lowest since 1865, when measurements began. But this is where their similarities end.

Israel's per capita residential water use is one third of California's and represents only a quarter of Israel's total annual water consumption. Eighty-five percent of wastewater in Israel is recycled toward agricultural use, while in California that percentage is much lower, around 9.5 percent. In fact, more than half of Israel's water—for residential, commercial, and agricultural consumption—is now "artificially produced," via desalination, recycling, and water treatment options.[7] And most new technologies seek to mimic the natural water cycle by engineering the replenishment of aquifers and minimizing groundwater pumping.

Over the past decade, in particular, Israel's large investment in an adaptive, resilient water system through conservation, desalination, recycling, and smart integrated management, has led to the production of about 20 percent more water than it consumes, exporting surpluses to Jordan and the Palestinian Authority. By 2013 the export of Israeli water technology had skyrocketed to $2 billion, according to the Israeli Export Institute, which also reported that there were 280 water technology companies in Israel in 2012, of which 150 were exporters.[8]

Meanwhile, fields in California continue to be "irrigated" by flooding, rather than by watering with smart-drip irrigation meters. Non-revenue water [the water that "disappears" from the water distribution system before it reaches the utility's customers], includes lost water attributed to leaks (physical losses) and/or faulty metering or water theft (apparent losses) accounts for an estimated 10−15 percent of water loss in California every year. The full scope of non-revenue water losses cannot be accurately measured or managed. The total drought-related economic hit across California agriculture for 2015 was expected to reach about $2.7 billion and a loss of 21,000 related job.[9]

California will discover, as did Israel, that there is no magic to ending the water crisis. Substantial and urgent change is required that will affect many stakeholders. Success will involve revolutionary technologies, institutional and legislative reforms, new financial and economic mechanisms, in attitude and behavior, all integrated and implemented through a portfolio of water technology transfers and a focus on continued managed innovation in the water sector.

In midsummer 2015, The Milken Innovation Center at the Jerusalem Center for Israel Studies held a Financial Innovations Lab in Jerusalem on water conservation in California, with a focus on various financial mechanisms that Israel successfully developed to support its local water-saving technologies, and how these innovations can be replicated in California. The technologies described include water recycling, smart water systems that predict and detect waste, “nutrigation” (application of plant nutrients through an irrigation system in precise combination and timing for optimal development and best yields) for conventional and new low-water crops, irrigation that reduces water use, and desalination that converts seawater and brackish wastewater into useable, potable water.

Based on the discussion in the Lab of new financial models for water sustainability, the Innovation Center is now forming work teams to create solutions specific to conditions in California, in the following areas:

- **Water solutions for farmers:** to demonstrate a financially feasible model to convert alfalfa, rice, and other commodity crops from flood irrigation to subsurface precision irrigation; and to demonstrate smart aquifer management, recycling, drought-resistant crops, smart watering, dairy waste-to-energy and waste-to-fertilizer, and small-scale desalination distributed water treatment systems to provide water to farmers
- **Water solutions for municipal systems:** to demonstrate a first commercial implementation of a bundle of multiple solutions in a single city or small region (water district) that can finance innovative solutions.
- **Water solutions for industry:** to demonstrate the bundling of multiple water technology solutions for private industrial water services.
- **Agriculture−water−energy demonstration projects:** to demonstrate the technology innovations in the connections among all three sectors that can be tested, developed, and brought to scale.
- **Groundwater monitoring and cleanup:** to demonstrate the economic and environmental potential in monitoring groundwater contamination and cleaning it.

Based on the use of selected financing programs to target farm and municipal projects, we estimate annual savings of 455 billion gallons of water, or 3.4 percent of California’s human water consumption. This could mean a savings of approximately $908 million on water and $59 million in energy costs per year. To accomplish this, we estimate an annual fiscal cost to the state of $141 million in tax credits to farmers or their investors over a ten-year period, and approximately $59 million annually in farm loans.

For California municipalities, a 6 percent increase in water efficiency across municipal water districts, would translate to an annual savings of 180 billion gallons of water, which comes to 1.3 percent reduction in human water consumption. This could mean an annual savings of approximately $552 million on water and associated energy costs. To accomplish this, we estimate a capital cost of approximately $1.16 billion, of which approximately $55.3 million would be loaned each year through California financial programs.

The Milken Innovation Center also estimates that a substantial portion of the repayments of these public loans could be made through savings from water and energy costs. Utilizing performance contracting (i.e., guaranteed savings contracts) as a core offering enables the monetization of cost avoidance at the water-energy nexus of production and distribution of water resources. These models can provide water and energy savings and other benefits to customers through the use of performance-based contracting. Both the value of water and energy benefits can offset some or all of costs including operations and maintenance savings, avoiding capital costs and tradable pollution allowance or water rights that can become part of cost analysis for water technology transfer projects. By introducing new models for finance and water system service companies, the Milken Innovation Center predicts that technologies that had their beginnings in Israel will meet California's water challenges.

INTRODUCTION

Wide-ranging advances in water technology can reduce the costs of desalination, recycling, and groundwater storage. The advances help manage smart water grids and root fertilization, enable real-time leak detection, eliminate non-revenue water losses, and improve water distribution efficiencies. The goal of this Lab was to catalyze and accelerate these kinds of technology transfers between Israel and California, two global centers of innovation. Based on the Lab, we are organizing work teams to identify potential projects and financial solutions, and to make preparations to expand them to regions beyond California that face similar challenges.

California and Israel share a warm Mediterranean climate, with recent record lows in rainfall. Both allocate a majority of water resources to agriculture, and both have dangerously overexploited their freshwater resources to accommodate rapid and substantial population growth. Where California and Israel differ is also important. Israel's population is only one-fifth that of California's, but per capita, it uses less than one-third the water for urban residential and non-agricultural commercial use. California still relies on natural sources of water, such as snowpack; Israel relies on man-made desalination and recycling. Most poignantly, California faces a drought emergency and long-term water deficit, regardless of the near-term rainfall. Israel's water security is assured by innovative technology at work throughout the water cycle.

In particular, the Lab focused on the following key questions:

- How can Israel and California leverage opportunities in the regulatory, ownership, management, technology, and financial systems to a mutually beneficial technology exchange?
- What can Israel teach California about building a system for technology development, transfer, and deployment of sustainable water systems?
- How can California (and Israel) involve leaders in translational research, business, finance, and policy in organizing program, project, and policy initiatives that will accelerate relevant sustainable water solutions through managed co-innovation?

The Financial Innovations Lab, held in July 2015, was a key part of the California−Israel Global Innovation Partnership launched by the Milken Innovation Center in conjunction with the University of California, Berkeley, University of California, San Diego's Rady School of Management, UCLA, and University of California, Irvine. The partnership's goals are to engage government, business, and communities in accordance with a Memorandum of Understanding (MOU) signed on March 5, 2014, by Governor Jerry Brown and Prime Minister Benjamin Netanyahu. As the basis of a strategic plan between Israel and California, the MOU encourages access and collaboration to "foster economic cooperation and development, facilitate joint industrial research and development, and enhance business relationships and educational opportunities to foster job creation and incubate global solutions from joint California−Israel innovation initiatives."[10]

Why is this important? Cooperation would create a global technology platform to "incubate" solutions to emerging markets also facing water resource crises. For California, the partnership will foster technology transfer and development into real-world applications. For Israel, the partnership provides a test bed for scalable solutions, a growing market for products and services, and co-investment opportunities.

ISSUES AND PERSPECTIVES

The Lab began with a description of the conditions that led to the questions being addressed. Lab participants had the opportunity to learn and share information about the water ecosystem trends and policy background at the global, national, and regional levels. As well, this discussion included social, economic, and environmental barriers and potential solutions to explore in overcoming them.

DRIVERS AND CONDITIONS

Lab participants discussed the mega trends in water issues, and acknowledged that many of the stresses and threats facing Israel and California are applicable on a global stage. Threats to water security derive from population growth, rising consumption demands, border politics, reduced water resources, and the effects of climate change. Presenters offered the following statistics:

- The global population is expected to surge by 1 billion people in just the next fifteen years, from 7 billion today to 8.3 billion people in 2030.
- Water demand will exceed supply for 60 percent of the world's population in the next ten years.
- As of 2015, 1.8 billion people live under water-stressed conditions; this number is projected to rise to 2.8 billion by 2025.
- Freshwater taken from rivers, lakes, and aquifers has risen by 600 percent since 1965.
- Energy production consumes 15 percent of all water in the developed world—more than that used in the residential sector and second only to agricultural use.

These conditions are severe. Yet they also create a huge market opportunity to test and scale solutions that strive to "decouple" water resource utilization from economic growth, and to accelerate renewable water technologies.[11] By decoupling, we use the definition of the UN Environmental program: "reducing the amount of resources, such as water or fossil fuels, used to produce economic growth and delinking economic development from environmental deterioration." This perspective requires major shifts in public policy, but it is the best way to propel innovative technologies in extraction, delivery, and other solutions to prevent disruptions in sustainable development and human well-being.

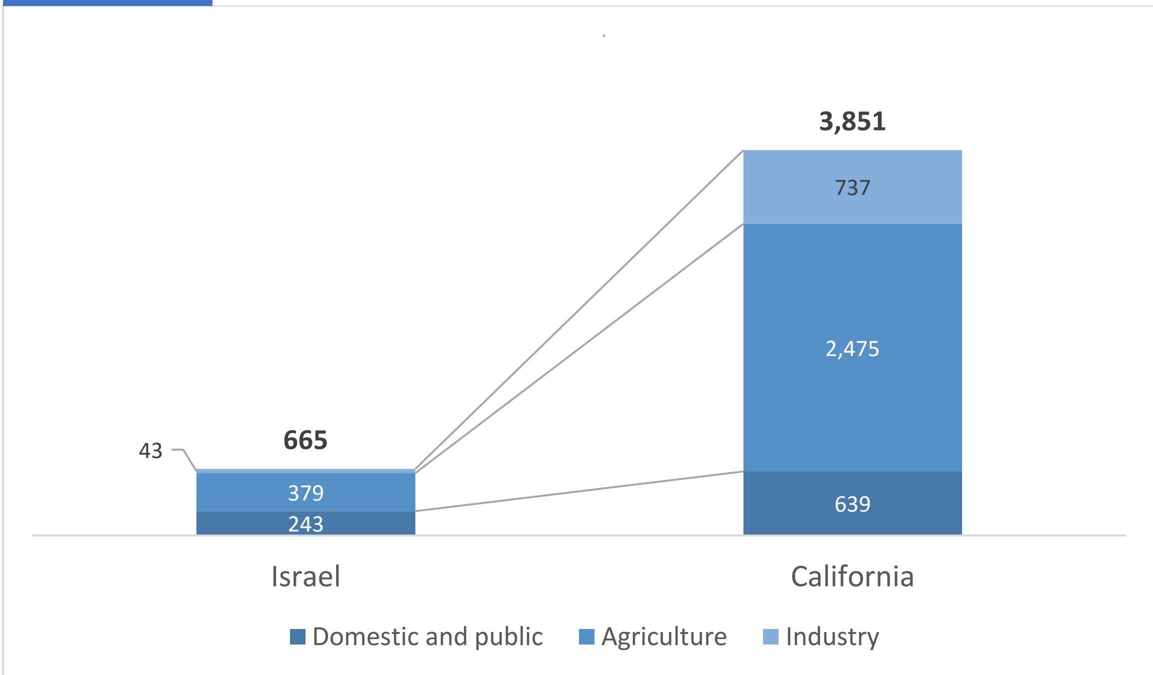
California and Israeli Baselines

Lab participants looked at comparisons of Israeli and California water usage and management. These comparisons highlight the gaps between the two, as well as opportunities in California to realize improvements in sustainable water practices. Overall, Californians consume six times more water per capita than Israelis, a trend not only among individual consumers but also across agriculture and industry, as indicated in Figure 1 below.

Water consumption includes all managed water sources for household, industrial, and agriculture uses. Using data from the Israel Water Authority and the US Department of the Interior's United States Geological Survey (USGS) California Water Science Center, Californians use almost six times more water than Israelis on a per capita basis, 3,851 and 665 liters per capita per day, respectively.

FIGURE 1

Per capita water consumption (in liters per day)



Sources: Israel Central Bureau of Statistics, Israel Water Authority, 2012; California Water Science Center, USGS, 2010; Milken Innovation Center.

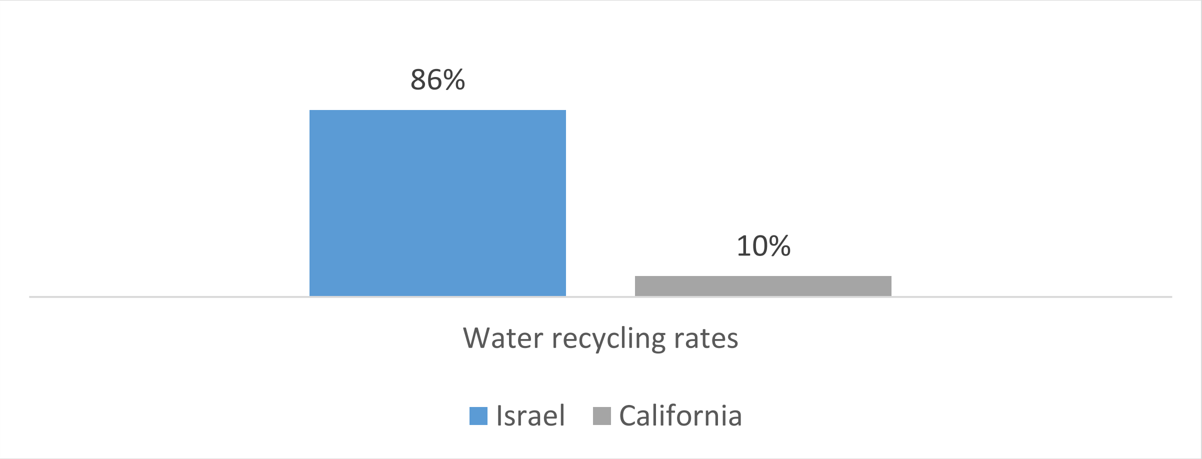
Domestic uses in California consume about two and half times more water per day than their Israeli counterparts, according to data from Israel's Water Authority and the California Water Science Center. On a per capita basis, agriculture in California uses almost six and a half times more than agriculture in Israel. Industry, which includes manufacturing, mining, and power generation in California, uses over seventeen times the water rate in Israel.[12]

Israel has fewer sources of natural water than does California; as a result, it has historically been harder pressed to develop technology to recycle wastewater. It currently recycles waste water at a rate about eight times higher than that of California.

Israel generates about 500 million cubic meters of household water waste per year, according to an estimate from a survey by Israel Nature and Parks Authority for the Israel Water Authority. Based on the treatment of household waste water at plants throughout the country. Israel returns approximately 428 million cubic meters to mainly agriculture uses, or a recycling rate of almost 86 percent[13] representing almost 23 percent of the total water needed for agriculture, according to the Israel Water Authority and a survey by the Israel Nature and Parks Authority. This compares to data from a survey by the California State Water Resources Control Board which identified approximately 825 million cubic meters of recycled water to a variety of uses, or a recycling rate of just over 9.5 percent of the estimated 8.7 billion cubic meters of municipal water waste.[14]

FIGURE 2

Water recycling rate

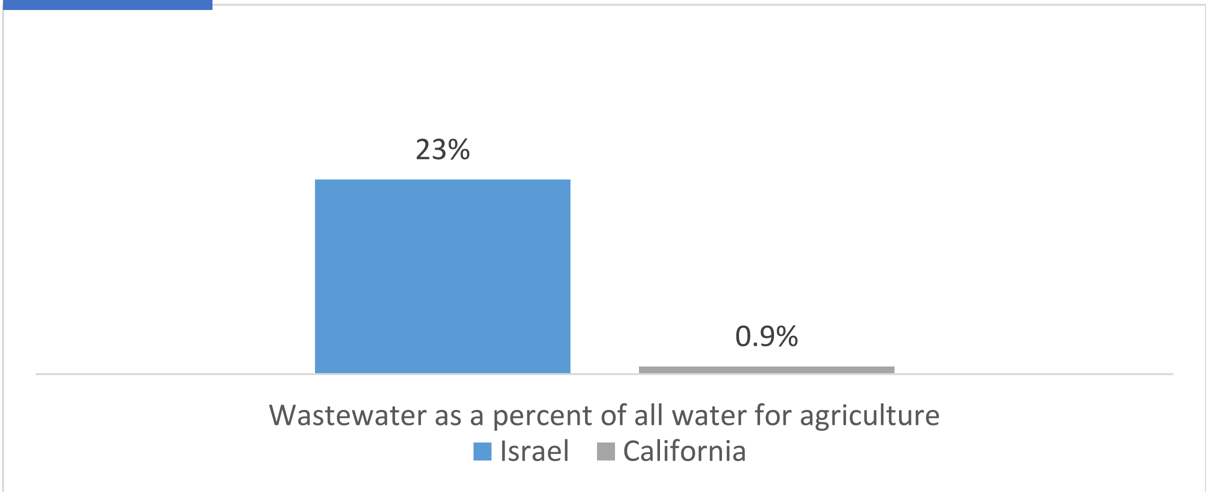


Sources: Israel Nature and Parks Authority Survey; Municipal Wastewater Recycling Survey; California State Water Resources Control Board; Milken Innovation Center.

