

## **Saving Watts to Save Drops: Inclusion of Water Efficiency in Energy Efficiency Programs**

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## Executive Summary

Energy and water resources are interdependent. Energy production and consumption require water, and water transport and treatment need energy. The relationship between water and energy is referred to as the energy–water nexus. Researchers and practitioners are increasingly interested in better understanding this relationship in order to design integrated programs to manage energy and water in tandem.

The end-use phase of the water utilization cycle provides the greatest opportunity to save energy and water. Measures implemented at this stage can achieve savings both upstream and downstream. Energy efficiency measures like appliance upgrades, low-flow showerheads, and faucet aerators not only save energy but offer nonenergy savings—whether reported or not—including less water use. Utilities typically do not focus on the avoided costs and indirect energy savings from reduced water consumption. Doing so would help them reduce costs and maximize the benefits of energy–water efficiency measures.

### **RESEARCH AIMS AND METHODOLOGY**

The American Council for an Energy-Efficient Economy (ACEEE) and its partners have been working for several years to highlight the ability of energy efficiency programs to reduce energy and water consumption in tandem. In 2010, ACEEE and the Alliance for Water Efficiency convened stakeholders from the energy and water utility communities to discuss areas of mutual interest and develop a blueprint for joint efforts. This group made a range of research recommendations including studying the effects of end-use efficiency programs on embedded energy associated with water (AWE and ACEEE 2010, 2013). Over the past five years, researchers have profiled a number of energy–water programs, but to our knowledge, relatively little research exists on how energy utilities integrate and value water efficiency, especially in demand-side management programs.

Examining selected utility-sector energy efficiency portfolios and programs, this study provides an overview of practices for quantifying and reporting water savings from demand-side measures. We also summarize the regulatory guidance available to energy utilities in select states for incorporating water savings into cost-effectiveness screening for energy efficiency programs.

### **CRITERIA FOR PROGRAM SELECTION**

In selecting programs for review, we examined a diverse geographic scope and considered a variety of program criteria, but generally sought to highlight utilities making a proactive effort to track and report water savings associated with their energy efficiency programs. Specifically, we considered portfolios and programs demonstrating at least some of the following best practices.

*Robust tracking of water savings.* Examples include energy utilities that make available water savings data, on a gallons or kWh basis, within annual claimed savings reports. We also considered efforts to streamline water data collection through leveraging smart electric meter infrastructure.

*Goal-setting for energy–water savings.* We considered efforts to align water savings from energy efficiency programs with short- and/or long-term conservation targets.

*Incorporation of the avoided cost of water savings as a nonenergy benefit in cost-effectiveness screening.* By establishing and following procedures for calculating and considering avoided costs from reduced water use within cost-effectiveness screening practices, program administrators can demonstrate the benefits of water savings to help inform future resource-planning efforts.

*Inclusion of energy–water savings in long-term resource planning.* We looked at efforts by energy utilities to consider water savings in integrated resource management plans and energy efficiency potential studies. The latter inform program budgets and performance targets.

*Efforts to foster collaboration between energy and water utilities.* These include informal information sharing and development of formal partnering strategies through a memorandum of understanding, as well as co-marketing strategies, joint funding mechanisms, and collaborative studies, audits, and educational campaigns.

*Promoting innovative equipment and program designs.* These include programs that promote new devices or appliances, efforts to achieve deeper whole-building savings, smart technologies for jointly tracking water and energy savings, and innovative financial models that integrate multiple funding streams.

*Calculating life-cycle embedded energy savings.* To fully consider the total potential savings from water conservation, one must first understand not only direct energy savings from water-related appliances but also upstream and downstream savings associated with treatment and conveyance to customers. This criterion looks at state and utility programs that have undertaken efforts to quantify and consider embedded energy use in water in resource planning.

### **HIGHLIGHTED PROGRAMS**

We highlight an array of strategies by energy utilities to calculate and evaluate water savings achieved through energy efficiency measures. Among these is ongoing collaboration among investor-owned utilities in California to update the California Public Utility Commission’s (CPUC’s) Water-Energy Cost Effectiveness Calculator to quantify embedded energy savings from water-saving measures. This will enable both investor-owned utilities (IOUs) and non-IOUs to claim these benefits as part of cost-effectiveness screening. Outside California, only a few utilities are tracking these embedded energy savings. For example, Wisconsin’s Focus on Energy and the DC Sustainable Energy Utility are analyzing energy data associated with regional water and wastewater treatment and including these upstream and downstream energy savings in cost-benefit tests. In other cases, utilities may use a proxy value based on average water and sewage rates to estimate avoided water costs rather than undertake a full assessment of embedded energy.

The administration and design of programs achieving water savings vary depending on numerous factors, including environmental conditions, regulatory landscape, customer class served, and technology employed. We tried to capture these in our review. The most

common examples of energy utilities documenting demand-side water savings were direct-install programs measuring avoided costs resulting from water-saving devices like low-flow showerheads, aerators, and efficient washing machines and dishwashers. However other programs serving the industrial and agricultural sectors also save water. Examples include Energy Trust of Oregon's irrigation modernization initiative and Pacific Gas and Electric Company's (PG&E's) third-party implemented industrial programs. In addition, utilities continue to experiment with an array of technological and behavioral pilot programs to identify new cost-effective ways to save water and energy together. For example, California's Water-Energy Nexus proceeding (R.13-12-011) has been instrumental in organizing ongoing statewide pilots to integrate water and energy meter data and advanced meter infrastructure (AMI) networks. The correlative analyses will help inform future program design.

## **FINDINGS**

We found that the leadership of utility regulatory commissions helped the states and utilities that are making the most progress in tackling the energy-water nexus. These commissions have the power to set utility priorities, convene stakeholders in service of those goals, and standardize guidance according to utility and other stakeholder input. Western states and others with a history of drought or increasing competition for water resources were more likely than those in other regions to cite specific water conservation goals as a driver of energy utility efforts to claim water savings. Program administrators in other regions cited indirect driving forces such as the 2016 Future Energy Jobs Act (SB 2814) in Illinois. This law has utilities seeking ways to strengthen and expand existing efficiency programs and revisit methodologies for quantifying previously unclaimed savings such as those from water.

Many utilities, particularly in California, continue to make progress in operating joint energy-water programs that leverage the respective strengths of the energy and water utilities to help fill service gaps and strengthen offerings. By combining programs and defining roles and responsibilities through a memorandum of agreement, these utilities have reduced administrative costs and should serve as a model for other utilities looking to do the same.

However technical and regulatory barriers remain. Among the most notable of these is the frequent disjunction in policy levers between energy and water utilities. In addition to the divergent legislative and regulatory drivers they each face, energy and water utilities typically report to different levels of government. For example, most US energy providers are large, investor-owned utilities regulated by their state, while water providers tend to be smaller public systems with fewer resources at their disposal. Therefore partnering and coordination are a challenge.

As one might suspect, we found that the estimated value of water and the energy intensity associated with it vary greatly according to analytical scope, technical assumptions, and location-specific factors. When they existed at all, energy utilities used a variety of strategies to calculate avoided costs and embedded energy savings associated with reduced water use. These included calculations based on proxy values (water/sewer rates, for example) and more analytical efforts to capture a range of benefits (such as avoided water capacity and

environmental benefits) and attribute them to their responsible entities. (*Avoided water capacity* refers to avoided expenses associated with adding new water supplies and building and operating new water infrastructure.)

While several states and energy utilities are increasingly trying to calculate and incorporate these values in cost-effectiveness screening, successful implementation has been limited to a handful of examples, including Wisconsin, Los Angeles, and the District of Columbia.

We found that common residential and commercial direct-install measures, such as low-flow showerheads and faucets, account for the majority of utilities' claimed water savings because they are easy to measure. However, although they are less readily quantifiable, the greatest savings are being realized from large custom industrial programs, leak detection initiatives, and irrigation modernization programs. As more utilities think outside the box to implement projects aimed at understanding these less-explored dimensions of the energy-water nexus, policymakers and practitioners will apply promising new technologies and program designs to leverage water savings as a resource.

## Introduction

Energy and water resources are interdependent. Energy production and consumption require water, and water transport and treatment need energy. The relationship between water and energy is referred to as the energy–water nexus. Researchers are increasingly interested in better understanding this relationship, and practitioners are designing a growing number of integrated programs to manage energy and water in tandem.

Close examination of the energy supply chain and water-use cycle shows the interdependencies of water and energy. According to United States Geological Survey (USGS) estimates, 38% of total US freshwater withdrawals in 2010 were for thermoelectric power generation.<sup>1</sup> In the same year, the public supply of drinking water accounted for 14% of such withdrawals (Maupen et al. 2010). Much of that water supply has embedded energy.<sup>2</sup> The process of treating water to a safe standard and transporting it to customers is highly energy intensive.

Several studies have revealed the embedded energy associated with the stages of the water-utilization cycle. In a 2002 report, the Electric Power Research Institute (EPRI) estimated that transport and treatment of water and wastewater accounts for almost 4% of national electricity use (EPRI 2002). Researchers at the University of Texas at Austin estimated that energy associated with the public water supply was 4.7% of the nation’s annual primary energy and 6.1% of national electricity consumption in 2009 (Twomey and Webber 2011).<sup>3</sup> A separate study found that direct water-related energy in the US residential, commercial, industrial, and power sectors accounts for 12.6% of national consumption (Sanders and Webber 2012). Water-related energy use can vary depending on regional differences, including the type of water source (surface versus groundwater), the level of treatment required, and the distance to treatment facilities and end users. In a 2005 study, the California Energy Commission found that water-related energy uses 19% of the state’s electricity and 32% of its natural gas (Klein 2005).

The end-use phase of the water-utilization cycle provides the greatest opportunity to save energy and water. Measures implemented at this stage can achieve savings both upstream and downstream (Griffiths-Sattenspiel and Wilson 2009). A variety of appliances use water and energy (water heaters, dishwashers, clothes washers). Figure 1 illustrates several examples of these energy–water relationships.

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<sup>1</sup> According to the report, roughly 86% of 2010 thermoelectric power withdrawals were in eastern states. Thermoelectric power plants using once-through cooling systems accounted for 94% of thermoelectric power withdrawals, with recirculating cooling systems making up the remainder.

<sup>2</sup> *Embedded energy* refers to the energy used to source drinking water, transport it using pumps, and operate treatment plants for drinking water or wastewater.

<sup>3</sup> This study considered public water and wastewater pumping, treatment, and distribution, as well as commercial and residential water heating. It did not include energy associated with water from the agricultural, industrial, and self-supplied sectors.



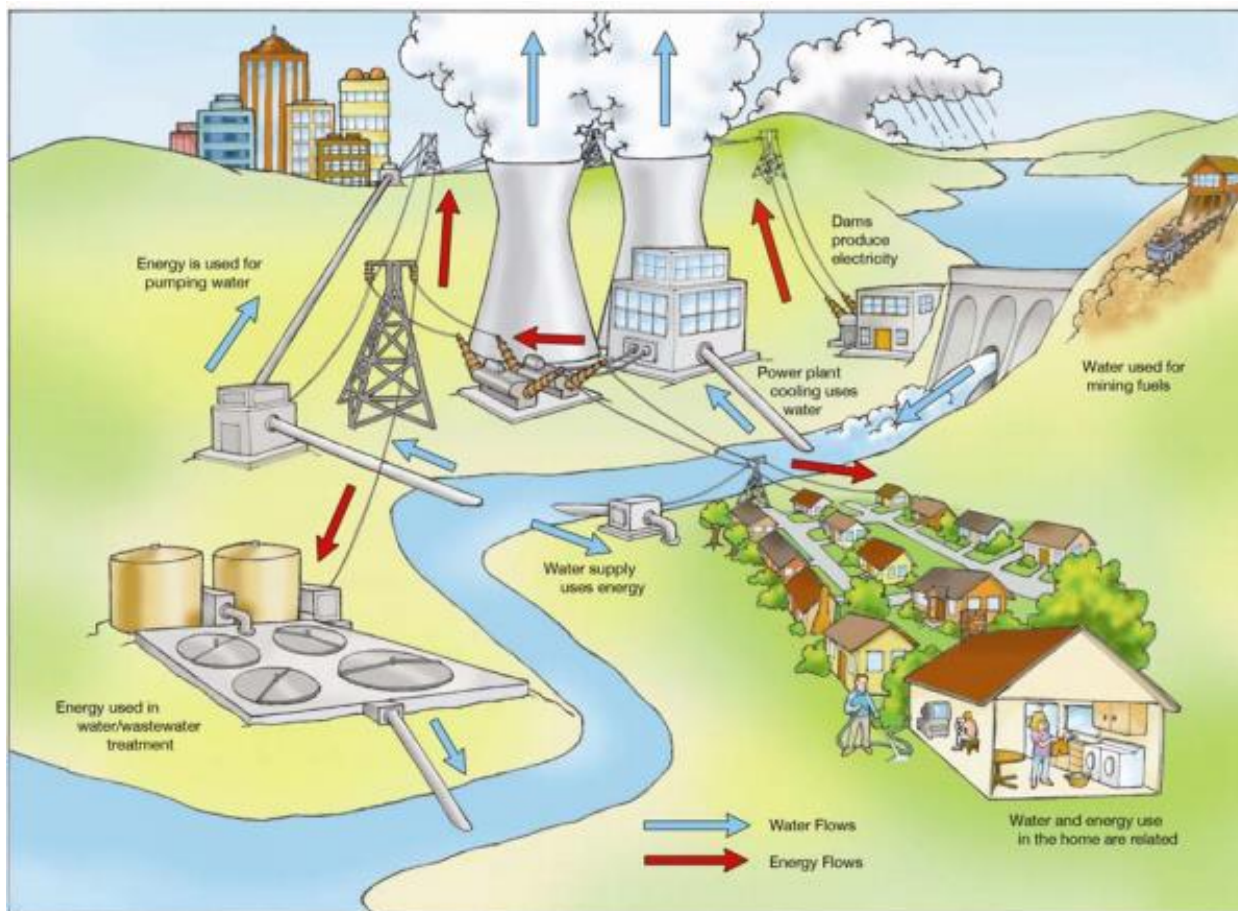


Figure 1. Relationships between energy and water use. *Source:* DOE 2006.

Because of the relationship between energy and water consumption, efforts to save one can save the other. Reducing water use lessens the need to treat that water, lowering overall energy demand. Using less hot water in homes, businesses, and industry also reduces on-site energy consumption. Saving energy on the demand side may reduce water requirements at thermal power plants; eliminating the necessity to produce some energy also removes the need to use water to generate it.

We begin with an overview of past research on energy–water program efforts, identifying common themes and best practices. We then review the energy–water nexus landscape and profile energy efficiency programs tracking avoided costs or indirect energy savings associated with water. Finally, we summarize key themes and findings, including state regulatory guidance and utility practices for calculating avoided water costs and embedded energy in cost-effectiveness screening.

### Past Energy–Water Program Efforts

Energy efficiency programs have been operating for more than 30 years. Similar efforts to conserve water have been occurring over approximately the past two decades. Historically, energy and water utilities have collaborated on efforts to save energy and water together

only in selected situations. Interest in energy–water programs has grown, however, as have efforts to document best-practice programs.