Israel's rate of recycled water in agriculture is about 25 times higher than California's, with an estimated 302 million cubic meters out of a total of 34 billion cubic meters of water used in agriculture or .9 percent of the total water usage.[15] Recycled wastewater is a major source of agricultural water in Israel but is negligible in California.

FIGURE 3

Percentage of wastewater used in agriculture



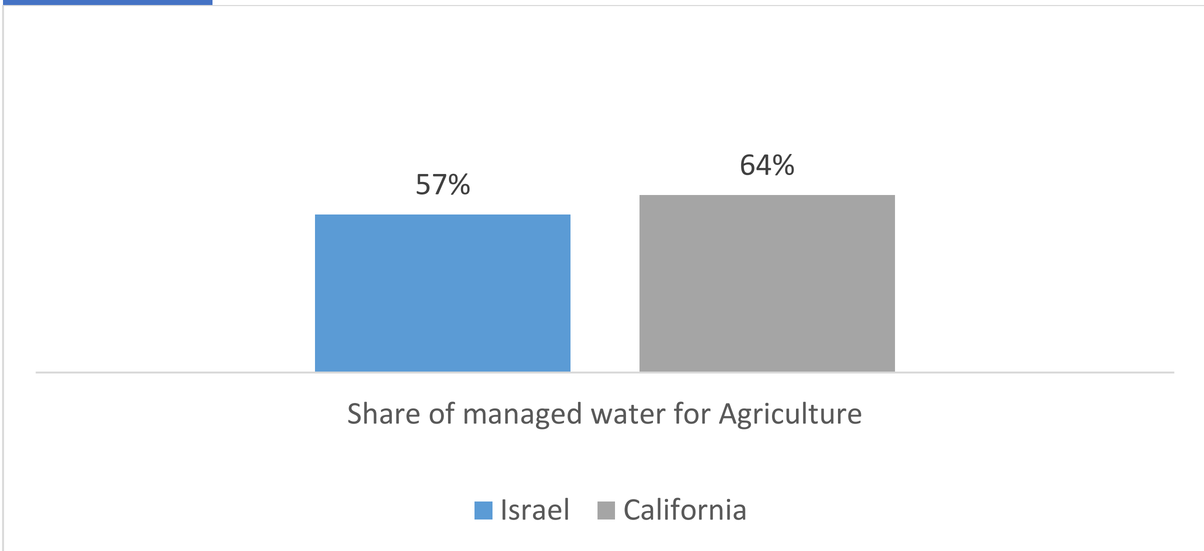
Sources: Israel Nature and Parks Authority; Israel Water Authority; State Water Resources Control Board; Milken Innovation Center.

Figure 4 compares the portion of managed water, including all water collected, transported, used, treated, and reused, that is allocated to agriculture in Israel and California. This does not include the allocation of water that remains in natural habitats for other uses, which accounts for about 50 percent of California's water.

Water for agriculture represents 57 percent and 64 percent of all water uses in Israel and California, respectively, according to the Israel Water Authority and the California Water Science Center. The estimate for California rises to almost 80 percent in some areas of the State, especially agriculture-intensive areas in the Central Valley, according to the Public Policy Institute of California.[16]

Share of water used for agriculture

FIGURE 4



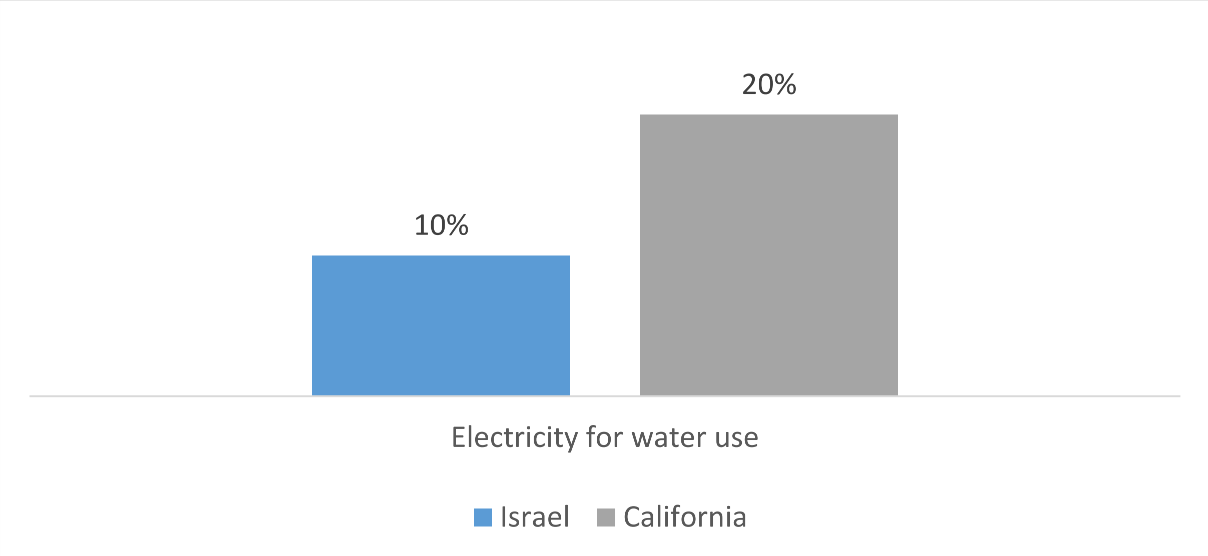
Sources: Israel Central Bureau of Statistics; Israel Water Authority; California Water Science Center; Bloomberg Business (2014); Milken Innovation Center.

Water is highly correlated with energy. Water is used in the extraction, production, and refining of fossil and plant fuels, and in the heating and cooling of power plants. Energy is used to process, store, and treat water supplies for redistribution to consumers. Thus water is highly correlated with energy. Sustainable solutions should acknowledge the correlation and search for solutions with a lower energy demand. In Israel the electricity use for water is half that of California.

Between water and energy, Israel supplies approximately 10 percent of its electricity production to the collection, conveyance, storage, desalination, and treatment of water, based on a study commissioned by the Ministry of Energy in 2013.[17] 20 percent of California's electricity is used in the water sector, according to the California Energy Commission.[18]

FIGURE
5

Electricity used for water processing, storage, and treatment



Sources: Israel Ministry of Energy; California Department of Water Resources; Milken Innovation Center.

California has the highest absolute State population growth in the country. Yet this rate isn't as high as Israel's. Projected growth for both makes the water problem more severe, highlighting the fact that sustainable water solutions must keep up with rising demand. Yet this challenging scenario also provides the potential for positive change: the larger the population, the more wastewater is produced, an opportunity to develop a "new" water source.

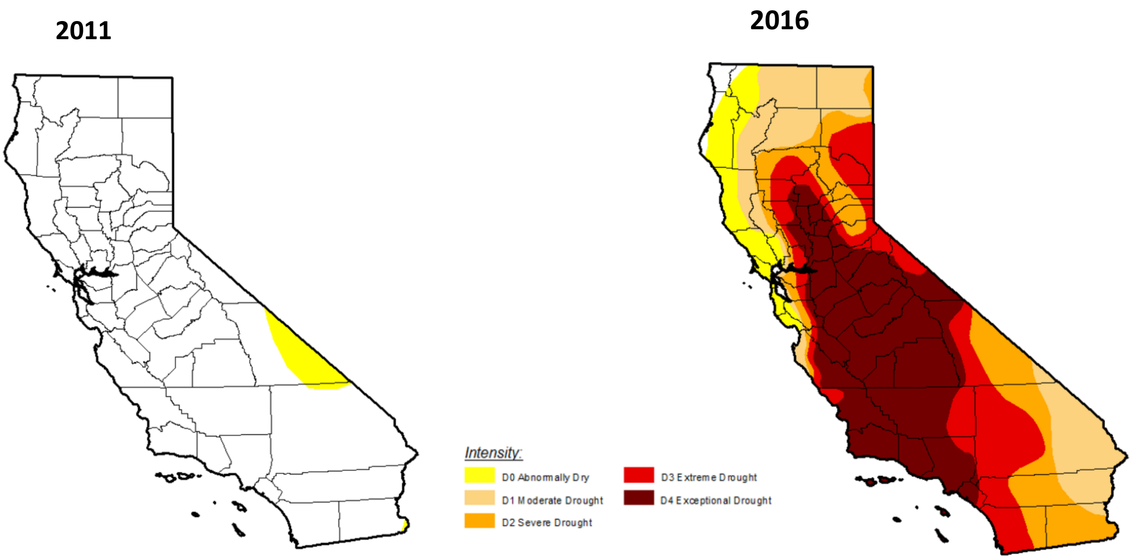
Lab participants noted that California's unprecedented drought over the past five years is not the sole cause of the growing crisis. The water fundamentals of overuse, low savings, waste, and ineffective policy all combine to create a systemic problem that requires systemic solutions.

California's Water Conditions

Jay Famiglietti, a professor at the University of California, Irvine, and water scientist for the NASA Jet Propulsion Lab in Pasadena, Calif., has documented the water depletion in aquifers worldwide using satellite hydrology sensing programs. He presented findings at the Lab, showing that the rate of use has far exceeded the supply for decades. NASA estimates that California needs 42,000 cubic kilometers[19] of water to recover to normal levels.[20]

California drought conditions, 2011–2016[21]

FIGURE 6



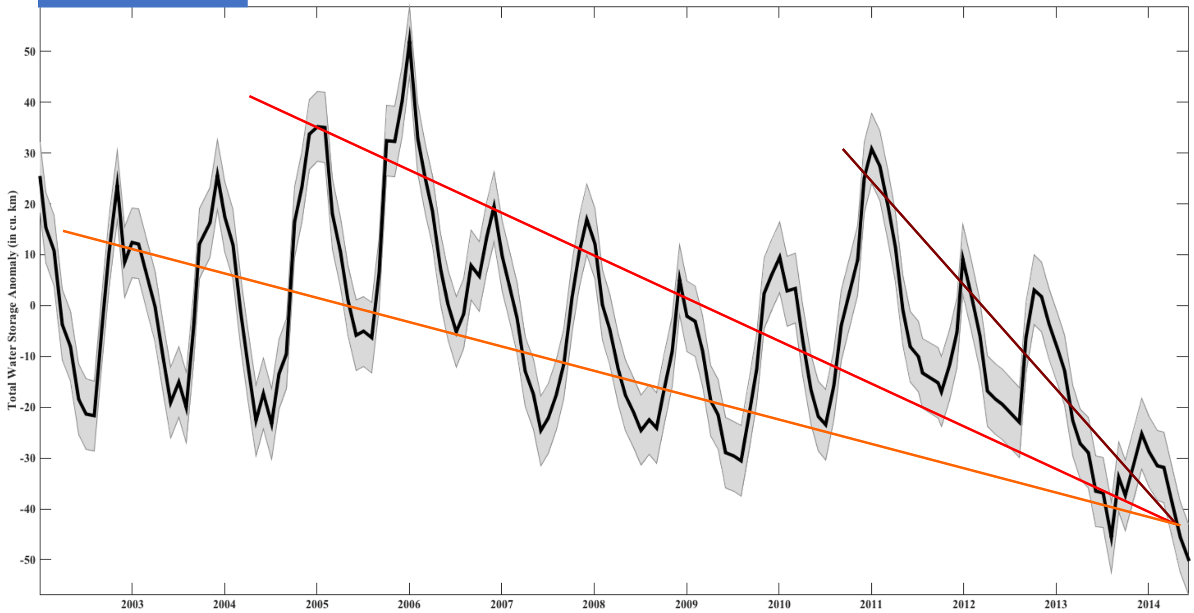
Source: National Drought Mitigation Center

Of note, the California Department of Water Resources has not conducted a comprehensive update on the conditions of the state's aquifers since 1980.[22] Analysis of the aquifer conditions by the Jet Propulsion Lab (JPL) provides a valuable window into this threatened resource. The JPL study also makes clear that no one knows how much water is remaining in underground aquifers, only how much has been depleted, because of the difficulty and expense of the drilling process through bedrock.[23]

Famiglietti explained the shifting baseline in California by showing that the new maximum water line is the previous droughts' minimum water line.

FIGURE 7

Change in total water storage in the Sacramento–San Joaquin River Basins from GRACE



Source: Time series computed from NASA JPL Mascons solutions by Felix Landerer

As previously noted, an end to the drought will not even bring temporary relief. The structural deficit caused by the imbalance between California's water use and its available resources, including those in its snowmelt aquifers, reservoirs, and water imported from neighboring states, can only be alleviated with technologies that achieve water conservation, recycling, and distribution.

Policy development trends

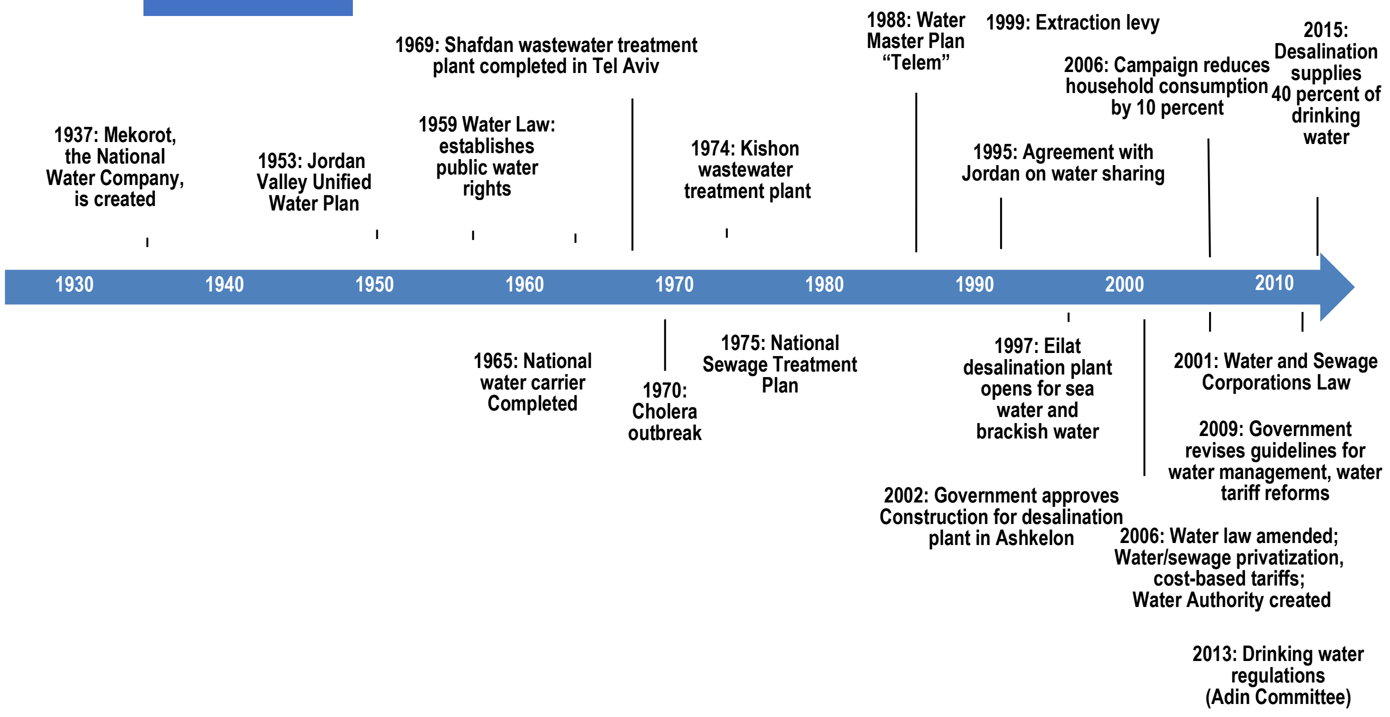
One of the most striking differences in policy development between Israel and California is the ownership of water resources. Early in its history, Israel designated water resources as a public good. California, whose water appropriation laws date from the Gold Rush era, has long supported the claims of private owners to water resources. So do most Western states. These two contrasting approaches underlie many of the challenges for creating solutions and insuring against overexploitation of scarce water resources.