After their 2010 stakeholder convening, the American Council for an Energy-Efficient Economy (ACEEE) and the Alliance for Water Efficiency (AWE) attempted to identify leading efforts for joint energy and water savings in 2013. Stakeholders nominated programs that reduced consumption across several areas including agriculture, residential, commercial, industrial, energy supply and generation, water and wastewater treatment, and research and development. A variety of entities administered the programs, including energy utilities, water utilities, private companies, and local governments. An ACEEE report found a patchwork of strategies working to save both energy and water and concluded that the programs needed nurturing to grow and achieve higher savings (Young and Mackres 2013).

In the 2013 study, some efforts stood out as effective. The expert panel named five as exemplary and gave seven honorable mentions. Darden Restaurants, the Massachusetts Water Resources Authority, and United Technologies Corporation ran exemplary programs. A particularly interesting effort was a leak detection pilot by Southern California Edison (SCE). SCE assisted water utilities in water system audits; it provided direct water savings by reducing leaks, and embedded energy savings by reducing electricity requirements in water treatment and delivery. The City of Boulder, Colorado, entered into an energy savings performance contract (ESPC) that proved effective. The ESPC improved the energy and water efficiency of 20% of the city’s public buildings, resulting in over \$600,000 in utility bill savings each year. Young (2013) built on these findings to recommend specific areas where energy and water programs could work together. In a subsequent study, she examined data on the electricity reduction associated with saving a gallon of water (Young 2014).

Other researchers have identified promising energy–water programs. Cooley and Donnelly (2013) surveyed stakeholders to understand the barriers to collaboration between the energy and water sectors. The authors found examples of efforts that overcame these obstacles, but also noted that the number of programs was still limited. Another study found that similar barriers exist abroad, such as in the United Kingdom (Lawson et al. 2012).

## **Aims of This Study**

ACEEE and its partners have been working for several years to highlight the ability of energy efficiency programs to reduce energy and water consumption in tandem. In 2010, ACEEE and the Alliance for Water Efficiency convened stakeholders from the energy and water utility communities to discuss areas of mutual interest and develop a blueprint for joint efforts. Eight themes emerged, including the need to improve collaboration between the water and energy communities (ACEEE and AWE 2010).

Utility ratepayer-funded programs offer customers a variety of energy efficiency measures (e.g., appliance upgrades, direct install, and weatherization). They not only save energy but offer nonenergy savings – whether reported or not – through reduced water consumption and decreased transport and treatment requirements. For example, many residential efficiency programs offer customers low-flow showerheads and faucet aerators.

Over the past five years, researchers have profiled a number of energy–water programs, but to our knowledge, relatively little research exists on how energy utilities integrate water efficiency into their energy efficiency efforts. By looking at selected utility-sector programs, we attempt to understand how these efforts have progressed. Also unclear is how many energy utilities receive guidance from their regulators on quantifying the water savings from efficiency programs. We address this by summarizing the regulatory guidance available to energy utilities in some states for incorporating water savings into cost-effectiveness screening for efficiency programs.

Beyond providing an overview of the energy–water nexus program landscape, our goal is to highlight a selection of energy efficiency programs that follow best practices for conserving energy and water. While past research highlights some exceptional programs, few examples of recent best-practice programs have been documented. We try to identify programs that proactively target and capture water savings, managing them as an important element of resource planning rather than an incidental and unmeasured nonenergy benefit. We present examples of recent innovative programs and discuss factors leading to their success. Our research provides a snapshot of where energy utilities are in their efforts to integrate water concerns into their portfolios and provides best practices to help inform future efforts. These programs can serve as models for program administrators in the energy and water production and distribution sectors.

## **Methodology and Scope**

To review the current energy–water efficiency program landscape, we undertook a multipronged research effort, gathering recent data from a variety of utilities. This involved circulating an online survey, conducting interviews with leading practitioners in the field, reviewing evaluation reports of utility programs, and updating data collected as part of past ACEEE studies (Young 2013; Young and Mackres 2013). We did not get many responses to our online survey, so we relied mainly on stakeholders’ recommendations and reviews of technical reference manuals (TRMs) and annual efficiency reports to select programs to highlight.

Investor-owned utilities (IOUs), municipal utilities, and utility cooperatives offer a multitude of programs. Drawing on expert input and a survey of states with clear policies, guidance, and/or targets for achieving greater savings through the energy–water nexus, we narrowed our scope. We selected programs from diverse geographic settings and customer segments. We also sought to highlight innovative programs targeting hard-to-reach customers and market segments through unique program designs.

We focused our analysis on programs that endeavored to track and report annual water savings from energy efficiency programs (as gallons saved or as avoided cost of water). Ideally, they worked in coordination with water utilities and in pursuit of an established target. We identified programs that calculated embedded energy savings from reduced water usage (i.e., associated with collection, transport, treatment, and distribution of water and wastewater). These are particularly challenging to quantify. The water-use cycle has many elements, and their energy intensities can vary widely depending on geographic, jurisdictional, and technological factors.

For utilities in selected states where TRMs provide deemed water savings calculations, figures for gallons saved are usually reported for at least some measures in annual performance reports. Some utility efficiency programs track and report reductions in both energy and water use. For example, National Grid's annual *Energy Efficiency Plan* filed with the Massachusetts Department of Public Utilities reports both annual and lifetime water savings in gallons for measures implemented during the most recent program year. These figures are multiplied by the statewide average customer costs for water and sewer to provide avoided costs of water for each measure within the Total Resource Cost test (which is in the annual report). Planned savings for future years are also provided. Similarly, Efficiency Vermont's annual claimed savings summaries track reduced water use and its avoided annual and lifetime costs.

Water savings were not clearly documented in all selected cases. For example, although tracked for their efficiency programs, Focus on Energy in Wisconsin indicated that their annual evaluation reports do not specifically break out water-related energy savings. One reason is that the proportion of overall program energy savings is small.

### **Criteria for Assessing Water-Saving Energy Efficiency Programs**

After reviewing the available guidance for calculating water savings, we collected data on individual programs. We assessed the programs using seven criteria:

- Robust tracking of water savings
- Goal setting for energy–water savings
- Incorporation of the avoided cost of water savings as a nonenergy benefit within cost-effectiveness screening
- Inclusion of energy–water savings in long-term resource planning
- Fostering collaboration between energy and water utilities
- Promoting innovative equipment and program designs
- Calculating life-cycle embedded energy savings

*Robust tracking of water savings.* Insufficiency of data is a fundamental barrier to improving joint management of energy and water savings from efficiency programs (Cooley and Donnelly 2013). For this criterion, we consider whether the program tracks and reports annual water-use reductions according to established guidance and publishes this data regularly so it is available for relevant stakeholders. We give added consideration to advanced efforts to streamline data collection using smart meters that track both energy and water savings.

*Goal-setting for energy-related water savings.* A crucial determinant of the success of any resource management program is establishing clear goals and objectives. This criterion considers whether water-saving efforts and data tracking are aligned with short- and/or long-term targets associated with improving the utility's management of the energy–water nexus. Examples might include a per capita water consumption reduction goal or a percentage reduction target. These also include water utility conservation targets if water savings from energy efficiency are applicable toward these goals.

*Incorporation of the avoided cost of water savings as a nonenergy benefit within cost-effectiveness screening.* Avoided costs are the basis for decisions regarding investment in and incentives for energy efficiency programs. If the value of water savings are not considered in program design and decision making, one cannot expect to manage these benefits to meet societal and environmental goals. Program administrators who incorporate avoided costs from water savings into cost-effectiveness screening can make more informed decisions and avoid neglecting potentially cost-effective measures that they might otherwise overlook.