In addition, while Israel has one central Water Authority, California has a highly decentralized water management system with hundreds of fragmented agencies responsible for water supply, wastewater treatment, flood control, and land use. This has resulted in chronic groundwater overdraft, pollution impairment of watersheds, ineffective ecosystem management, and overdevelopment in floodplains.

The California Public Utilities Commission regulates 108 privately owned water utilities, with annual revenues totaling $1.4 billion.[24] The Association of California Water Agencies states that its "430 public agency members are responsible for 90 percent of the water delivered to communities, farms, and businesses throughout California."[25] The legal blog PrivateWaterLaw breaks down the system into: 285 incorporated cities that own and operate water utilities; 129 county districts operating county service areas, county waterworks districts, or county maintenance districts operated as separate enterprises; 537 special water districts; 138 public utilities, which together own 255 separate water systems; privately held, member-controlled mutual water companies, of which there are approximately 1,200; and 467 public water systems operated by mobile home parks.[26]

FIGURE 8

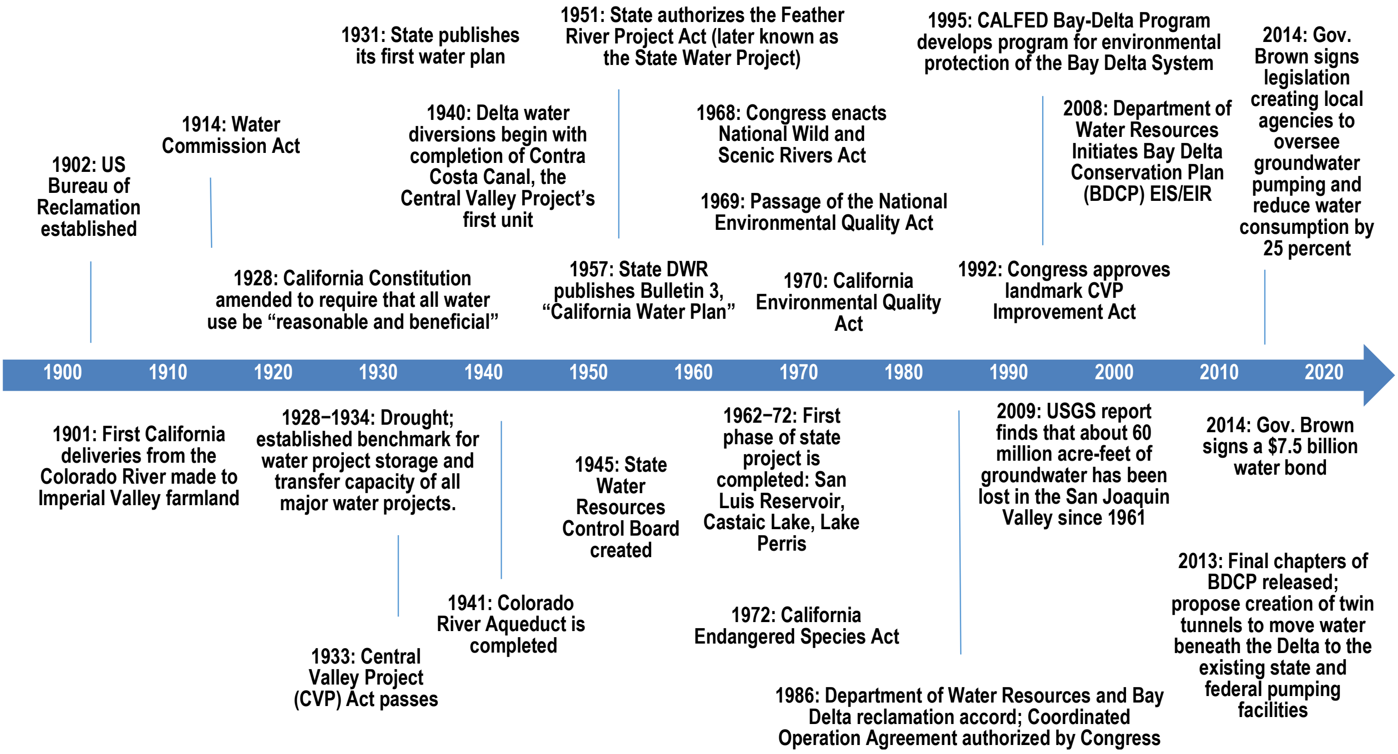
Timeline of policy development in Israel



Source: Milken Innovation Center.

FIGURE
9

Policy development in California



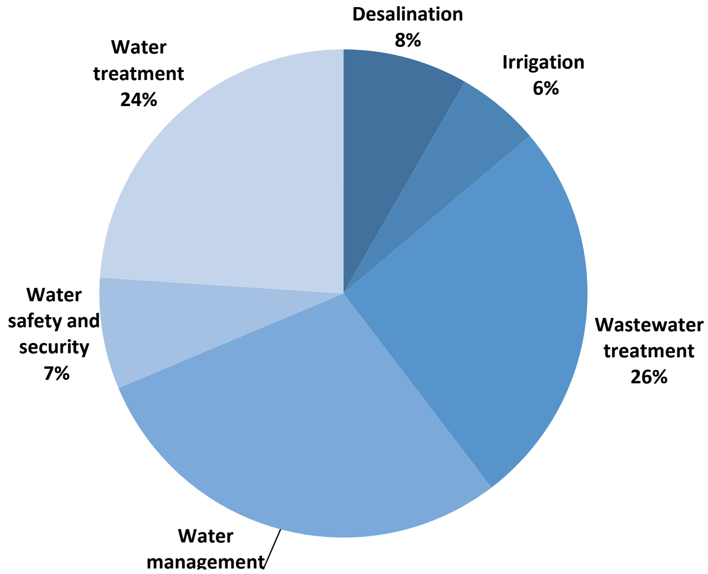
Source: Public Policy Institute of California; Milken Innovation Center.

Israeli Technologies and Practice

The Israeli water industry is recognized as a global leader, thanks to innovations in desalination, drip irrigation, water recycling, and water network security, among others. Israel's R&D programs, its expertise in advanced technologies, and its traditional strengths in water management and agriculture have resulted in a vibrant export enterprise. Its water industry exports stood at approximately $2 billion annually in 2014.

FIGURE 10

Companies in the Water industry, by sector



Source: NewTech Office.

The water industry comprises more than 300 Israeli companies, 120 of which are seven years old or younger. Key water subsectors include:

- *Agriculture*, in which collaboration between farmers and researchers has led to advanced irrigation technologies, such as drip irrigation, constructed wetlands, and smart metering systems.
- *Water management*, including various governmental and private sectors, led to the development of management technologies, such as measuring water usage and maximizing efficiency in water distribution systems.
- *Wastewater treatment*, including numerous efficient technologies of purification and reclamation of wastewater.
- *Cost-efficient desalination*, resulting in construction in Israel of the world's largest reverse osmosis (RO) desalination plant. Advances in reverse osmosis have reduced costs, and emergent technologies—such as forward (engineered) osmosis, advances in membrane technologies, photochemical water purification, oxidation processes, and natural systems—are targeting water treatment solutions for seawater and brackish water.
- *Water safety and security, developed through* Israel's operational defense research and experience, making the country a world leader in water security, risk management, and disaster solution technology.

The Ministry of Economy's Office of the Chief Scientist (OCS) is responsible for encouraging and supporting industrial R&D in the water sector, and provides a variety of related programs that operate on an annual budget of about US$300 million. The main OCS program offers recoverable grants of up to 50 percent of the approved R&D expenditure.

Lab participants heard presentations from representatives of a number of leading Israeli companies, who explained how these technologies can be used to create sustainable water strategies for California farmers, cities, and industry. These companies are listed in Appendix 3.

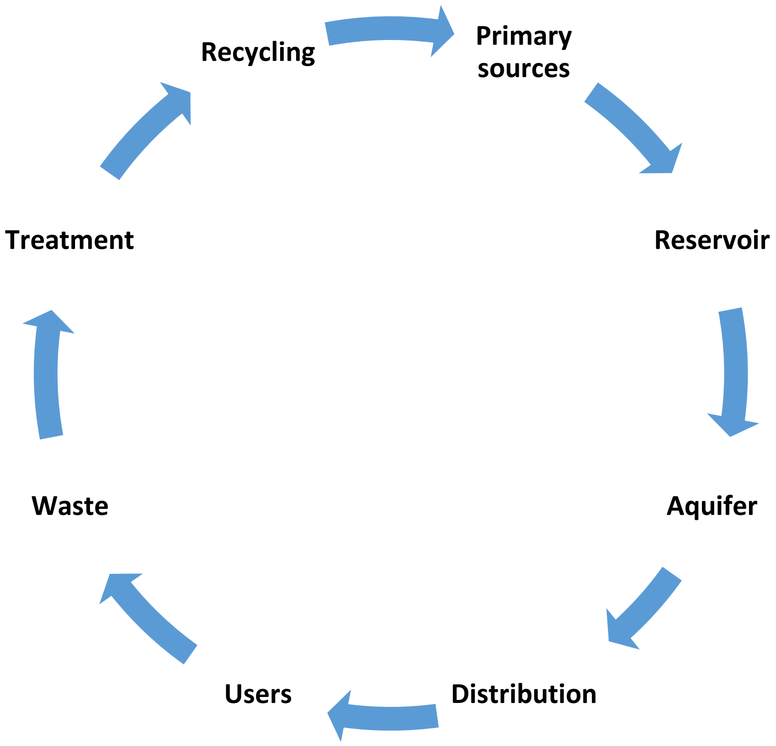
In addition, the Israeli Water Authority (Israel has just one central authority), in collaboration with the Ministry of Economy, offers grants for first implementation of water technologies in municipalities. These grants enable deployment of innovative technologies and bridge serious financial gaps for startups.

Barriers

The issue of water scarcity is composed of many factors, and Lab participants considered social, economic, and environmental components. A severe drought between 1999 and 2001 in Israel opened a policy window to consider integrated management programs that would mimic and support the natural water cycles through technology interventions. The result was a series of public-private partnership tenders launched to accelerate desalination, recycling, conservation, storage, and technology deployment in agriculture, industry, commercial, and residential applications.

In the natural world, water in its various forms—rain, ice and snow, steam, and cloud condensate—cycles through a closed system, with gains and losses in the form of water exchanges between watersheds and between land and air. In the industrial world we inhabit, the water cycle is more complex, as shown in Figure 11. In fact, Lab participants pointed out that a "hidden flow of water" exists if one considers the food and other water-dependent commodities exported from one place to another.

FIGURE 11 ***Water cycle***



Source: Milken Innovation Center.

Lab participants considered the water cycle, the environment, and the managed components to understand the barriers to improvements and the opportunities for interventions to overcome these barriers.

The water cycle begins with the primary water sources which include rainfall, snowmelt, rivers, aquifers, and lakes. These may be found within the watershed in which the water is used, or beyond its "borders." In general, each of these natural sources must be protected before it becomes an increasingly unrenewable near-term resource. From each of the primary sources, water flows naturally and sometimes into reservoirs, which are natural or man-made surface facilities. Often, the man-made reservoirs require infrastructure for transporting water over long distances. After the water is collected, it must be distributed to users, which involves the collection, preparation, and transport of stored water, including filtration, and may include municipal or other regional water district facilities. Aquifers are an important intermediary in this water cycle. They are a natural subsurface collection of water, usually in rock or other porous geological structures. They act as a holding area, naturally cleaning the water through filtration. However, these natural aquifers are overused and often damaged, and difficult to restore.

Water users include all consumers, municipal, industry, and agriculture. From each of these users, the cycle continues with the treatment of wastewater and residual waste streams from all users. Cleanup may be done at a variety of levels, depending on the technologies and the uses of treated waste. Cleaned or treated wastewater eventually finds its way back to the ecosystem in the form of evaporation and precipitation. Alternatively, recycling includes the reuse of a portion of the cleaned or treated water for agriculture, municipal uses, gardens, and even direct human consumption.

Lab participants observed numerous barriers along the value chain that can lead to market failures. Some of these occur in nature, while others result from existing or absent public policy interventions. These failures can also represent opportunities for interventions, strategies, and initiatives that lead to growth.

Figure 12 summarizes many of these barriers. For this purpose, the water value chain, depicted previously as a continuous cycle, is now represented in linear fashion. It will be seen that barriers can be divided between water supply (the left side of the diagram) and water demand (the right side). Generally speaking, it is easier to address the supply side, which in many cases requires smaller behavioral and institutional changes, though it may not necessarily be better in environmental and economic aspects. Solutions are addressed along the value chain in the following section.

FIGURE 12

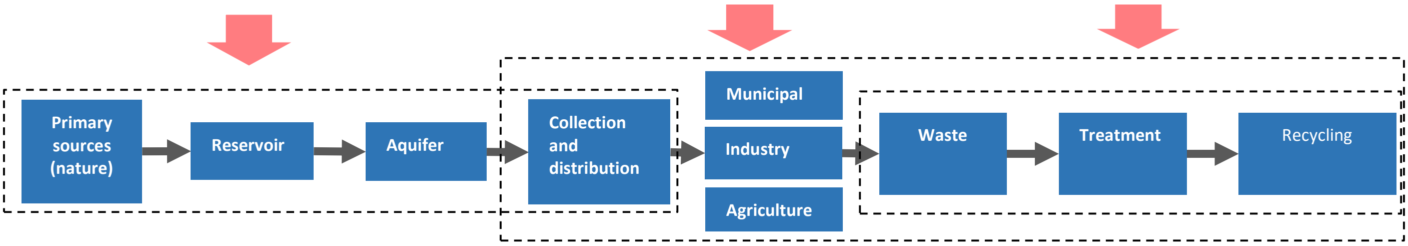
Selected Barriers by water cycle stage

Barriers

- Levels and intensity of rain and snow
- Flooding from storm run-off
- Combined storm and sanitary systems
- Long distance to sources
- Unaccounted cost of ecosystem services
- Evaporation
- Brackish water, seawater, sewage, and toxic waste contamination
- Private water rights
- Development encroachment

- Resistance to new technology adoption
- High maintenance costs
- Regulatory hurdles
- Ownership and governance complexity
- Financial risk
- Scaling limitations
- Environmental hurdles
- Private water rights
- Unconnected small farm holders and towns

- Public and market resistance
- High energy cost
- Technology, financial, regulatory, and political risks
- High capital costs
- Scaling limitations
- Limited returns on equity
- Ownership and governance limitations



Source: Milken Innovation Center.

1. ***Primary sources:*** As a result of precipitous climate change, the planet is experiencing increased temperatures and higher frequency of extreme weather events. These phenomena significantly affect the natural water supply. These changes, both short- and long term, propel public policy initiatives. In addition, the physical designs of water catchments and treatments in urban and rural areas can have dramatic conservation impacts; flawed and aging infrastructure, or a lack of any infrastructure at all, result in massive run-off and low residual (both sewage and brackish) water quality.

   Another barrier at this stage of the cycle is the undervaluation of ecosystem services and their resulting deterioration. This means that the natural terrains, streams, and flora, all of which provide nature's infrastructure for the provisioning of water sources, are not given a representative economic value. Lab participants pointed out that when these watersheds work, they are taken for granted. When they don't, it is time to assign an economic value and begin to pay for these services to ensure their sustainability and protection of this valuable natural capital infrastructure. With climate change and the extreme drought conditions in California, the potential to manage the water balance in forest ecosystems increases.[27]

   These hidden benefits from natural water sources result in the under valuation of water resources in the entire water value chain, and a "cost" of water far below its real economic value. Lab participants pointed out the variability of water prices by country and that the price is reflective of its value, not the cost. For example, the cost of water isn't necessarily where it is most expensive to deliver, but rather where it is valued most highly. Importantly, this results in the inability to monetize, leverage, and protect these natural capital resources which make human life possible.