*Inclusion of energy–water savings in long-term resource planning.* We looked at efforts by energy utilities to consider water savings in integrated resource management plans and energy efficiency potential studies. The latter inform program budgets and performance targets.

*Fostering collaboration between energy and water utilities.* The water and energy sectors traditionally are governed and managed independently and deliver services to customers through separate and distinct utility business models. This makes sense given their differing natures and complexities (DOE 2014). However, as noted in previous ACEEE research, joint management of programs offers a variety of benefits, such as allowing program managers to learn from each other, lowering program costs, and achieving greater energy and water savings (Young 2013). A variety of institutional and technical challenges make collaboration between these sectors difficult. These challenges include availability of funding, inadequate guidance to inform allocation of costs and benefits, variability in data and pricing policies, and others (Cooley and Donnelly 2013). This evaluation criterion considers programs that have made significant efforts to overcome these barriers. We examine a broad range of conservation-related partnering efforts designed to foster collaboration between energy and water utilities. These include informal information sharing and development of formal partnering strategies through a memorandum of understanding, as well as co-marketing strategies, joint funding mechanisms, and collaborative studies, audits, and educational campaigns.

*Promoting innovative equipment and program designs.* Utilities have an important role in supporting the use of new high-efficiency equipment and technology to spur greater end-use efficiency and market penetration (Young 2013). This criterion considers programs making strides to leverage and encourage adoption of emerging technologies and approaches for achieving joint water and energy savings. These include programs that promote new devices or appliances, efforts to achieve deeper whole-building savings, smart technologies for jointly tracking water and energy savings, and innovative financial models that integrate multiple funding streams.

*Calculating life-cycle embedded energy savings.* To fully consider the potential savings from water conservation, one must understand the costs associated with collecting, treating, and delivering water for customers, as well as the costs associated with the ecosystem services that water provides. As ACEEE and others have noted, literature has provided a relative dearth of end-use information, empirical data, and examples regarding the energy embedded in water throughout the system (AWE and ACEEE 2013). This criterion looks at state and utility programs that have undertaken efforts to model and quantify the embedded energy use in water and energy production, as well as to pursue water savings as an energy efficiency resource.

## Highlighted Programs

We gathered information on a variety of utility energy efficiency offerings, analyzing portfolio-wide services, specific programs serving the commercial, industrial, and agricultural sectors, and joint programs co-administered by energy and water utilities. We also considered several pilots ongoing among California IOUs that aim to integrate collection of energy and water AMI to help inform future program design. Table 1 summarizes the portfolios we reviewed.

Table 1. Utility energy efficiency portfolios reviewed

Utility/third-party administrator	Description of water savings across portfolio	Tracks end-use water savings	Reports end-use water savings	Water savings included in cost-effectiveness test	Tracks embedded energy savings from water
Efficiency Vermont	Efficiency Vermont reports annual avoided costs of water savings associated with a number of its programs including Thermal Energy and Process Fuels Residential/Business Energy Services, Electric Business New Construction, Electric Business Existing Facilities, Electric Residential New Construction, Electric Existing Homes, and Electric Efficient Products. Roughly \$5.4 million in water savings was reported in 2015.	•	•	•	
Southwestern Electric Power Company (SWEPCO)	In response to new guidance provided in Protocol L2 of the Arkansas Technical Reference Manual, SWEPCO began calculating the value of avoided water and wastewater consumption due to measures installed under electric and gas utility efficiency programs. These include the Commercial and Industrial Energy Efficiency Program (CIEEP), Home Performance with ENERGY STAR (HPwES), and Residential Energy Improvement Program (REIP).	•	•	•	
National Grid (Massachusetts)	National Grid tracks gallons of water saved for its Residential Home Services and commercial and industrial retrofit programs. Cost-effectiveness testing includes avoided cost benefits, including monetized water savings.	•	•	•	
NV Energy	NV Energy demand-side management program offers a range of energy efficiency offerings to customers, including energy education programs, energy usage reports, home energy assessments, and miscellaneous prescriptive and custom rebates. While end-use water savings are not directly calculated or incorporated into cost-effectiveness screening, a 10% environmental adder is used in the Societal Cost test to approximate nonenergy benefits. The utility also tracks upstream water savings at the thermoelectric generator resulting from demand-side energy efficiency.				•

Utility/third-party administrator	Description of water savings across portfolio	Tracks end-use water savings	Reports end-use water savings	Water savings included in cost-effectiveness test	Tracks embedded energy savings from water
PG&E	PG&E offers a variety of measures to enable residential and commercial customers to reduce their water use. These include rebates and incentives for efficient clothes washers, low-flow showerheads, ice machines, combination steam cookers, etc. The utility started calculating embedded energy savings from reduced water use for certain measures in 2017. However formal incorporation of embedded energy savings from water is pending further refinement of the CPUC's water-energy calculator.	•	•		•
Focus on Energy (Wisconsin)	Starting in 2015, the state Public Service Commission authorized Focus to begin claiming credit for "indirect" upstream and downstream energy savings achieved by installing water-reducing measures. Any energy efficiency measures that also save water are eligible, though most savings are attributed to residential prescriptive measures with water heating (showerheads, aerators) and custom projects for industrial and commercial processes that can save water.	•		•	•

*Sources:* Efficiency Vermont 2016; SWEPCO 2017; National Grid 2017; K. McMaster, policy manager, NV Energy, pers. comm., December 6, 2017; C. Weiner, manager, PG&E, pers. comm., December 7, 2017; J. Fontaine, Focus on Energy performance manager, Public Service Commission of Wisconsin, pers. comm., November 8, 2017.

Table 2 summarizes the programs we reviewed.



Table 2. Utility energy efficiency programs reviewed

Utility	Sector	Program name	Program summary	Tracks water savings	Water or energy-water savings goal	Water savings included in cost-effectiveness test	Collaboration between energy and water utilities	Innovative equipment and program designs	Life-cycle embedded energy savings
Austin Energy	Joint water/energy utility program	Multifamily Energy and Water Efficiency Program	Provides multifamily building owners holistic water and energy efficiency evaluations, rebates, and other incentives to save water and energy.	•	•		•	•	
Los Angeles Dept. of Water & Power / Southern California Gas	Joint water/energy utility program	Master Inter-Utility Agreement/Joint Energy and Water Efficiency Programs	Sets forth the general terms and conditions under which programs for energy efficiency and resource savings can be developed and implemented jointly by the two utilities.	•	•	•	•	•	•
Southern California Edison	Behavioral pilot	10-10-10+ Multi-Family Pilot (aka "Communities for Conservation")	Drawing from behavioral economics literature, specifically studies showing that people are more likely to conserve electricity when compared to their neighbors, the program is designed to generate competition between multifamily complexes in different cities to achieve 10% savings in electricity, water, and gas separately. Results are expected in 2017.	•	•		•	•	

Utility	Sector	Program name	Program summary	Tracks water savings	Water or energy-water savings goal	Water savings included in cost-effectiveness test	Collaboration between energy and water utilities	Innovative equipment and program designs	Life-cycle embedded energy savings
Energy Trust of Oregon	Agricultural	Irrigation Modernization Program	The irrigation modernization initiative is a partnership between Energy Trust and the Farmers Conservation Alliance. The program saves water by helping irrigation districts replace open canals with pressurized pipe, which in turn can enable agricultural users to generate hydroelectricity, reduce water losses, and leave more water in-stream.	•				•	
PG&E	Commercial and industrial	Dairy and Winery Industry Efficiency Program	Provides a comprehensive approach to help dairy, winery, and brewery customers identify and evaluate energy saving opportunities and facilitate customer action.	•				•	•
PG&E	Commercial and industrial	Process Wastewater Treatment Energy Management (EM) for Agricultural Food Processing	Helps agriculture, food-processing, and beverage-processing facilities implement energy efficiency and water conservation projects to achieve wastewater treatment energy savings.	•				•	•

Sources: J. Gomez, program coordinator, Austin Energy, pers. comm., November 30, 2017; LADWP 2015; SCE and SoCalGas 2015; CESA 2016; CLEARresult 2017; PG&E 2017b.

The following sections describe several programs that are notable according to our review and application of the evaluation criteria.

### ***ADVANCED METER INFRASTRUCTURE PILOTS (PG&E, SCE, SOCALGAS, SDG&E)***

Spurred by the CPUC's ongoing energy-water nexus proceeding (R. 13-12-011), California's energy utilities have been at the leading edge of efforts to account for and capture embedded energy savings from water conservation. Among the most ambitious of these initiatives is a series of advanced meter infrastructure (AMI) pilots. Using varying designs, these programs run in partnership between the investor-owned energy utilities and local water utilities.

In November 2015, an Assigned Commissioner's Ruling (ACR) Regarding Advanced Meter Infrastructure Pilot Proposals Workshop directed California energy IOUs to identify technical issues with a water corporation piggybacking on an electric or gas corporation's AMI infrastructure. The long-term intent is to facilitate energy and water savings through emerging AMI technology. In follow-up filings under R. 13-12-011, energy utilities have been active in identifying challenges and potential technical barriers to system integration. These include system upgrades needed to facilitate two-way communication, integration of back office systems, and determination of data exchange protocols and data security standards. Table 3 summarizes the ongoing AMI pilot programs, their respective project partners, and program design elements.

PG&E has shown the most progress toward enabling its AMI network to accommodate data collection and validation for multiple water utilities. A 2014 PG&E pilot program, which involved 200 water meters, successfully addressed some of the major technical challenges involved with data separation, transformation, and transmittal (CPUC 2016). The ongoing pilot, initiated in 2016 and expected to wrap up in 2019, involves a partnership with the Center for Water Energy Efficiency (CWEE) at UC Davis and the East Bay Municipal Utility District (EBMUD). The program measures the potential for behavior-based water conservation to achieve substantial energy savings. Specifically, the project utilizes a randomized control trial between a treatment group (receiving AMI meters and regular notifications enabled by AMI-based data collection) and a control group (receiving no feedback on water consumption beyond standard bimonthly water bills) (PG&E 2016). By collecting detailed water, gas, and electricity consumption data through AMI meters, the team hopes to strengthen its ability to detect potential customer savings as well as supply-side savings through water loss reduction and pipeline leak detection. Treatment customers are invited to view their water use in an online AMI portal that provides information about hourly water use, leak notification, daily water budget thresholds, climate data, and conservation tips and services.

Other California IOUs offer similar AMI pilots on a smaller scale. Due to technical challenges, SCE's pilot found that piggybacking off their AMI infrastructure is not feasible. However, by leveraging Green Button technology and a common display developed by Triton (a third-party vendor), SCE has been able to work with the City of Beverly Hills to conduct a similar pilot to assess behavioral changes and reduced water use. SCE anticipates releasing results in late 2017 or early 2018. Depending on the outcome of the pilot, SCE may work to incorporate the strategy into an existing energy efficiency program (SCE 2016).

With support from third-party vendor Valor Water Analytics, Southern California Gas Company (SoCalGas) launched two water-energy nexus AMI pilots in 2016. One is with the San Gabriel Valley Water Company. The other is with California American Water. The 2016 deployment of 1,800 water meter transmission units, which enabled water data to be transferred over the SoCalGas Advanced Meter Network, made the pilot possible.

San Diego Gas and Electric (SDG&E) operates a similar pilot in partnership with Rainbow Municipal Water District (RMWD) in northern San Diego County and Itron Corporation. The purpose is to test how RMWD’s water metering and leak detection devices might leverage SDG&E’s Smart Meter Network to eliminate redundant networks and reduce the water district’s implementation costs. If successful, leveraging SDG&E’s network would enable RMWD to conduct correlative analyses to identify leaks and determine energy and water savings opportunities (SDG&E 2016).

**Table 3. Energy-water advanced meter infrastructure pilot programs in California**

	Pacific Gas & Electric	Southern California Edison	Southern California Gas	San Diego Gas & Electric
Partner orgs	East Bay Municipal Utility District, Center for Water Energy Efficiency at UC Davis	City of Beverly Hills, Triton	San Gabriel Valley Water Company (SGVWC), Valor Water Analytics	Rainbow Municipal Water District
Description	Builds upon PG&E efforts to piggyback water smart meter data on its gas AMI to assess the value of providing customers with near real-time water-use data and determine behavior- and technology-based impacts to water and energy usage.	SCE will leverage existing Green Button processes to provide customer electric usage data to a third-party provider and Beverly Hills to share water/energy data with customers in a common display through a mobile application.	Allow water utility meters to piggyback on SoCalGas AMI network paired with third-party analysis of gas and combined gas/water usage data to identify and evaluate potential hot-water leaks. A corresponding SGVWC pilot will conduct a cost-benefit analysis of water AMI.	The pilot will test the feasibility of piggybacking RMWD water meter data across the SDG&E Smart Meter Network to an Itron-hosted analytics system. The program will compare smart metering with manual-read metering.
Project goals	Determine how high-res water consumption data from AMI systems affects water consumption and potential corresponding energy savings in household gas and electricity use; analyze direct water savings as well as direct/embedded energy savings through use of the CPUC’s Water-Energy Calculator.	Assess potential customer behavioral changes from sharing near real-time electric and water usage data and account for embedded energy in water by utilizing measurement and valuation (M&V) savings calculations to estimate gallons of water savings.	Refine processes for identifying hot-water leaks. Valor Water Analytics will perform joint water-gas analytics for hot-water leak detection and quantifying water use, embedded energy, and greenhouse gas (GHG) benefits.	Evaluate the costs/benefits of deploying Smart Meter technology across the RMWD service territory. Explore scalability of new tech for providing secured multitenant network access on a two-way communication network infrastructure.

	Pacific Gas & Electric	Southern California Edison	Southern California Gas	San Diego Gas & Electric
Pilot project size	Up to 10,000 meters (5,000 installed smart meters, 5,000 control group participants)	500 participants (250 Beverly Hills AMI customers, 250 control group participants)	1,000 participants (500 water AMI customers, 500 control group participants)	300 RMWD customers
Project timeline	Aug 2016–Dec 2018	Sep 2016–Sep 2018	Sep 2016–March 2018	Sep 2016–March 2018

Sources: PG&E 2016; SCE 2016; SoCalGas 2016; SDG&E 2016.

### **ENERGY TRUST OF OREGON**

A review of annual program data from Energy Trust of Oregon and discussions with program staff showed careful documentation of 1.66 billion gallons of water saved from Energy Trust programs in 2016. Custom irrigation measures accounted for the majority of the savings – approximately 1.4 billion gallons. The remaining 263 million gallons were the result of single-family and multifamily measures (e.g., low-flow showerheads, efficient clothes washers) and, to a lesser extent, similar measures in the lodging and food service sector.

Energy Trust describes its calculation of benefits from water savings measures as a rough and conservative estimate, though one that has improved over time. Energy Trust generally relies on the Regional Technical Forum (RTF) savings estimates and protocols for guidance in tracking water savings. As in many states, water savings – and in turn nonenergy benefits – are calculated by factoring in the difference in flow rate between the current baseline and the installed low-flow product. Staff may adjust RTF-provided protocols in certain cases, substituting local volumetric water rates where appropriate.