2. ***Reservoirs and aquifers:*** The challenges in this phase of the water cycle range from high direct costs (construction and maintenance of reservoirs); protection from encroachment; overuse and contamination from surrounding growth and development; and water loss through evaporation. Another major challenge as well is the long-established assignment of private water rights, including senior rights that allow for the unlimited use (and depletion) of these assets.

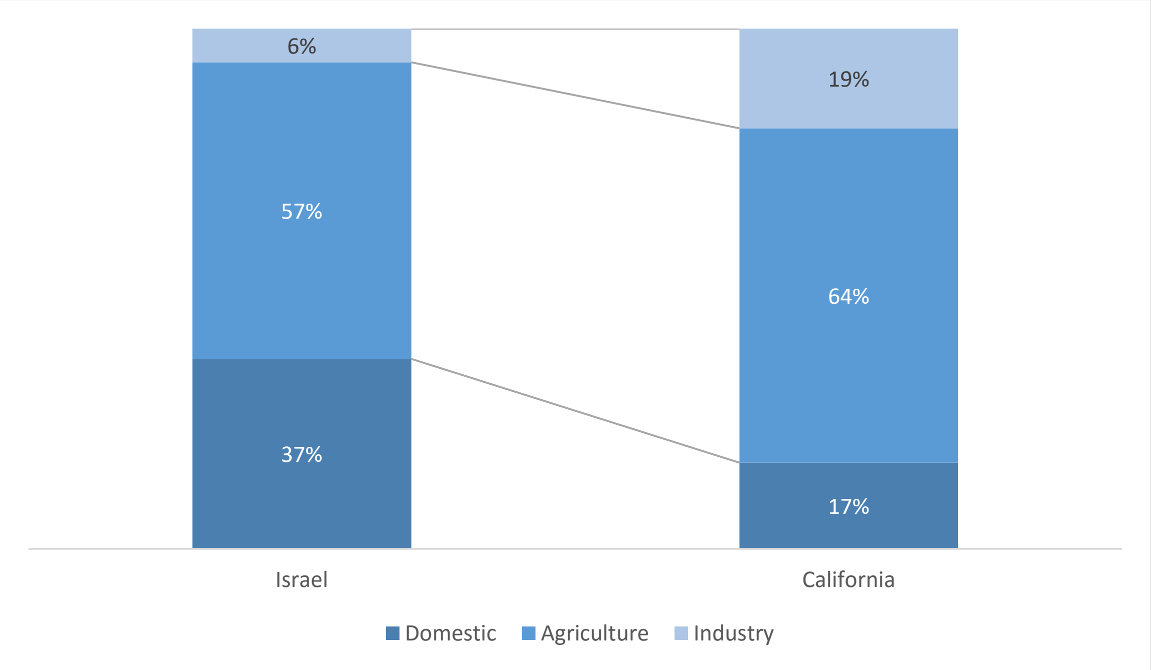
   In 1999 it was estimated that the average annual groundwater "over drafting" in California—the extraction of groundwater in excess of an aquifer's ability to replenish itself—was around 2,200,000 acre-feet (2.7 billion cubic meters), with 800,000 acre-feet (987 million cubic meters) in the Central Valley alone. Since then, unfortunately, "over drafting" had significantly increased. Satellite measurements have found that in just the combined Sacramento and San Joaquin River Basins, including the Central Valley, over drafting between 2011 and 2014 totaled 12,000,000 acre-feet (14.8 billion cubic meters) of water per year. Furthermore, the California Department of Water Resources estimates that water users are over drafting groundwater basins by 1 million to 2 million acre-feet (1.2 billion to 2.4 billion cubic meters) annually.[28]

3. ***Distribution:*** This stage of the cycle presents a variety of challenges, including the large capital and operating costs of major infrastructures, such as dams, pipes, and pumps; the large amount of energy used to pump and transport water; the costs to introduce new and expensive technologies, including regulatory compliance; financing limitations of the sponsoring governmental entities; and fragmentation and duplication among ownership, managers, and various levels of government sponsorship. In California there are more than 400 water districts managing 40,000,000 acre-feet (49.3 billion cubic meters) per year. The 60-year-old infrastructure system is challenging to monitor, manage, and maintain. In some locations there is a real risk of failure from major earthquakes or floods. Infrastructure deterioration contributes to losses of between 10 and 15 percent, through leaks in pipes and valves, and faulty metering. The costs of the infrastructure often exceed the financial depth and capacity of the user base. Finally, the water sector consumes over 20 percent of the state's electricity, resulting in increased carbon emissions and higher costs.

4. ***Users:*** Lab participants identified challenges among the three sectors served at in part by municipal systems: domestic, agriculture, and industry. Key among these challenges is the measurement, management, and performance of technologies designed to save water. Also, Lab participants also pointed out that many of these user systems, may lack scale sufficient to finance implementation. The lack of scale extends the payback period of technical solutions and lowers the returns for investors and customers. The Lab focused on creating scalable solutions in each of these sectors.

FIGURE 13

Water use by sector, Israel vs. California



Source: Israel Water Authority; Israel Central Bureau of Statistics; California Water Science Center, USGS.

5. ***Waste and treatment:*** The collection of wastewater from each sector poses challenges, including the cost of infrastructure, the introduction of new processes and technologies, and the costs of regulation and enforcement. These barriers are exacerbated by ambiguous ownership and responsibility for run-off and non-point sources (leaks or leaching from indefinite or many locations) of wastewater and contamination. Similarly, treatment is expensive: capital costs are high, operating revenues are limited by rate payers, and new technologies are difficult to regulate and implement in old infrastructures (legacy systems).

6. ***Recycling:*** Barriers to recycling wastewater include technical hurdles, regulatory questions, and limitations of the market. While Israel has demonstrated a very high rate of wastewater recycling for certain agriculture uses, Lab participants identified a generally high level of resistance to it in the California market. The main reason identified was the low price of fresh water, against which it is very difficult for treated wastewater to compete.

As shown in Figure 14, the Lab was able to identify possible solutions to a number of the barriers. The solutions are organized according to the same water cycle, showing how these solutions address various economic and financial obstacles. Each of these solutions are explained in the next section.

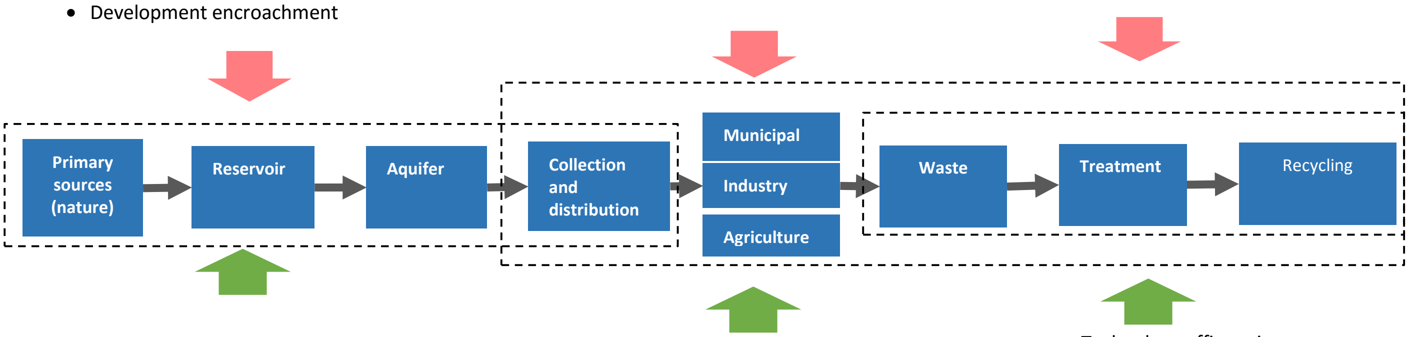
FIGURE 14 Selected Barriers and Solutions

Barriers

- Levels and intensity of rain and snow
- Flooding from storm run-off
- Combined storm and sanitary systems
- Long distance to sources
- Unaccounted cost of ecosystem services
- Evaporation
- Brackish water, seawater, sewage, and toxic waste contamination
- Private water rights
- Development encroachment

- Resistance to new technology
- High maintenance costs
- Regulatory hurdles
- Ownership and governance complexity
- Financial risk
- Scaling limitations
- Environmental hurdles
- Private water rights
- Unconnected small farms and towns

- Public and market resistance
- High energy cost
- Technological, financial, regulatory, and political risks
- High capital costs
- Scaling limitations
- Limited returns on equity
- Ownership and governance limitations



Solutions

- Watershed credits (to compensate for senior water rights)
- Targeted financing for separation of storm and sanitary sewers
- Valuation of water-based ecosystem services

- Regional and/or watershed authority for ownership, and governance
- User fees based on tiered pricing to incentivize water savings
- Public financing, including guarantees, reserve funds and loans
- Tax credits for investment in sustainable water technologies
- Desalination: seawater, brackish water, and sewage
- Front-of-the-line permitting
- R&D investments to encourage innovations with new techniques and technologies
- Performance-based financing for whole-system solutions
- Public-private Partnerships for financing, ownership, and operations

- Technology efficacy insurance
- Take or pay contracts for waste-to-energy production
- Public health monitoring and reporting
- Community and consumer education

SOLUTIONS

Lab participants discussed potential solutions to each noted barrier. The solutions included policy, regulatory, program, and financial recommendations. The highlights, summarized according to each link in the water value chain, follow:

1. ***Primary sources, reservoirs, and aquifers:*** Similar to the carbon cap-and-trade market in California, which permits the trading of carbon credits for money, a watershed credit could be created and traded within or among watersheds (those with surplus water and those with insufficient water). It would allow a water user with unused water rights to monetize their water conservation by selling those rights, effectively removing rights from the market or making those rights available where they are most needed. Investment in watershed services covers "incentive- or market-based mechanisms being used to protect the natural infrastructure of watersheds," according to the Ecosystem Marketplace an initiative of Forest Trends, a nonprofit that gathers information on environmental markets. It could include "payment for ecosystem services, payment for watershed services (PES), water-quality trading markets, and reciprocal or in-kind agreements."[29]

   This solution would assign a market value to the savings and allow traders to buy and sell those rights, reflecting a value of water and, more particularly, water savings in the market. It could also become a mechanism to solve the economic barriers that exclusive water rights create between users with those rights and users needing those rights. The undervaluation of ecosystem services provided by snowmelt, rivers, natural reservoirs, and aquifers is the outcome of a lack of information about these resources. Ecological economists have conducted extensive mapping and valuation, including of market value and externalities, allowing planners and governments to consider their use, protection, and development.

   Another potential solution is the expansion of existing infrastructure financing at the state level to repair and separate storm drains from sanitary sewers, particularly in the coastal urban areas. The separation and capture of storm run-off would allow for the proper retention and diversion to natural or man-made wetlands (such as those being developed in San Diego urban areas) and recharging the depleted aquifers throughout the Central and Imperial Valleys. At a large scale, however, this solution is very costly. Nevertheless, smaller scale and cost-effective storm water capture systems can be implemented.

2. ***Distribution, users, and waste:*** The fragmentation of ownership, management, and operations of water treatment and waste facilities into hundreds of municipal water districts could be mitigated by regional ownership/operations. Consolidation would allow for coordination and implementation of policy initiatives that encourage efficiencies in management, operations, and financing. This approach was implemented in Israel in 2007, as described by Uri Shani of Southern Arava R&D at the Lab. Shani was the first director of the Israel Water Authority when it brought more than 115 separate water authorities and municipal companies under one administrative umbrella.

Shani explained Israel's tiered pricing for household water usage: the structuring begins with a base rate for each household up to a certain amount. Over that, the price per cubic meter rises substantially.[30] For a period during the drought in 2008, the Water Authority imposed a 30 percent increase on the domestic water prices to further slow consumption. Marketing and public outreach featured prominently in the Water Authority's campaign. Lab participants were impressed with the multimedia marketing blitz, which included the "face" of the water shortage. [Fig. 15]

FIGURE 15 *"Israel Is Drying Up" ad campaign*

Source: Israel Water Authority (2008).

The campaign succeeded in a number of other ways. Leak detection and better management reduced losses of "non-revenue water"—water lost through leaks in pipes, valves, and other means—from 15 percent to 8 percent. The Authority's policies also led to increased use of recycled municipal wastewater for agriculture, from about 220 million cubic meters in 2008 to 400 million cubic meters in 2015, an 82 percent increase in only seven years.[31] These initiatives allowed the Authority to reduce the use of freshwater for agriculture while maintaining agriculture production on the same land area at the same level.[32]

Desalination plants are another major solution. Israel began development in this area in 2001, before the 2006–2008 drought, and today five desalination plants along the Mediterranean Sea yield over 600 million cubic meters of water per year.

With the high capital costs for water collection and waste infrastructure, financial solutions include public financing, tax-exempt financing to lower the interest cost,[33] guarantees to shift risk from the lenders, and tax credit financing to help raise equity investments in these projects.

For large infrastructure projects, to shorten the time required to move from idea, to plan, to approval to implementation, Lab participants considered a fast-track approval process for projects that are expected to meet sustainable water goals for the state.

Technologies for water collection, user distribution, and waste infrastructures are rapidly changing. Israel's NewTech program within the Ministry of Economy is the center for the clean-tech sectors, and works in four areas: (1) investment in future human capital through educational programs in elementary schools and university scholarships; (2) supporting R&D activities through grants for innovative water companies; (3) bridging the commercialization gap by the use of grants for first commercial installations in water utilities; and (4) penetrating international markets through better communication, marketing, and standardization processes.

Adoption, however, is time-consuming and expensive, especially for infrastructure projects with traditional organization and regulatory systems. Paradoxically, while many technologies may lead to the most substantial water savings and long-term economic savings, the technical risk is high.

In the Lab, Tim Strobel of OpTerra Energy Services described the use of energy services companies, or ESCOs, to attract capital investors, manage project and technology risks, deliver savings, and return capital to investors on a performance basis. This method of performance-based project financing transfers the risk from the water system and user base to private investors.

3. ***Treatment and recycling***: Israel has developed the capacity to completely recycle treated wastewater. At the Shafdan treatment facility, the largest owned and operated by Mekorot (Israel's National Water Company) 60 percent of the wastewater is recycled and deployed to agriculture and municipal gardens.[34] At the Lab, Diego Berger a hydrologist at Mekorot described the pretreatment, primary, secondary, and tertiary treatment technologies, allowing for the use of treated water in unrestricted irrigation for agriculture crops. He also described the deployment of innovations to use desalination techniques for treating wastewater to restore the water to drinking-level standards. This technology will supplement the soil-aquifer treatment system (SAT)—in effect, replenishing the aquifer with treated effluent that is then naturally filtered as groundwater—allowing a more efficient method to treat and recycle the expected increases in demand.[35]

BEST PRACTICES

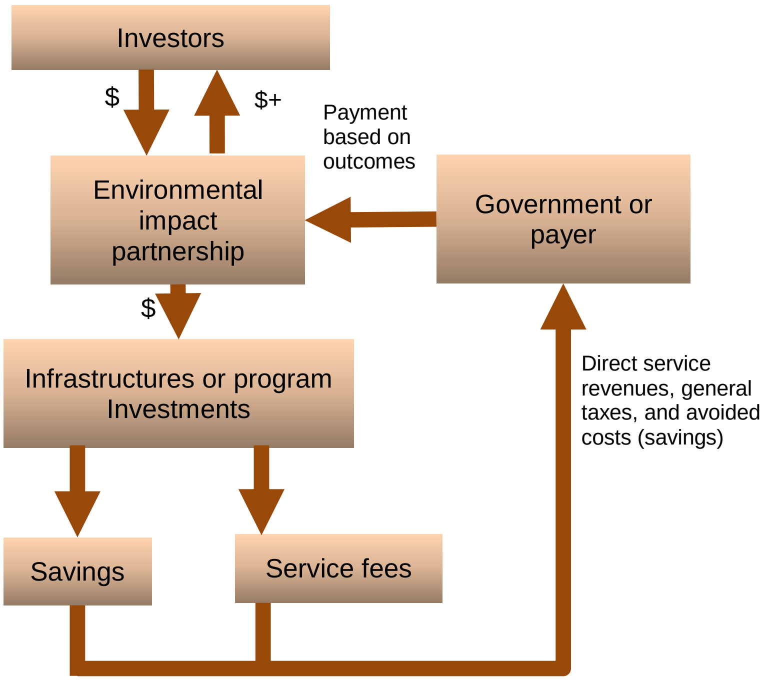
Lab participants offered several approaches and best practices, borrowed from the social and development finance, and energy infrastructure markets, which offer methods of introducing technology solutions into the water markets.