The largest reductions in water use are provided through Energy Trust’s irrigation modernization initiative and agricultural production efficiency program. Water saved from these measures however is treated differently from water saved from direct-install measures for residential and commercial buildings (such as showerheads and faucet aerators). Staff are careful to avoid the term *water savings* when referring to agriculture efficiency programs due to lack of guidance on counterfactual water use assumptions in an agricultural setting (i.e., how the water would have been consumed or how it would have flowed back to the environment in the absence of an installed measure). In these cases, staff prefers the term *avoided water use*.

The irrigation modernization initiative reduces water use by helping irrigation districts replace open canals with pressurized pipe. This can enable agricultural users to generate hydroelectricity, reduce water losses, and leave more water in-stream. The initiative is funded and managed through a unique partnership between Energy Trust and the not-for-profit Farmers Conservation Alliance (FCA). Replacing open canals with pipes not only conserves water regularly lost to seepage and evaporation, but also harnesses gravity to pressurize the pipe. This reduces the need for water pumps and enables generation of hydroelectric power.

Having worked together with several Oregon irrigation districts, Energy Trust and FCA have become partners in applying modernization strategies to hydropower projects. In collaboration with Energy Trust, FCA now leads the development of these strategies for individual irrigation districts, leveraging a large coalition of public- and private-sector partners. In addition to Energy Trust, funders include the US Bureau of Reclamation, the Oregon Water Resources Department, the USDA's Natural Resources Conservation Service, the Freshwater Trust, the Nez Perce Tribe, and others (Clean Energy States Alliance 2016).

### **FOCUS ON ENERGY**

Wisconsin's Focus on Energy program has been particularly active in efforts to account for the avoided cost of energy achieved through water savings. Prompted by growing national interest in the energy-water nexus, Focus on Energy staff began considering how to address embedded energy savings from water in 2014, during the early stages of the 2015–2018 Quadrennial Planning cycle. Starting in 2015, the Public Service Commission (PSC) of Wisconsin authorized Focus on Energy to begin claiming credit for indirect energy savings achieved by installing water-reducing measures. These are defined as the savings achieved by decreasing the amount of water pumped to customers on the front end and treated by wastewater utilities after use.

Statute explicitly establishes Focus as an energy-specific program funded by energy utility customers. Therefore the goal of the PSC guidance was to refine the program in a way that addressed the energy-water nexus without allowing its scope to broaden to water conservation. That could not be legally supported given Focus' statutory mission.

The commission's jurisdictional authority over both water and energy utilities aided efforts to develop the guidance. The fact that since 2012 Wisconsin public water supply utilities have reported their energy use to the commission as part of their annual reports was also helpful. Drawing from these data, as well as energy use sampled from wastewater utilities as part of a 2006 report by Focus on Energy (*Water and Wastewater Energy Best Practice Guidebook*), program staff were able to calculate recommended water-related energy savings. Calculations were based on simple ratios of energy use per gallon of water processed for both water supply utilities and wastewater treatment facilities. Recommended ratios varied according to water source (surface water or groundwater) and size and type of wastewater system (large activated sludge systems or smaller systems using aeration lagoons or oxidation ditches).

Any energy efficiency measure that saves water is eligible to use the calculation. In practice, most documented energy-water savings are achieved by residential prescriptive measures with water-heating-related savings (e.g., showerheads and aerators) and from custom business projects for industrial and commercial processes.

### **SWEPCO, OG&E**

Beginning with Version 6.0 of its Technical Reference Manual for program year 2016, the Arkansas Public Service Commission provides guidance, known as Protocol L2, to utilities for calculating the value of avoided water and wastewater consumption from electric and gas utility efficiency programs. This is the only TRM we reviewed that provided explicit guidance regarding recommended marginal retail water rates and average water sewage

rates (both on a per-gallon basis) for calculating water savings. Table 4 lists the TRM’s average proxy values based on research by the independent evaluator. Separate values based on customer class and usage volume price tiers are also given. Program administrators may use alternative water costs if they are more appropriate for the electric and gas service territory and are transparent in PSC filings.

**Table 4. Avoided water costs in Arkansas as listed in Protocol L2 of the Arkansas TRM (per 1,000 gallons)**

Customer class	Water rates		Sewage rates		Total combined water rates	
	First 1,000 gallons	Additional gallons	First 1,000 gallons	Additional gallons	First 1,000 gallons	Additional gallons
Residential	\$4.13	\$2.86	\$3.82	\$2.72	\$7.95	\$5.58
Commercial	\$2.93	\$2.79	\$4.29	\$4.29	\$7.22	\$7.08
Average cost \$/gallon	\$3.53	\$2.83	\$4.06	\$3.50	\$7.59	\$6.33

*Source:* Arkansas TRM Version 6.0 (based on primary research conducted by the IEM of six Arkansas water districts)

Use of this methodology is still in its infancy among Arkansas electric utilities. Our review of annual demand-side management (DSM) reports indicated that Southwest Electric Power Company (SWEPCO) and Oklahoma Gas and Electric (OG&E) have been the most successful in applying it toward valuation of their program portfolios. In 2016, SWEPCO calculated avoided water costs for simple measures including residential and commercial faucet aerators and low-flow showerheads. OG&E has similarly applied the methodology to its Multifamily Direct Install program, SEE LivingWise, its weatherization program, and its commercial and industrial standard offer.

### **PG&E**

Like other IOUs in California, PG&E has been active in the CPUC’s Water–Energy Nexus proceeding (R.13-12-011) to incentivize efforts to reduce water consumption by better understanding and quantifying the energy–water relationship. PG&E offers customers a variety of measures to reduce their water use (e.g., rebates and incentives for efficient clothes washers, low-flow showerheads, ice machines, combination steam cookers, and pre-rinse spray valves). The utility also offers incentives to agricultural customers for converting sprinkler systems to water-efficient drip irrigation and for transitioning to efficient pumping systems.

PG&E’s efforts to account for water savings from energy efficiency measures began during 2013–2014 as part of a statewide effort to address drought conditions and demonstrate the relationship between water conservation and energy efficiency. In discussions, PG&E staff acknowledged that these initial efforts were often rough estimations. Efforts to proactively track water savings did not begin in earnest until 2016. PG&E now uses deemed savings values from California’s Database for Energy Efficiency Resources (DEER) to track data on gallons of water for a variety of prescriptive measures. The utility also provides guidance

and direction to custom project developers to encourage more robust calculations of water savings on a gallons-saved basis early in the design stages.<sup>4</sup>

As of 2017, PG&E has updated its internal reporting protocol and information technology (IT) system to derive embedded energy savings associated with sourcing, treatment, and transport of water using the CPUC's Water Energy Calculator. However the CPUC and utilities are still trying to resolve technical questions related to formally incorporating the calculator into program cost-effectiveness tests, including IOU and non-IOU savings attribution issues. Until these questions are settled, PG&E is not permitted to claim, or provide incentives based on, embedded energy savings. Project developers will likely use the calculator on a relatively limited basis until utilities receive CPUC approval.

PG&E's commercial-sector efficiency programs are estimated to have helped save customers more than 20 million gallons of water and 51,000 kWh in embedded energy during the first ten months of 2017, mostly through food service-related measures.<sup>5</sup> Over the same period, residential programs helped save 22 million gallons of water and nearly 45,000 kWh in embedded energy, most of which have been attributed to installation of efficient clothes washers. Although most of the portfolio's water savings, more than 300 million gallons, is attributed to agricultural sprinkler-to-drip irrigation measures, embedded energy savings are not currently tracked for this sector.

### **NV ENERGY**

Nevada state regulations require NV Energy to quantify environmental costs (including air emissions, water, and land use) associated with operating and maintaining a supply plan or demand-side plan (NAC § 704.937(4)). Although not claimed as an avoided cost in its cost-effectiveness screening, NV Energy annually calculates and reports generation-level water savings resulting from demand-side management programs. Calculations are based on total estimated water consumption of its thermoelectric power plants. This includes both operational water use (water consumed for cooling and cleaning throughout the process of generating electricity) and preoperational water use (water needed to acquire and prepare the fuel sources). Operational water use is estimated using established water coefficients of cooling systems and fuel types used in the plants. Preoperational water use is based on past studies on fuel sources (Acharya et al. 2015). Estimated water savings associated with each measure are calculated from these data and respective levels of verified energy savings. Table 5, adapted from Sierra Pacific Power Company (2017), provides results.

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<sup>4</sup> Custom project areas that have accounted for a sizeable portion of water savings include the Dairy and Winery Industry Efficiency Solutions Program (DWIES), implemented by third-party CLEAResult, and the Agriculture and Food Wastewater Program, currently implemented by third-party BASE Energy, Inc. In 2016, the DWIES program estimated 213.4 million gallons in water savings.

<sup>5</sup> PG&E's food service energy efficiency program offers measures such as ice machines, steam cookers, combination oven/steamers, and prerinse spray valves. In the first ten months of 2017, it saved more than 16 million gallons of water and 41,000 kWh in embedded energy. This is in addition to direct energy savings of 722,000 kWh.



**Table 5. 2016 Sierra Pacific Power Company annual demand-side management program energy and water savings**

Programs	Verified energy savings (kWh)	Water savings (gallons)
Energy Reports Program	8,515,557	1,371,005
Educational Services total	8,515,557	1,371,005
Residential Lighting	6,441,578	1,037,094
Residential Demand Response Program: manage	585,545	94,273
Residential Demand Response Program: build	418,656	67,404
Residential Program total	7,445,779	1,198,770
Schools Program	1,730,824	278,663
Commercial Program	42,809,439	6,892,320
Commercial Demand Response Program: manage	274,005	44,115
Commercial Demand Response Program: build	344,869	55,524
Business Program total	45,159,137	7,270,621
DSM portfolio total	61,120,473	9,840,396

*Source:* Sierra Pacific Power Company 2017

NV Energy represents an interesting contrast to other utilities mentioned in this report. While it reports generation-level water savings from reduced energy consumption, it does not track end-use water savings from energy efficiency measures. However, as workshops begin to establish new annual energy efficiency targets for NV Energy (as directed under SB 150 legislation signed in 2017), opportunities exist to address the nonenergy benefits of water as part of the utility's future energy efficiency portfolio.

## Findings

The following section highlights themes, trends, and best practices from notable programs reviewed.

### **POLICY DRIVERS**

In most cases, the greatest reported water savings were from residential efficiency programs. This is likely because savings from simple measures like low-flow showerheads, aerators, and efficient dishwashers and washing machines, which are commonly listed in state TRMs, are easy to calculate. Savings from commercial and industrial programs, particularly custom projects, were less likely to be calculated or reported and usually accounted for a far smaller share of claimed savings. Assumptions about water savings for custom measures are estimated using site-specific engineering analyses with some oversight by program administrators; staff are generally deferential to the professional judgment of project engineers.

Not surprisingly, we found that western states and others with a history of drought or increasing competition for water resources were more likely than those in other regions to cite specific water conservation goals as a key driver of energy utility efforts to claim water savings. California, in particular, has a long history of legislative and commission rulings aimed at managing water consumption. Such decisions have directly spurred ongoing programs and pilots to address the energy-water nexus. These include the Safe, Clean & Reliable Drinking Water Supply Act of 2010 (SBX7-7), which requires the state to achieve a 20% reduction in urban per capita water use by December 31, 2020. The commission's 2010 update to its Water Action Plan has also been important in organizing utility efforts toward a long-term strategy of strengthening energy-water programs (CPUC 2010). In 2013, the CPUC issued a rulemaking (R. 13-12-011) that has provided the framework for partnering investor-owned energy utilities and the water sector to develop methodologies for measuring embedded energy savings from water conservation and allocating costs among participants (CPUC 2013).

Program administrators in other regions cited indirect driving forces that had led to an interest in capturing water savings. In Illinois, for example, the 2016 Future Energy Jobs Act (SB 2814) sets new utility savings targets. This law has motivated utilities to both strengthen and expand existing efficiency programs as well as revisit methodologies for quantifying savings to ensure that benefits are not overlooked. These include burgeoning efforts to better track the avoided cost of water savings.

In Wisconsin, a coalescence of interest culminated in a memorandum, *Guidelines to Estimate Water-Related Energy Savings*, in Docket 5-FE-100 (PSCW 2015). According to Focus on Energy staff, the issue took hold in 2014 as the PSC of Wisconsin began determining Focus on Energy policies and goals for 2015–2018. The growing national interest in the energy-water nexus helped earn the issue a spot on the PSC's formal agenda. With the already existing relationship between water and energy staff at the commission (the Wisconsin PSC regulates both energy and water, and the water conservation coordinator frequently attends Focus on Energy meetings), work quickly began to incorporate embedded energy from water into program valuation.

### **BARRIERS TO IMPLEMENTATION**

Interviews with program staff and a review of past research revealed a variety of obstacles to accounting for water savings from efficiency programs. Chief among these were a shortage of data on water/wastewater intensity, limited funding for water utility participation, and lack of regulatory guidance. Also cited was the disjunction in policy levers between energy and water utilities. In addition to the divergent legislative and regulatory drivers they each face, they typically report to different levels of government. As others have noted, roughly 75% of the US population is served by large investor-owned energy utilities regulated by the state. Large investor-owned water utilities cover only about 10% of the US population (RAP 2011; Bluefield Research 2014). This makes the water utility landscape far more fragmented, with most of the country served by smaller public water systems that have fewer than 4,000 customers (Eisenberg 2014). With fewer resources and staff at their disposal, partnering with larger IOUs can be difficult.

## **REPORTING WATER SAVINGS**

In discussions, program administrators frequently characterized avoided costs of water savings as marginal. They sometimes described such savings as a drop in the bucket in relation to the overall level of benefits reported for cost-effectiveness evaluation purposes. For example, National Grid's water savings accounted for approximately \$3.16 million of the \$981 million of portfolio-wide resource benefits from efficiency programs. However administrators also acknowledged that the value of water considered in cost-benefit tests is typically narrowly informed by average water and sewer rates. These rates fail to account for a multitude of externalities and generally suffer from inaccurate price signals and rate design that fails to encourage efficiency. A 2011 US Government Accountability Office (GAO) report on energy needs of the urban water life cycle included interviews with a range of specialists. These experts indicated that the true cost of water is often not reflected in customers' rates and that subsidies and a lack of full accounting of the energy costs associated with treating and transporting water keeps rates artificially low (GAO 2011). This creates a lack of incentive for customers to use water efficiently. It also impedes utilities' recovery of the actual costs of providing and treating water. Therefore they do not generate enough revenue to implement water- and energy-saving technologies.