ENVIRONMENTAL IMPACT FINANCING (EIF)

Impact financing works by using "avoided costs," i.e., savings resulting from the success of the project, to attract private capital. By shifting the risk from government to private investors, and compensating the private investors for assuming the risk, government gains a successful project and the investors see a risk-adjusted return on their funds. This impact financing model has been applied to a number of health and social service areas, including youth at risk, diabetes prevention, and school retention programs, in the United States, the UK, and Israel. The model can be applied to environmental and water sectors as well, where reduced water usage results in savings. Figure 16 shows how an environmental impact bond could be structured.

FIGURE 16

Structure for environmental impact financing



Source: Milken Innovation Center.

In an environmental impact bond (EIB), institutional pension funds, insurance funds, philanthropies, and other traditional investors could invest funds in proven environmental "impact projects" that deliver reduced or avoided costs to farmers or to municipal water authorities. The realized savings would support the repayment of the obligation. The savings could be shared, thereby, reducing the overall cost to the payer.

ENERGY SERVICES COMPANIES

An energy services company (ESCO) is another financing option. Found mostly in the energy sector, ESCOs are performance-based contracting companies that perform multiple services for their clients, including helping them engineer the most efficient solutions and harvest the benefits from the improved performance through a special purpose company.[36]

In an ESCO applied to water solutions, according to Tim Strobel of OpTerra Energy Services,[37] investors would provide the capital for the ESCO to design and implement a water-saving solution in a municipal system or even a large institutional setting, such as a university or hospital complex. Due to the strong water-energy correlation, water savings also result in substantial energy savings. The ESCO would be paid based on a series of performance milestones and savings thresholds. The returns to the ESCO, and then the dividends paid to investors, would compensate for shouldering the risk. Stoebbel noted that solutions are rarely based on a single technology. Rather, the ESCO is adept at bundling or combining technologies. Such a "bundling" of proven Israeli technologies could be a key part of the path forward for California.

The Israeli government already supports joint ventures among Israeli companies through its foreign trade unit. This support should be extended or re-created in California for pilot projects.

TECHNOLOGY EFFICACY INSURANCE

The adoption of new technologies can be guaranteed through a system of insurance or limited guarantees. Efficacy insurance can reduce the cost and increase the availability of financing projects. Warranty insurance, for example, already covers certain performance-related risks and could be expanded to early commercial technologies. Precedents from satellite launches or joint public-private approaches used in terrorism risk or nuclear energy could be translated to applications in water technologies.[38] Large financial products companies, such as Euler Hermes in Germany, use technology efficacy insurance to promote technology solutions in target sectors. The insurance covers the adoption of technologies that may be new to the market, and may also cover a range in performance issues, including development, regulation, production, and delivery. Local and regional government bodies responsible for large infrastructure projects, such as water distribution, collection, and treatment systems, are risk averse, so having an insurance coverage or a guarantee is important.

WATER POLICY INNOVATION

During the Lab, current and former government officials, as well as a number of Israel companies, explained what contributes to the success of the country's water policy. The discussion focused on the following smart practices that differentiate the Israeli water sector from its counterparts elsewhere in the world.

- ***Public responsibility:*** Water is a public good. It has been legally owned by the public, as detailed in the Israel Water Law, since 1959 and in subsequent measures, to analyze, devise, and implement water management and use policies.[39] The public sector has the responsibility to ensure that the public and industry, have a safe and sustainable water supply. While the state has assumed responsibility for the organization, management, treatment, and delivery of water, every individual is also responsible. The ethos of saving water, the preciousness of water resources, and the personal responsibility of each citizen have been consistent themes in the history of the country.

- ***Graduated pricing/shock pricing to change behavior:*** Key factors that helped Israel celebrate "water independence" in 2013 were the pricing measures instituted in 2008. The "real" costs of water—including developing alternative supply sources and infrastructure required to produce and deliver clean water to consumers—shocked the public into making dramatic changes in consumption.

- ***Mobilization of the private sector:*** Israel has allowed the private sector to innovate through public-private partnerships. The government helps fund both basic and applied research, and supports financing for the introduction of new technologies across industries (e.g., cybersecurity for leak detection, information technology for smart metering). Both public and private investors recognize the importance of direct and indirect financial and public returns on investment.

- ***Operation of facilities as "laboratories" for managed innovation:*** Coming up with a solution is good. Continuous innovation that improves performance and outcomes is better. Through the combination of its entrepreneurial culture and existential demands, Israel has consistently rolled out innovations in key sectors, including defense, energy, agriculture, and water.

- ***Sound risk management:*** New installations present development, financial, political, and technological risks. Each risk category is addressed through appropriate mitigation measures, including regulatory reform, pricing, alignment of stakeholder interests, and performance guarantees by those with the most to gain (and lose). Israeli policy addresses each of these risks to the satisfaction of the government, industry and consumer stakeholders. For stakeholders, the ability to manage and mitigate risk is most important.

- ***IT integration:*** Israel has leveraged world-class achievements in information technologies into water infrastructure as an "Internet of Things."[40] Examples are found in the real-time data collection and transmission for leak detection, smart meter reading available to both the consumer and water company, precision irrigation management that can customize water delivery, and embedded security systems to protect municipal infrastructures against hacking. Many of these innovations came from the defense and communications industries, and have been adapted and implemented in scalable installations in Israel and elsewhere.

BUILDING A FRAMEWORK FOR CHANGE

With these smart best practices as background, Lab participants focused on approaches and a framework to crafting possible recommendations for model projects:

- ***Use capital structure to shift risk to private sector:*** Lab participants agreed that innovative technologies are key to saving water in California. Equally important is the innovative use of new capital structures to accelerate the adoption of new technologies. Two elements are crucial to this shift: attracting private investment (through tax credits, accessible and lower-cost credit, and limited guarantees) and incentivizing the private sector to perform well by paying for performance. A third element is recognition that a water system is a service, not a product, and that the providers of the water technology in that system should be viewed as performance-based service providers.

- ***Invest in continuous innovation:*** In Israel, companies like IDE Technologies (the world's leading desalination company) have built their business models around continuous "managed" innovation—constantly re-evaluating their engineering processes (through a "value engineering" methodology) for efficiency, effectiveness, and outcomes. They use their installations (or some portion of the installations) as test laboratories, assuming the risks and rewards from their performance. The downside from this approach has been rare but is also obvious, for example, interruptions of service, penalties, capital investment losses, write-offs, etc. The upside, however, shows in improved, immediate time-to-market installations, and marketable technologies worldwide.

- ***Design regulations to facilitate market-driven change:*** The regulatory system must facilitate innovation in both project and capital structure. It should allow for rapid permit processing, value-engineering, and outcomes-oriented contracting, and allow for collaboration between regulators and the industries they regulate. While not compromising on quality and continuity of services, regulation should ease bidding requirements when considering water-saving improvement on both new and legacy systems.

- ***Bundle solutions to create financeable scale:*** Capital improvements in municipal water systems are usually financed with low-cost, long-term debt. However, many of the technology investments necessary to save water are smaller capital investments, such as smart metering, leak detection, storm water capture, and water recycling. These separate bond issues may not be financially feasible. In order to achieve scale and full functionality of water technology improvements, local water authorities should consider bundling technologies that are often provided by separate vendors, and structuring a systems financing solution in which the relationships among multiple parts of the system reinforce the financial quality of the asset being financed. Smart metering, for example, could offer real-time information to consumers; automated leak detection, and preventive maintenance (based on demand levels); and wastewater recycling to estimate overall demand and use levels, and the need for replenishment in the system. In a systems financing scenario, these components contribute part of the solution and are used to calculate the water savings and performance payments to vendors.

- ***Leverage cross-sector linkages (energy, agriculture, and water):*** There are numerous ways to correlate water and energy savings in order to create new financial opportunities. These could include creating new assets in carbon-trading markets and monetizing the water/energy savings to support alternative energy production and energy-efficient technologies, such as desalination and wastewater recycling. This would reduce the energy costs of long-distance water conveyance, or deep drilling and pumping in California's aquifers. Lab participants also pointed out that the use of water and energy in California's immense agriculture industry puts the state in the position of exporting both, and thereby making water availability in California a national issue. Some of the largest savings in water will come from addressing technology investments in both the agriculture and energy sectors.

These lessons lay the groundwork for pilot projects that will demonstrate what is possible, how to do it, and what specific tools are needed.

FIGURE 17

Pilot project design framework

Source: Milken Innovation Center.

RECOMMENDATIONS

Based on the lessons identified in each of the best practices discussed in the Lab, we identified the following project models and program initiatives to illustrate how project and capital structures can be designed to achieve sustainable water extraction and delivery in California.

PILOT PROJECT MODELS

Each project proposal demonstrates the "who, what, where, why, and how" of implementation, and focuses on financing mechanisms. Each produces measurable outcomes, and uses these outcomes to incentivize collaboration from a group of necessary stakeholders. Cross-cutting technologies (in agriculture, municipal and rural systems, industrial sites) and emergent technologies with local "smart" water systems, can augment a centralized water infrastructure and produce cost savings. Desalination systems, for example, can treat not only seawater, but also agricultural drainage water, industrial water, brackish water, and secondary treated municipal wastewater.[41]

The pilot projects include:

1. **Water solutions for farmers**, to demonstrate a practical and financially feasible model to convert alfalfa, rice, and other commodity crops from flood irrigation to subsurface precision irrigation; and to demonstrate smart aquifer management, recycling, drought-resistant crops, smart watering, dairy waste-to-energy, and small-scale desalination to provide water to farmers.
2. **Water solutions for municipal systems**, to demonstrate a first commercial implementation of a bundle of multiple solutions in a single city or small region (water district).
3. **Water solutions for industry**, to demonstrate the bundling of multiple water technology solutions for independent industrial water services.
4. **Agriculture−water−energy demonstration projects**, to demonstrate the technology innovations in the connection between all three sectors that can be tested, developed, and brought to scale.
5. **Groundwater monitoring and cleanup**, to demonstrate the economic and environmental potential in monitoring groundwater contamination and cleansing.

Pilot Project (1) Water Solutions for Farmers

Performance-based financing focuses on innovative technologies in commodity farming. Commodity farms produce high-volume, usually undifferentiated products, such as alfalfa, soy, cotton, etc. These agricultural commodities are usually added to other products or provide feed for another product. Commodity crops account for 5 million of the approximately 8 million irrigated acres in California, and are singled out here because most use inefficient flood irrigation. Our "commodity" farm model focuses on converting flood irrigation to precision irrigation, using Israeli technologies.

Lab participants David Sunding of UC Berkeley's Water Center and Naty Barak of Netafim, among others, highlighted this segment of the market as an opportunity. In California, 64 percent of water usage is for agricultural purposes.[42] Of that, 15 percent is for alfalfa,[43] and 73 percent of the state's alfalfa fields are still irrigated using flood irrigation, which is 60 percent less efficient than drip irrigation.[44] For alfalfa farmers alone, there is a potential savings of 1.5 million acre-feet of water per year and 500M kwh/year of energy,[45] and therefore a large incentive for drip irrigation installation. A demonstration project could include smart aquifer management, recycling, drought-resistant crops, "smart watering," and small-scale desalination to provide water to farmers who are not connected to municipal water grids.

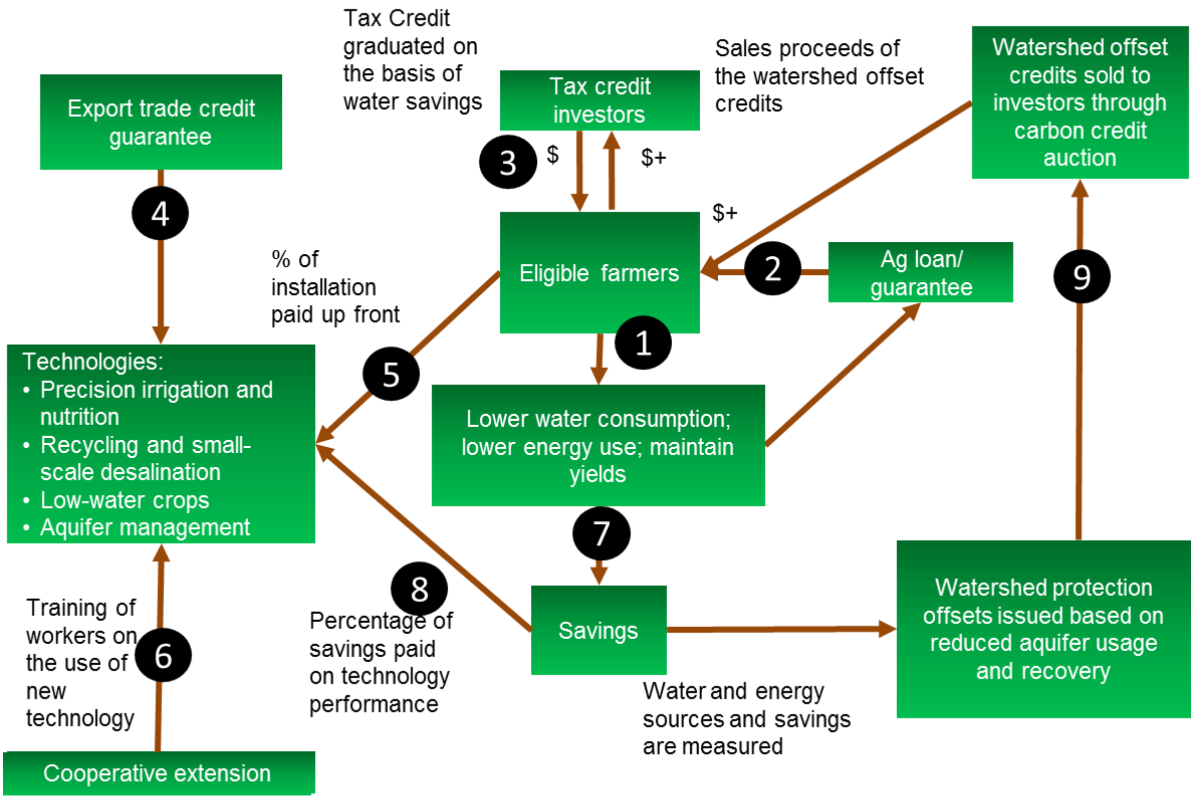
Overlapping with commodity farms are farms with senior water rights, i.e., the farmers have not had to buy water in the past, just drill for it. We call these farms "independent" because they're not usually buying water from the public tap or another regulated source. However, these farmers are finding it increasingly expensive to drill for water, and they have to purchase additional water at high prices and/or leave their fields fallow. Some are removing trees in order to save water. As a result, it would be beneficial to provide them with tools to use their water more efficiently (such as precision irrigation and wastewater recycling), to find new sources (small-scale desalination for brackish water), and repair some of the damage done by extensive over drafting of the aquifers (aquifer remediation and management). Lab participant Yoram Cohen of UCLA's Water Center, identified this segment as a significant part of the agriculture market and an opportunity to demonstrate significant benefit.

In this model, we consider the following.

- Farmers decide **(1)** that they want to save water, reduce energy use, and save money.
- Farmers secure affordable financing from the state loan funds **(2)** for agriculture producers. The local or state government may capitalize an agricultural revolving loan fund or a loan-loss reserve fund to provide lower-cost loans to small holder farms for eligible capital equipment purchase and installation.
- Farmers receive state tax credits **(3)** to use themselves or to sell to tax credit investors. Tax credit investors could provide some of the capital needed to install new technologies, e.g., drips in alfalfa fields.
- Farmers contract with equipment providers to meet the farmers water savings needs. The technology providers have arranged **(4)** a trade credit guarantee (where needed). A portion of the initial installation is paid by the farmer through the financing **(5).**
- The University of California's Cooperative Extension of its Division of Agricultural and Natural Resources could be deployed (6) to train farmers in the use of the new water technologies.
- Savings from the deployment of the equipment and technologies would be measured **(7).**
- Once the savings are realized, the farmer pays a portion of savings **(8)** to the equipment and technology suppliers to reimburse the remainder of the capital costs plus a cost of capital and risk premium.

- Savings would result in watershed savings credits issued **(9)** by a "watershed district bank" and given to farmers.[46] Farmers can sell watershed credits to investors or use "senior water rights" themselves.

FIGURE 18 ***Pilot Project 1: Capital and project structure (farms)***



Source: Milken Innovation Center.

Pilot Project (2) Water Solutions for Municipalities

This demonstration project targets a municipal water system that would use a performance-based contracting model.

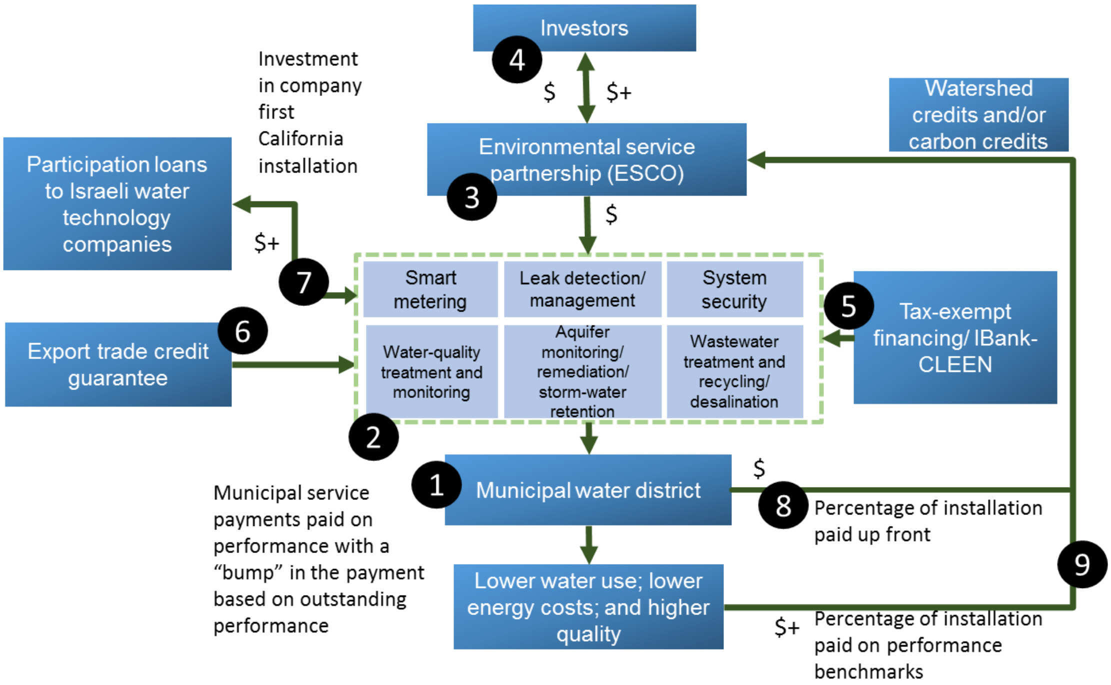
In this model:

- The municipal water district decides **(1)** what water savings technologies **(2)** it wants to use.
- The municipality contracts **(3)** with an environmental services company (structured as an ESCO) to bundle the technologies and solutions. The ESCO partnership would contract with an array of companies to provide a systems solution based on the needs of the water district.
- The ESCO raises investment capital **(4)** to provide the needed funds to organize and deploy the technology solutions for the municipal water authority.

- The municipal water district would secure financing **(5)** through existing (tax-exempt financing) or expanded programs (iBank's California Lending for Energy and Environmental Needs (CLEEN) targeted to water savings solutions.
- The Israeli export trade office would provide trade guarantees **(6)** to cover the credit on the Israeli companies' trade risks.
- The Israeli companies can apply for special export programs **(7)** offered by the Israeli export trade office. The Israeli Office of the Chief Scientist would provide R&D investment to test innovations implemented in live beta sites (such a program exists in Israel and is considered to be significant in the implementation of new water technologies in municipal water systems).
- The US water district would pay **(8)** a portion of the capital costs up front and a contingent portion of the capital costs based on the "solution set" meeting successful outcomes **(9)**. Additional service payments may be based on meeting savings outcomes, including a share of savings on high success thresholds being met.

FIGURE 19

Pilot Project 2: Capital and project structure (municipalities)



Source: Milken Innovation Center.

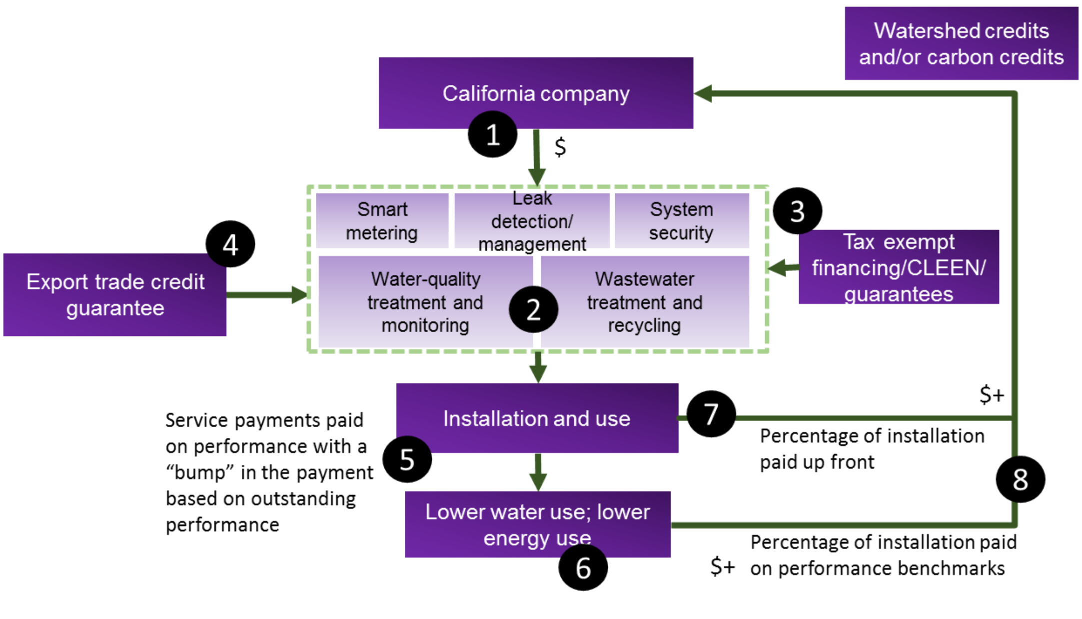
Pilot Project (3) Water Solutions for Industry

This pilot would use a demonstration site to offer proof of solutions for industrial companies, especially those with high water uses in production. Large industrial companies often build their own water production, treatment, and recycling operations to lower their water costs.

In this model, the industry pilot project would bundle services to create scale for suppliers and investors; incentivize vendors to perform well; and provide water savings technologies as a "service" supplier to company.

In this scenario, the demonstration company would contract with water services company that would bundle a group of technology solutions tailored to the needs of the company. For example, the bundle could include smart metering and leak detection to manage and control water usage within a production process, collection and treatment of water wastes, recycling of treated water within the industrial process, and reuse of the waste water for related or ancillary purposes, such as irrigation on company or nearby agricultural lands. An example of this company solution is the engineered solutions used by the Israeli company, Palgay Maim, in the many locations in Israel.

FIGURE 20 ***Pilot Project 3: Capital and project structure (industry)***



Source: Milken Innovation Center.

Pilot Project (4) Agriculture–Water–Energy Demonstration Projects

Decision makers throughout California and beyond would be able to visit the demonstration site to learn how to achieve energy and water savings, as well as higher outputs at lower costs, for agricultural production. This site or network of sites would also demonstrate the technical and financial sustainability of a range of new water technologies to support managed co-innovations and de-risk future investment in sustainable water. The State of California has a network of "Innovation Hub"s or "IHubs," managed by the

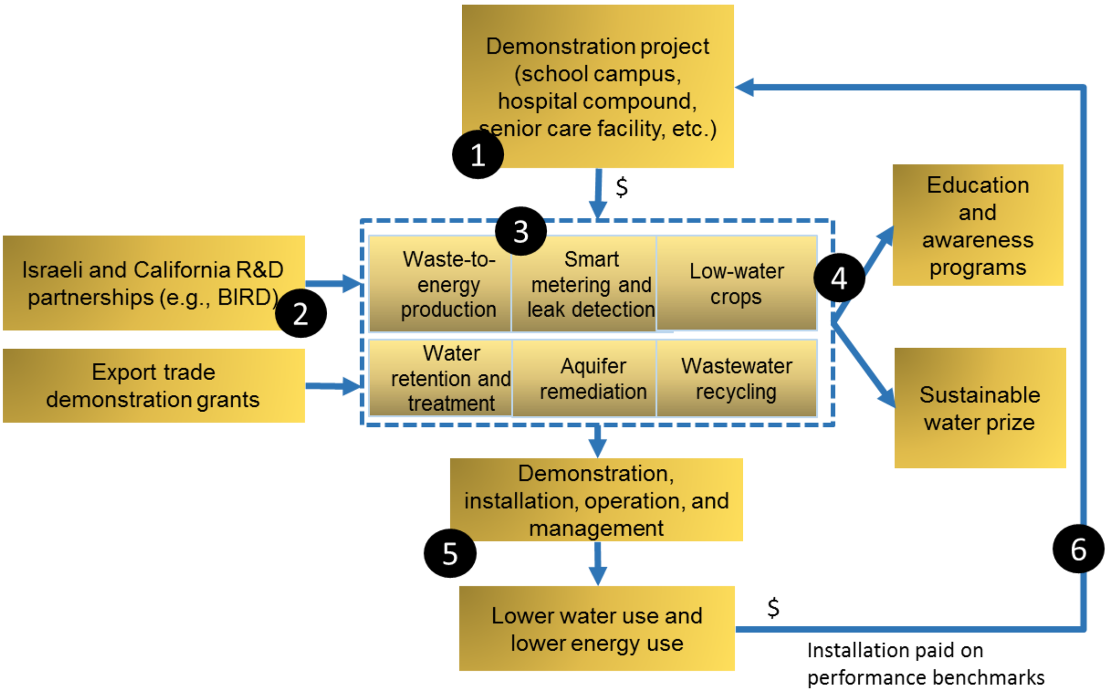
Governor's Office of Business and Economic Development, which are regional partnerships between industry, venture capital, and universities committed to creating, demonstrating and transferring innovative solutions in strategic areas, including water, energy, agriculture, and information technologies. California's IHub network is well positioned to implement water, energy, and agriculture solutions. Furthermore, the network was identified as a central asset the State of California would offer Israel as part of their industrial R&D agreement, at the MOU signing.

The R&D demonstration site(s) would include the following features.

- Active test site(s) would be chosen **(1)** in a partnership between California and Israel.
- The partnership would be supported **(2)** through export trade support, research and development collaborations, and industry support. The Israeli export trade office could provide a portion of the capital and operating costs to the Israeli company. The Israeli Office of the Chief Scientist could provide R&D investment to test innovations used at the demonstration sites.
- The active site(s) would use a series of proven technologies **(3)** to demonstrate how they work, collect and disseminate performance data, and how the technologies may be implemented.
- The initiative would become a virtual and actual clearinghouse platform **(4)** for education and awareness about the opportunities and outcomes.
- Israeli and California agriculture, water, and energy research centers (IHubs) would provide research partnerships and joint ventures **(5)** to support translational (applied) research and proof-of-concept demonstration sites (moving from testing to markets).
- A portion of the capital costs reimbursements **(6)** would be based on the "solution set" meeting successful outcomes (savings, clean standards, yields, energy consumption, etc.) in an actual setting. Service payments to support the clearinghouse would also be based on meeting savings outcomes, and could be funded through an allocation of a share of savings.

FIGURE 21

Pilot Project 4: Capital and project structure (Demonstration)



Source: Milken Innovation Center.

Pilot Project (5) Groundwater Monitoring and Cleanup

This pilot program addresses the monitoring of perchlorate pollution and implementation of environmentally friendly and cost-effective technologies to remediate soil and water contamination.

Perchlorate is a toxic soil contaminant from industrial uses that leaches into the aquifer. It is found in current and former industrial sites around many of California's urban areas, and has been shown to cause cancer and other grave ailments. The widespread presence of dangerous perchlorate levels in contaminated soil makes it a nonpoint source pollutant (meaning that the pollution is caused by run-off). Groundwater contamination poses severe health risks, and California has instituted more stringent cleanup requirements and standards.

In 2010 in Ramat HaSharon, a city in Israel's central coastal region, authorities discovered what would be cited as the worst case of perchlorate groundwater pollution in the country's history. Seepage from industrial rocket fuel waste into the aquifer had spread to more than 16 square kilometers, forced the closure of nearly a dozen wells, and threatened water sources in several cities. Cleanup was expected to last for up to a decade.[47] In 2012 the US company Envirogen Technologies, in a joint venture with Israel's Shikun & Binui Water Ltd., was selected to perform a pilot demonstration of a bioreactor technology for the remediation of the perchlorate-laden groundwater. “The pilot project,” according to a news release from the company, “would lead to the development of a full-scale treatment system that would be one of the largest perchlorate treatment installations in the world.”[48]

Groundwater cleanup projects in California need the following services:

- continuous monitoring.
- bio-cleanup of contaminated soil.
- bio-cleanup of contaminated water.
- identification of the potentially responsible parties (PRPs) to be cited for groundwater contamination.
- an environmental impact partnership (EIP) that provides some investment project management.
- installation of groundwater monitoring systems, and creation of a baseline for measurement.

Program Initiatives

Despite considerable effort by California in 2014 to allocate $7.12 billion to fund key water projects, a $2–3 billion annual funding gap remains for all areas of integrated water management, including storm-water capture; safe drinking water for small, disadvantaged communities; aquatic ecosystem management; and other capital needs in commercial, industrial, residential, and agricultural water projects.[49]

Operationalizing longer-term finance facilities (loans) through "green bonds," or "Green Climate Fund" bonds, as they are called in California, is a fast-growing financial instrument that earmarks private financing to fund environmental projects. These can help bridge this funding gap for a stable portfolio of environmental infrastructure projects. Other tools—such as investment tax incentives, machinery and equipment loans in agriculture, and monetizing avoided costs in municipal and industrial systems—will also accelerate the models that have emerged from post-Lab work groups. Finally, the research, development, and demonstration at the core of the water–energy–food technology nexus will also provide a next generation of co-innovation for projects in California, Israel, and other water-stressed regions of the world.

In follow-up discussions, Lab participants developed a set of program recommendations to support the pilot models described above. These are introduced here, including a brief description of the terms and conditions of such programs, which of course would be developed or amended based on existing programs. Selected program initiatives below are summarized in Appendix 2.

> **Roadmap**
>
> **Step 1: Project Structuring**
>
> 1. Identify measurable outcomes (savings, efficiency, quality, etc.).
> 2. Define scope of work (projects) to achieve outcomes.
> 3. Prepare request for information (engineering and project solutions to meet scope of work).
> 4. Source the technologies/providers.
> 5. Identify potential participants/partners.
>
> **Step 2: Capital Structuring**
>
> 1. Identify the capital budget.
> 2. Identify sources of equity and debt.
> 3. Define returns on investment and break-even milestones.
> 4. Identify the financial feasibility and/or gaps.
> 5. Determine feasibility capital structure, including credit and collateral support, cash flows, and leverage.
> 6. Evaluate returns and project financial feasibility.
> 7. Identify potential capital sources.
>
> **Step 3: Program Development**
>
> 1. Review existing programs and performance (program).
> 2. Match programs to financial gaps/needs.
> 3. Identify program changes/amendments needed.
> 4. Determine leverage, performance, feasibility, and sustainability.
> 5. Estimate program impacts, financial, industry, sustainability, etc.
> 6. Develop program proposals.
> 7. Secure funding and financing for programs.
>
> **Step 4: Implementation**
>
> 1. Define organization and roles.
> 2. Issue contract.
> 3. Engineering and design.
> 4. Regulatory reviews and approval.
> 5. Bidding and contracting.
> 6. Project financing.
> 7. Execute project plans.
> 8. Deliver outcomes.

1. Structure a state-level tax credit for investment in the sustainable water project for investors in agricultural products (or the farms themselves) to improve the returns on equity.
    a. Basis: The tax credit could be based on some portion of the capital investment (as documented by the technology provider), allocated on an annual basis over a relatively short period of time (say three years).
    b. Performance: The tax credit could also be graduated based on the performance (e.g., water savings) with the performance bump being given in the last year of the tax credit.

    c. Market: The market for the tax credit could be the farmers, banks/lenders to the agriculture producer, or other taxable entities with direct tax liabilities from the project investment or unrelated tax liabilities from other investments.
    d. Period: The tax credit could be carried forward but would not be refundable (payable if there is no tax liability).
2. Structure a watershed district credit for farmers to provide economic incentive for tangible (with outcomes) sustainable water practices.
    a. Basis: Given a reduction in water consumption, the agriculture producer would be granted watershed district credits, the amount based on a performance scale of actual reductions in water use.
    b. Valuation: The watershed district credits would be saleable to others trading in a state or regional watershed district credit bank or exchange. The "bank" would limit the amount of credits granted and ensure liquidity of the credits. The value would be based on market-priced sales of credits through the bank.
    c. Sales: The sale of the credits would be intended to compensate the agricultural producer for the water saved and/or for not selling the water rights to others.
    d. Market: The watershed district credits could be combined with carbon credits from the reduced energy use resulting from less water use.[50]
3. Create a state-level agriculture producer revolving loan fund for water-saving equipment and systems purchase and installation.[51]
    a. Term: Seven years or the depreciable life of the asset being financed, whichever is longer.
    b. Amount: Up to 80 percent of capital equipment and installation.
    c. Eligible activity: Water saving technologies, and those connected with alternative energy systems
    d. Eligible applicants: Agriculture producers (e.g., farmers); small holders not connected to a water system.
    e. Source: Initially capitalized through equity provided by government (possibly from the California State Water Resources Control Board) and thereafter by a revenue bond issue; secured by loan receivables. Bond issues would have a reserve fund to act as a first-loss protection to the bond holders.
4. Extend export trade credit guarantees to technology providers.[52]
    a. Term: Up to three years.
    b. Amount: 50 percent of the performance-based portion of the capital costs.
    c. Eligible activities: Technologies to reduce the use of water, lower energy costs, and increase water sustainability.
    d. Eligible applicants: Israeli technology firms with a contract to install technologies in farm production.
    e. Source: Government guarantee.
    f. Security: Company pledge and priority lien on performance payments.
5. Structure an environmental services partnership composed of technical, financial, organizational, and management expertise.
    a. Performance: The partnership would operate as a performance-based environmental services company, raising private debt and equity to pay for the capital expenses.
    b. Revenues: The revenues from service payments would pay for a portion of the capital and operating costs. Additional revenues would be paid on the basis of some portion of the savings from lower water uses, lower energy uses, and the sale of watershed credits.

    c. Market: The partnership would market a comprehensive set of solutions that could be engineered to meet the specific needs of a community, including a water district, municipality, or even a company.
    d. Bundled services: Based on the needs and the value engineering of applicable solutions, the environmental services partnership would assemble a team through a tender of some other form of competitive and fair contracting process, which conforms to applicable procurement rules and regulations.
6. Institute a water technology development program through the Israeli Office of the Chief Scientist to promote industry-based technology development (translation and beta only) for application in the California market.
    a. Convertible equity: Equity investments in companies participating in performance-based solutions.
    b. Amount: Up to 50 percent of the cost of new technology use, including materials, equipment, and working capital (operating expenses, labor, and fees).

7. Support an R&D partnerships program: This would involve sponsorships of specific applied research conducted between Israeli and California-based companies and/or researchers in conjunction with Israel's R&D Authority and California's IHub program. Similar programs already exist; one is governmental and supported by the Ministry of Economy through the government's research and development programs, known in Israel as Matimop; another is the Bilateral Israel Research and Development (BIRD) foundation, an R&D collaboration between Israel and the US involving business and university research projects.
8. Institute education and outreach (public campaigns): The program would provide an installation, demonstration, and dissemination of information about techniques and outcomes to assist with educating the public, businesses, and the importance of the on-going research.

    a. Water Co-Innovations Prize: Every two, years Israel and California, through the Israel R&D Authority and California's IHub program, would offer a cash prizes for outstanding demonstration and implementation of technology that move California and Israel toward a sustainable water solution. The prizes would be allocated to schools, universities, and companies.
    b. University of California's Cooperative Extension Program: Leveraging another existing asset in the State, UC's Cooperative Agricultural Extension would provide training and technical advice to farmers on the use of new Israeli developed and proven water-saving technologies.
9. Export trade demonstration installation: This program would involve grants to offset a portion of the capital and operating cost for an Israeli company to install its technology solution at the demonstration site.
    c. Amount: Up to 90 percent of the capital and operating cost (for a period of two years).
    d. Performance: Initial amount would be graduated, based on meeting performance objectives; ongoing operating support would also be graduated to performance (water savings, agriculture production, energy savings, etc.).
    e. Eligible participants: Israeli-based companies.

10. Develop convertible loans to property owners of contaminated sites, including groundwater problems, so they may utilize both cleanup and monitoring technologies. Based on successful remediation, the loans would be repaid based on the increased value of the property realized at sale or refinancing.

Program Costs and Potential Outcomes in California

Based on implementing selected financing programs to target farm and municipal projects in the state, we estimate the costs and potential financial and water saving benefits for farms and municipalities.

TABLE 1 ***Estimated Program Costs and Water Savings***

	Farms	Municipalities[53]	
		Scenario A	Scenario B
Share of market or target savings goal	10 percent	6 percent	25 percent
Water volume (gallons)	8.6 trillion	2.2 trillion	2.2 trillion
Total capital investment	$1.2 billion	$1.16 billion	$4.8 billion
Estimated savings (gallons)	455 billion	180 billion	750 billion
Savings, percentage human water consumption	3.4 percent	1.3 percent	5.6 percent
Water cost avoidance (annual)	$908 million	$552 million	$2.3 billion
Energy cost avoidance (annual)	$59 million		
Tax credit fiscal cost (annually)	$141 million	N/A	N/A
Loans (annual)	$59 million	$55 million	$240 million

Source: Milken Innovation Center.

Farm projects

If new technologies are implemented on 10 percent of the eligible farms in California, and those account for an estimated 8.6 trillion gallons of water use per year in agriculture, an annual savings of 455 billion gallons of water, or 3.4 percent of the state's human water consumption, is estimated. This will save approximately $908 million on water and $59 million in energy costs per year. To accomplish this, the Milken Innovation Center estimates an annual fiscal cost of $141 million in tax credits to farmers or their investors over a ten-year period and approximately $59 million annually in farm loans. Initial funding to capitalize the farm loan program will be less because funds will be recycled.

Municipal projects

If we use a bundle of new technologies with a goal of 6 percent increase[54] in water efficiency across municipal water districts, this will translate to annual savings of 180 billion gallons of water, which comes to 1.3 percent reduction in human water consumption in California. This will avoid spending approximately $552 million on water and associated energy costs annually. To accomplish this, the Milken Innovation Center estimates a capital cost of approximately $1.16 billion, of which approximately $55.3 million may be loaned through California's IBank programs.[55]

CONCLUSION

The shift to greater sustainability of water resources is urgent and imperative, impacting multiple stakeholders and necessitating game-changing policy and decisions. It also requires technological innovations, creative financial and economic resources, and new behaviors, all integrated and implemented together for a critical cause.

The Milken Innovation Center's Water Lab focused chiefly on financial mechanisms that would support the application of Israeli technologies in California. Specifically, desalination, water recycling, smart water systems to predict and detect waste, low-water crops and "fertigation" irrigation. All are part of the portfolio of solutions. By introducing new capital structures in systems financing and new water services models, the technologies that have taken root in Israel can meet California's water challenges.

APPENDICES

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Programs to Support California Water Pilot Projects

Based on a review of existing California programs, the Milken Innovation Center proposes content, regulatory, and statutory changes to enable the support of the project initiatives identified in this Lab Report. These program initiatives were drafted and developed in conjunction with the California Governor's Office of Policy Research staff and policy staff at the California Department of Food and Agriculture.

	Tax Credit	**Farm Loan Fund**	**Municipal Loans**	**R&D Partnerships**
Objective	Supplement the equity required for new water-saving technologies on California farms	Provide access to credit for farmers investing in water-saving technologies on California farms	Provide accessible financing for municipalities, nonprofits, schools, and hospitals to install water-saving technologies	Promote R&D initiatives in water-saving technologies, including a demonstration site and managed innovations in active installations
Eligible borrowers or beneficiaries	Farmers and/or farm investors	Farmers	Municipal water districts, municipalities, nonprofits, hospitals, schools, and/or private service companies working on their behalf	Joint ventures between California universities and water technology companies making investments in California farms, public water systems, and industry
Eligible Activities	Water recycling, monitoring, treatment, irrigation, aquifer restoration and management, farm waste treatment and reuse, alternative energy equipment used in conjunction with water conservation	Water recycling, monitoring, treatment, irrigation, aquifer restoration and management, farm waste treatment and reuse, alternative energy equipment used in conjunction with water conservation	Water recycling, storm water retention, smart metering, leak detection and management, aquifer remediation and maintenance, energy-efficient water purification systems, water-efficient cooling systems, other technologies that reduce the use of water. Credit enhancement	Water and related energy savings technologies to be used by farms, municipalities, nonprofits, or industry.

Amounts	4 percent of eligible capital costs and direct soft costs associated with the design, engineering, and permitting	Up to 80 percent of the total eligible project cost or $1 million per project, whichever is less.	Up to 50 percent of the eligible project cost, including design, engineering, contracting, financing, installation, construction, and inspection	50 percent of the capital investment in a demonstration site
Interest Rate	N/A	4 percent above prime rate for comparable maturities; fixed	Comparable rate municipal debt for comparable maturities; fixed	Assignable royalty or license agreements from the development of new technologies or new processes.
Term (Years)	Credit available in each of five years from credit award date. If there is no tax income in a certain year, credit may be carried forward for a maximum of five years. The cumulative credit may not exceed 20 percent of the total eligible capital cost.	Up to seven years or the average depreciable life of the assets being financed, whichever is less.	Up to fifteen years or the average depreciable life of the assets being financed, whichever is less.	R&D funding is to be provided for a period of three years.
Subordination	N/A	Senior or shared first lien	Senior or shared first lien	N/A
Security/Collateral	N/A	Collateral position on financed assets, corporate and personal guarantee pledge, unless waived.	Collateral position on financed assets; limited recourse to guarantees or letter of credit pledged.	N/A

Performance	Investment in demonstrated technologies that will reduce water consumption from the base year by 15 percent.	Participation with a performance-based technology provider, with incentives based on amount of water to be saved. Minimum target must be 20 percent as a result of the planned investment.	Participation with a performance-based technology provider, with incentives based on amount of water to be saved. Minimum target savings must be 15 percent as a result of the planned investment.	Demonstration project will identify, measure, and deliver water savings in the demonstration site.
Disbursement	Credit may be used by the farmer on the farmer's state corporation and/or income tax; or sold to investors.		Disbursement subject to commencement of the project.	Disbursements to be made on a pro-rated basis with other investors.
Refundable	No; tax authority will not refund the tax credit in the event of no taxable income	N/A	N/A	N/A
Claw back/Default	Tax credit must be paid back in the event that the water savings technology (scope of project plan) installation is not made per agreement.	Loan, including full interest due over the term of the loan, is due immediately if scope of work is not made per loan agreement.	N/A	Full repayment is due if the project is in default of its performance obligations.
Existing programs operating in California	California Competes Tax Credit	IBank (SBLGP) Farm Loans	IBank California Lending for Energy and Environmental Needs (CLEEN); Statewide Energy Efficiency Program (SWEEP) is yet to be launched.	Possible through the Water Energy Technology (WET) Program
Major change needed, if any	Modify outcome measures/criteria for awarding tax credit: Allowance for water-saving among farmers to replace job creation requirement	Activities: Water-savings technologies	Activities: Water and related energy savings technologies. Eligible borrowers: environmental services companies (ESCOs)	Activities: water and related energy savings technologies

Companies Who Took Part in the Lab

The Lab included demonstrations of exciting and existing technologies by Israeli companies. Many of whom were present for the Lab or hosted a field visit for Lab participants. These companies are listed with a short description of their product or service. All of these firms have US subsidiaries, affiliates, or can do business in the United States. In addition to the US market, most are already engaged in international markets, including Asia, Europe, and Africa.

Company	Description
Aquanos Energy Ltd.	Founded in 2013, Aquanos offers wastewater treatment at up to 90 percent energy savings with an added opportunity for resource harvesting. Its process utilizes the symbiotic relationship between algae and microorganisms in wastewater treatment. Algae produce oxygen through photosynthesis and use the nutrients present in the wastewater, while the bacteria utilize the oxygen to break down organic and nitrogenous compounds, and produce CO_2, which is then taken up by the algae as a carbon source.
Aqwise	Founded in 2008, Aqwise's family of solutions increases biochemical oxygen demand (BOD) and nutrient removal capacity in water and wastewater treatment plants, offering enhanced utilization of existing reactors and efficiencies in the implementation of new ones. From process design through project supervision to turn-key and financing solutions, Aqwise's solutions have been installed in over 300 municipal and industrial plants in more than 35 countries, serving a variety of industries, including food and beverage, pulp and paper, pharmaceuticals, oil and gas and more.
Arad Group	Arad Group is a leader in the field of water metering. The company designs, develops, manufactures, sells, and supports its cutting-edge water meters to residential, bulk, irrigation, and water-management companies. Millions of its water meters are installed worldwide; the company manufactures over 500,000 units a year, and is one of the leaders in the global water-measuring industry. Arad has an in-house molding and injection manufacturing plant and operates a sophisticated testing and quality control bench, which examines each water meter separately.
Atlantium	Established in 2003 to provide the world safe and sustainable water-treatment solutions, Atlantium has teams of scientists and engineers who design solutions based on UV (ultra violet) disinfection, fiber optics, and hydraulics. The firm takes water safety to levels never before achieved with other UV systems, or without chemicals, and provides industry and municipalities with a sustainable, measurable option. The company's customer service centers provide immediate, ongoing support. Atlantium's solutions are third-party validated to strict US FDA and EPA regulations.
AutoAgronom Israel Ltd.	The AutoAgronom is the first commercially available system that irrigates and fertilizes plants based on computerized hardware and software and optimizes the fertigation process. AutoAgronom's systems sample and monitor in real-time the chemical and physical changes in the upper levels of the root zone. Using various sensors, each system collects data from the soil; performs computerized analysis; and automatically activates irrigation and fertilization.

	Holds two registered patents for irrigation according to root needs and availability of dissolved oxygen to the roots.
Ayala	Ayala approaches simultaneous purification of soil, water, and air through development of natural biological systems (NBS) that are applicable to practically all pollutant sources (urban/ sanitary, agricultural, industrial, lake, and river rehabilitation, etc.) and in all environmental conditions. It relies on phyto-technology, and is based on the interactivity of plants with microorganism communities in the root zone. The technology helps degrade, accumulate, extract, and volatilize contaminants in water, soil, and the air, resulting in clean and purified outflow.
Ayyeka	Founded in 2011, Ayyeka simplifies and improves monitoring quality, saving time and money for water utilities, municipalities, and institutions. Starting from the smart sensors, across the transmission platform, through data management, the company has created kits to measure and monitor a range of water quality, water supply, wastewater, hydrologic, and agricultural parameters. Its remote monitoring systems allow for improved network visibility, reduced operating costs, enforcement of regulation compliance, faster leak detection, more exact billing and other advantages.
Emefcy	Founded in 2008, Emefcy offers advanced energy-efficient wastewater treatment technologies for municipal and industrial plants. The company's Electrogenic Bioreactor uses electricity-generating bacteria to treat wastewater, and produces green electricity as a byproduct. Thus organic contamination in water becomes a fuel source. Its Spiral Aerobic Biofilm Reactor is a self-respiring, prefabricated modular unit for biological wastewater treatment that reduces energy consumption as well as sludge production.
IDE Technologies	IDE specializes in the development, engineering, construction and operation of enhanced desalination facilities and industrial water treatment plants. The company provides small- and large-scale desalination solutions, and partners with a wide range of customers, including municipalities, oil and gas companies, mining, refineries, and power stations, on all aspects of water projects, and delivers some 3 million cubic meters a day of high-quality water worldwide. IDE's track record includes building 400 plants in 40 countries over the course of more than 4 decades.
MIYA	MIYA was established in 2008 with the vision of ensuring an abundance of freshwater through efficient management of Israel's existing freshwater resources. The company helps to improve the efficiency of urban water distribution systems by effective water loss management. Today, MIYA optimizes the water supply in urban water systems worldwide. It partners with utilities to design and implement comprehensive technology-based solutions. MIYA's solutions entail an audit of the city's water system, full project planning, on-site execution, maintenance, and training.
Netafim	Netafim's motto is "Grow more with less." A global leader in drip and micro-irrigation solutions for sustainable productivity, the company has 28 subsidiaries, 16 manufacturing plants, and over 4,000 employees worldwide, and works in 110 countries. Founded in 1965, Netafim pioneered the drip irrigation system revolution, creating a paradigm shift toward low-flow agricultural irrigation. Netafim delivers end-to-end engineering, project management, and financing services accompanied by agronomic, technical and operational training and support.

RealiteQ	RealiteQ offers complete IT "cloud" infrastructure that facilitates the remote monitoring, data acquisition, and control of water and energy systems at various locations, even worldwide. It allows for complex decision-making with regard to optimization of water supply, sewage, energy, smart grid, and other systems that require innovative technologies and software to aggregate, filter, and process high volumes of incoming data. RealiteQ provides an end-to-end solution, without the cost of purchasing and maintaining dedicated servers.
Smart Water Networks Forum (SWAN)	The Smart Water Networks Forum (SWAN) is a worldwide industry forum whose members promote the use of data technologies in water networks, making those networks smarter, more efficient, and more sustainable. A collection of data-driven components help to operate the data-less physical layer of pipes, pumps, reservoirs and valves, turning the discrete elements into a cohesive "overlay network."
TaKaDu	TaKaDu enables water utilities to manage their networks more efficiently and make smarter decisions by harnesses utility data and translating it into actionable insights. The TaKaDu solution offers a comprehensive decision-making platform that can be integrated across the utility, from the analyst monitoring the network to the executive team considering long-term strategic investment. TaKaDu's patented technology uses raw data from multiple sources, analyzing it to manage the full life-cycle of network events, such as leaks, bursts, faulty assets etc.
Palgey Maim	Palgey Maim is a full-service engineering, construction, and operations/maintenance company that provides turnkey wastewater collection, treatment, and recycling distribution systems for industry, municipal water systems, and agriculture. Palgey Maim integrates multiple technologies and financing methods into efficient and sustainable recycling systems, and offers planning and operation of wastewater and water systems, reclaiming effluents, sewage and sludge solution, manure treatment, supervision and managing of projects, among other areas.

ENDNOTES

[1] “Dwindling Water Supplies Make Every Drop Count,” Leahy, S., *Our World*, United Nations University, Nov. 9. 2013, citing “Global, regional, and country level need for data on wastewater generation, treatment, and use” in *Agricultural Water Management*, December 2013. Elsevier.

[2] “Quantifying renewable groundwater stress with GRACE,” Richey, A.S., B. F. Thomas, et al., Water Resources Research, 51:5229. Published online July 15, 2015.

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[5] “California has about one year of water stored. Will you ration now?” Jay Famiglietti, Op-Ed, LA Times, March 12, 2015. See http://www.latimes.com/nation/la-oe-famiglietti-drought-california-20150313-story.htm.

[6] “Aided by the Sea, Israel Overcomes an Old Foe: Drought,” New York Times, May 29, 2015. From the 1920s through the 1940s, Elwood Mead, Walter Lowdermilk, John Savage, James Hayes, and other prominent American water and agricultural engineers from the Tennessee Valley Authority, the Hoover Dam, and other major public works projects identified the water-land nexus central to economic development in British Mandate Palestine and later Israel.

[7] Ibid.

[8] “Israeli Water Technology Is a Blossoming Industry Helping to Solve the Global Water Crisis,” Jewish Business News, May 31, 2015.

[9] Howett, R., D. MacEwan, et al., “Economic Analysis of 2015 Drought in the Agricultural Sector,” University of California-Davis, Center for Watershed Sciences, August 17, 2015.

[10] “California and Israel Sign Pact to Strengthen Economic, Research Ties,” Office of the Governor. See: www.gov.ca.gov/news.php?id=18438.

[11] Fischer-Kowalski, M., Swilling M., et al., “Decoupling Natural Resource Use and Environmental Impacts from Economic Growth,” UN Environment Program. 2011. Also, Debaere, P. (2012),” The Global Economics of Water: Is Water a Source of Comparative Advantage?” CEPR Working Paper, No. 9030.

[12] With agriculture comprising about 2 percent of the GDP in both Israel and California, the differences in water uses in agriculture are largely based on the inefficient methods of irrigation in core agriculture sectors. In industry, however, the key differences include the substantial size and composition of industrial sector in California compared to Israel. Israel Central Bureau of Statistics, Water Authority, Report Table ST21-04, 2012. California Water Science Center, USGS, 2010. Data downloaded from http://ca.water.usgs.gov/water_use/ 2010-california-water-use.html.

[13] "Israeli Wastewater Policy Continues to Pay Off," Zafrir Rinat, Haaretz, March 23, 2015.

[14] Municipal Wastewater Recycling Survey, Water Recycling Funding Program, State Water Resources Control Board; See http://www.waterboards.ca.gov/water_issues/programs/grants_loans/ water_recycling/ munirec.shtml.

[15] Based on a survey released in 2012, California agriculture consumes an estimated 34 billion cubic meters of water, of which 302 million cubic meters are from treated waste water, according to the State Water Control Board. In Israel, agriculture consumes an estimated 1.9 billion cubic meters, of which an estimated 428 million cubic meters are from treated waste water, according to a 2012 survey by the Israel Nature and Parks Authority for the Israel Water Authority.

[16] In Israel, agricultural water consumption is an estimated 1,085 million cubic meters out of a total of 1,902 million cubic meters. In California, agricultural water consumption is estimated at 33.7 billion cubic meters out of a total estimate of 52.5 billion cubic meters per year.

[17] “Connection Between Energy and Water in Israel and the World,” ADAN Technical & Economic Services, Ltd, Ministry of Energy, Contract number 212-13.011, May, 2013 (Hebrew).

[18] Managing an Uncertain Future,” State of California, Department of Water Resources, October 2008, p 8.

[19] A team of JPL scientists studied the aquifer systems through the use of NASA's Gravity Recovery and Climate Experiment (GRACE) satellites; GRACE data reveal that since 2011, the Sacramento and San Joaquin River Basins decreased in volume by 4 trillion gallons of water each year (15 cubic kilometers). That's more water than California's 38 million residents use each year for domestic and municipal purposes. About two-thirds of the loss is due to depletion of groundwater beneath California's Central Valley. It will now take 11 trillion gallons of water to help the state recover from continuing drought; and the volume this water would occupy (roughly 42 cubic kilometers) is half again as large as the biggest water reservoir in the United States. See: http://science.slashdot.org/story/14/12/16/2358213/11-trillion-gallons-of-water-needed-to-end-california-drought.

[20] For more information on NASA's remote satellite sensing capabilities, see: J. S. Famiglietti, A. Cazenave et al., "Satellites Provide the Big Picture," Science, October 15, 2015:684−85. See also A. Richey et al., "Uncertainty in Global Groundwater Estimates in Total Groundwater Stress Framework," Water Resources Research, 51/7 (July 2015): 5198−5216.

[21] Maps from the US Drought Monitor for March of each year, 2011 and 2016. See http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?CA

[22] Famliglietti, J. S., M. Lo, et al., "Satellites Measure Rates of Groundwater Depletion in California's Central Valley," Geophysical Research Letters, 38/3 (February 2011). See also J. S. Famiglietti, "The Global Groundwater Crisis," Nature Climate Change, 4 (November 2014): 945−948.

[23] "Study: Third of Big Groundwater Basins in Distress," Jet Propulsion Laboratory, California Institute of Technology, June 16, 2015, see http://www.jpl.nasa.gov/news/news.php?feature=4626.

[24] California Public Utilities Commission website. See www.cpuc.ca.gov/water/.

[25] Association of California Water Agencies. See www.acwa.com/content/about-acwa.

[26] "The Organization of Water Utilities in California," Wes Strickland, PrivateWaterLaw blog. September 25, 2013.

[27] Kevin O'Hara, "Forest Management, Water Yields and Ecosystems Services," California Institute of Water Resources, University of California, Berkeley, 2015.

[28] "California's agricultural and urban sectors use about 42 million acre-feet of water per year, of which 1 million to 2 million acre-feet come from excess pumping of groundwater," according to the Public Policy Institute of California. See: www.ppic.org/main/publication_show.asp?i=1106.

[29] Bennett, G., N. Carroll, et al., "Charting New Waters: State of Watershed Payments 2012 Ecosystem Marketplace," 2012. See: www.forest-trends.org/documents/files/doc_3308.pdf.

[30] According to Lab participants, Proposition 218 in California restricts tiered pricing. See: www.forest-trends.org/documents/files/doc_3308.pdf.

[31] Recycled water is referred to as treated effluents and can be used safely in certain types of agriculture. These treated effluents have high levels of nitrates serving as a natural fertilizer particularly well suited for certain crops.

[32] These policies include government subsidies for treated wastewater reservoirs, and water allocation bonuses of 20 percent for farmers using recycled water, according to Israel Water Authority, 2015.

[33] Tax-exempt financing is available for qualifying infrastructures, either as public or private activity bonds. While the lower interest costs are important to projects, an equally and often more important benefit is the ability to attract bond buyers interested in this long-term stable asset class. Since the public objective of this initiative is to reduce water consumption, precautions should be taken to ensure that the subsidy is not transferred to the consumer through lower water costs.

[34] Mekorot treats 190 million cubic meters of wastewater per year, 35 percent of Israel's wastewater. Mekorot reuses about 60 percent of the treated effluents for agricultural purposes. The effluents meet all the required guidelines for unlimited irrigation of agricultural crops or any public area, without any sanitary restrictions. See: www.mekorot.co.il/Eng/Activities/Pages/Wastewater Treatment and Reclamation.aspx.

[35] The soil-aquifer treatment (SAT) method requires large infiltration fields and substantial capital investment. See: www.mekorot.co.il/Eng/newsite/Solutions/WastewaterReclamation /Pages/EffluentReclamation.aspx.

[36] Examples in energy services including Ennovate, Benham Companies, Chevron Energy Solutions (acquired by OpTerra), Clark Energy Group, Lockheed Martin Services, and Brewer Garret.

[37] OpTerra is a pioneer in advancing the sustainable energy economy, energizing opportunity, and building positive impact for the communities, institutions, and businesses. It uses energy as a foundation to build programs and partnerships that save money, generate revenue, improve assets, protect the environment, and accelerate consumers' success. As such it is a leader in energy efficiency, renewables, and infrastructure development. It acquired Chevron's renewable-energy subsidiary, Chevron Energy Solutions, in 2014.

[38] Jamison, E., and D. Schlossberg, "Insuring Innovation: Reducing the Cost of Performance Risk for Projects Employing Emerging Technology," October 2011. National Renewable Energy Laboratory, Office of Energy Efficiency and Renewable Energy, US Department of Energy.

[39] Becker, N. (Ed.), Water Policy in Israel: Context, Issues and Options. Springer Netherlands, 2013.

[40] The Internet of Things refers to the interconnectivity of objects through embedded Internet, Wi-Fi, RFID, or other system-based communication systems. This interconnectivity allows for real-time data gathering, analysis, and deployment.

[41] "Los Angeles County Community Water Systems, Atlas and Policy Guide," Luskin Center for Innovation, UCLA, January 2016. See: http://164.67.121.27/files/Downloads/luskincenter/water/Water_Atlas.pdf.

[42] "California Agricultural Statistics: 2011 Crop Year." California Field Office, National Agricultural Statistics Services, US Department of Agriculture. See: www.nass.usda.gov/Statistics_by_State/California/Publications/California_Ag_Statistics/Reports/2011cas-all.pdf.

[43] B. Hanson, "Irrigation of Agricultural Crops in California." University of California, Davis, and Department of Land, Air, and Water Resources. See: www.arb.ca.gov/fuels/lcfs/workgroups/lcfssustain/hanson.pdf.

[44] Netafim Subsurface Drip Irrigation Resource Center. See: www.netafimusa.com/subsurface.

[45] For purposes of understanding the magnitude of the gap and possible solution, our estimates assume savings for alfalfa to achieve 40 percent water reduction for the same yield with a 100 percent conversion for all alfalfa farms.

[46] Among the estimated 80,000 California farmers, even those with senior water rights, up to 75 percent of their water is coming from the Federal Bureau of Reclamation during this most recent drought. For this water, farmers are paying $1,000 to $1,800 per acre-foot, about 10 times what they normally pay. These costs are leaving farmers with limited margins or the choice of leaving their land fallow. See www.bloomberg.com /news/ articles/2014-07-24/california-water-prices-soar-for-farmers-as-drought-grows.

[47] "Bomb Plant Seepage Creating Israel's Worst-ever Water Pollution," Haaretz. Feb. 24, 2010. See: www.haaretz.com/bomb-plant-seepage-creating-israel-s-worst-ever-water-pollution-1.266190.

[48] "Envirogen Technologies/Shikun & Binui Joint Venture to Demonstrate Bioreactor Treatment of Perchlorate-Laden Groundwater for Israeli Community," Envirogen Technologies press release. Dec. 10, 2012.

[49] Hanak, E., B. Gray, et al., "Paying for Water in California," Public Policy Institute of California, March 2014. See: www.ppic.org/content/pubs/report/R_314EHR.pdf.

[50] The US Department of the Interior announced on December 15, 2015, the establishment of a Natural Resource Investment Center to use such market-based tools for public-private collaborations to increase investment in water conservation and critical water infrastructure.

[51] Existing California Infrastructure Bank, California Capital Access Program (State Treasurer's Office), and other undersubscribed loan facilities could be pooled for this program. Additionally, some of the elements of US Senator Dianne Feinstein's (D-CA) recently proposed (January 21, 2016) legislation builds upon these ideas to utilize state revolving funds for areas of inadequate water supply for storage provisions, desalination, water reuse and recycling, conservation, reclamation infrastructure finance and innovation.

[52] ASHRA, Israel's export trade financing authority, uses government guarantees on trade credit for transactions in developing markets. In January, 2016, ASHRA extended its trade credit guarantees to transactions by Israeli water technology companies in developing markets, including water technologies in California.

[53] The Milken Innovation Center modelled two scenarios for estimated municipality investments and water savings. Scenario A assumes a targeted reduction level for municipal water of 6 percent. Scenario B assumes the targeted water reduction level of 25 percent.

[54] The Milken innovation Center estimated another scenario based on the Governor's 25 percent goals for municipal water savings. If a bundle of new technologies is deployed with a goal of 25 percent reduction in the total urban water use in California, this would translate to a savings of 750 billion gallons of water, or 5.6 percent of the human water consumption in California. This will avoid estimated spending of approximately $2.3 billion on water and associated energy costs. To accomplish this, a capital investment of $4.8 billion is estimated, $240 million of which would be invested annually through California's financial programs for municipalities.

[55] The IBank California Lending for Energy and Environmental Needs (CLEEN) Program provides loans to municipalities for infrastructure. In order to use the IBank CLEEN program to invest in clean water technologies, the Milken Innovation Center recommend modest changes in the program regulations to permit investments in relevant technologies, including smart metering, recycling, leak detection and management. See http://www.ibank.ca.gov/ for more information about the current program.

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