## **JOINT ENERGY–WATER PROGRAM COLLABORATION**

Efforts to develop collaborative partnerships between energy and water utilities varied. They included informal communication, coordination on planning studies, and more dynamic joint administration of water–energy programs. Combined energy and water utilities like the Los Angeles Department of Water and Power (LADWP) offer some of the most robust and streamlined examples of tandem energy and water efficiency programs. LADWP operates eight joint energy efficiency and water conservation programs. Many of these involve direct installation of water and energy savings measures for the residential, multifamily, and small business sectors. Other programs, such as outreach and education, development of codes and standards, and support for emerging technologies, offer indirect savings as well (LADWP 2015). LADWP also benefits from strong collaborations with others. Through an award-winning Master Inter-Utility Agreement (MIUA) with SoCalGas, a number of efficiency programs are currently offered jointly by the two utilities. This provides an efficient one-stop shop to LADWP customers while also allowing them access to previously unavailable SoCalGas programs. The agreement helps overcome a number of administrative barriers by identifying one of the utilities as the lead and the other as the partner for each program. Program orders identify the roles and responsibilities of each utility, provide project contacts and an amendment process, and establish project cost and invoicing procedures (DOE 2013).

In California, we reviewed examples of energy and water collaborations going back sometimes to the 1990s. They pick up speed in 2008 under CPUC directives that utilities pursue energy–water pilot programs. Past research by the Pacific Institute has profiled several of these efforts. One example is PG&E working with Bay Area water utilities to combine individual rebate programs for high-efficiency clothes washers into a single coordinated program. Another is SoCalGas working with the West Basin Municipal District on an audit program to improve water efficiency in commercial kitchens (Cooley and Donnelly 2013). In recent years these have evolved into more intensive initiatives to develop integrated energy and water program infrastructures. For example, in 2017, both SDG&E

and Southern California Edison worked with Water Energy Innovations, a California-based consulting firm, to develop water-energy strategic plans. SDG&E intends for the strategic framework to help accelerate adoption of cost-effective energy and water programs through joint delivery by SDG&E and San Diego County Water Authority (SDG&E 2017). The two entities established a formal institutional partnership in 2006.

Because of the enormous amount of water used by the agricultural industry, efforts to build partnerships with farming operations have the opportunity to produce the greatest savings. The irrigation modernization initiative between the Energy Trust of Oregon and Farmers Conservation Alliance has been highly successful in improving the energy and water efficiency of irrigation districts across the northwest. As of early 2017, system assessments were ongoing at 16 irrigation districts, and other districts have shown interest in participating in the program. Efforts are ongoing to develop best practices resources and technical assistance toolkits to enable replication of the program's success elsewhere.

### **AVOIDED WATER COSTS IN COST-EFFECTIVENESS SCREENING**

To ensure that ratepayer funds are spent wisely and provide sufficient benefits and return on investment, cost-effectiveness screening practices have long been applied to energy efficiency programs. Types of screening practices vary in design and application between states. Cost-effectiveness tests typically seek to identify programmatic costs and benefits incurring to customers, utility systems, and society at large.

While savings of direct site energy uses associated with water, such as water heating, are commonly considered in cost effectiveness, an area of increasing focus has been improving how nonenergy impacts (NEIs) are considered and quantified as part of cost-effectiveness screening. Even though efficiency programs produce a wide range of NEIs – such as benefits related to public health, air quality, and other environmental resources – consideration of NEIs is relatively limited. With no clear prevailing approach, a variety of differing measures for NEI estimation and calculation have emerged (NEEP 2017b).

This neglect of NEIs often extends to consideration of avoided water costs. Efforts to track and incorporate avoided costs from water savings into cost-effectiveness screening are varied. They typically are not a focus of long-term resource planning and are not coordinated in any meaningful way with water utilities.

Most NEIs, including many benefits of water-conserving measures, are not easily quantified. Many states however still give some consideration to water benefits in energy cost-benefit tests. As Malmgren and Skumatz (2014) describe, methods for incorporating NEIs into cost-effectiveness tests generally fall into one of several categories: incorporating a simple conservative “adder” to approximate impacts, incorporating “readily measurable” NEIs, or a hybrid of these methods.

Multiple states use a conservative adder. In several of these, avoided costs of water are considered as part of a larger adder for nonenergy benefits. Iowa, Nevada, and Oregon, for example, each use a broad 10% nonenergy benefit adder to account for these benefits that stakeholders agree exist but are difficult to quantify (NEEP 2017b). Colorado's modified Total Resource Cost (TRC) includes a 5% NEI adder for gas programs and a 10% NEI adder

for electric programs (NEEP 2017b). Utilities in the state do quantify water savings for easy-to-calculate measures in utility-specific TRMs.

In our review of the literature, we found that guidance on calculating water savings from energy efficiency programs is usually limited to easy-to-quantify measures in states with TRMs. However their application in practice is often difficult to ascertain from annual claimed-savings reports. For custom commercial and industrial projects in particular we were referred to work papers that were not easy to find or access.

Conversations with utility program administrators and evaluators and review of various technical reference manuals revealed that deemed savings values or deemed savings algorithms for annual gallons saved are often, but not always, provided in TRMs for easy-to-quantify water-saving energy efficiency measures. Improving water conservation however is rarely a focus of these programs. Faucet aerators, low-flow showerheads, and efficient dishwashers and clothes washers are examples of commonly offered energy efficiency measures that provide direct water savings. Specific examples are discussed in the next section.

#### **Consideration of Water Savings in Select TRMs**

A number of state cost-effectiveness policies call for nonenergy benefits to be calculated on a case-by-case basis or when easily quantifiable (Woolf et al. 2012). Table 6 summarizes the available utility commission guidance for calculating avoided costs of water for a selection of states. It includes additional information regarding practices for doing so by investor-owned utilities. These findings are based on our review of state TRMs and correspondence with utility regulators.

Table 6. Guidance for calculating avoided costs of water within selected state TRMs

State	Avoided costs of water savings are quantified and included in benefit-cost testing	Deemed gallons saved values/calculations provided for certain energy efficiency measures within TRM	Guidance provided for calculating avoided costs/kWh from water saved	TRM	Additional information
Arizona	Yes	Yes	No	Utility-specific	Arizona Public Service Company (APS) has quantified and reported water savings (in millions of gallons saved) in annual DSM progress report. However no guidance has been provided for including avoided cost of water savings from the Arizona Corporation Commission.
Arkansas	Yes	Yes	Yes	Arkansas Technical Reference Manual 7.0	Arkansas TRM Version 6.0 (2016) introduced Protocol L2, which assesses statewide water rates/sewer rates to provide an average proxy value for all avoided water usage benefits.
California	Low-income programs only	Yes	Yes	California Database for Energy Efficiency Resources (DEER)	Under the direction of the CPUC, investor-owned utilities began reporting embedded energy savings from water savings in 2017 using the CPUC's water-energy calculator; however ongoing questions regarding savings attribution and incorporating avoided water capacity costs must be resolved before these savings are claimed.
Colorado	Yes	Yes	No	Utility-specific	No statewide TRM. However utility-specific TRMs include avoided costs of water savings as part of participant nonenergy operations and maintenance (O&M) benefits.
Connecticut	Yes	Yes	No	Connecticut Technical Reference Manual	Eversource calculates and includes avoided costs from water savings in its TRC test, but not its Utility Cost Test (UCT). The utility relies on water and sewer cost provided by the Tighe & Bond Water & Sewer Rate Surveys (Tighe and Bond 2017).
Delaware	Yes	Yes	Yes	Delaware Technical Reference Manual (2016)	Avoided costs of water estimated at \$5 per \$1,000 according to studies by University of Delaware (2014) and AWWA (2015)
District of Columbia	Yes	Yes	Yes	DC SEU Technical Reference Manual	The Vermont Energy Investment Corporation (VEIC) maintains the DC SEU TRM. DC SEU calculated avoided costs of water at \$10.25/ccf in 2017. The utility also claims embedded energy savings of 2.07 kWh/ccf based on analysis by VEIC of energy use associated with drinking water and wastewater treatment.

State	Avoided costs of water savings are quantified and included in benefit-cost testing	Deemed gallons saved values/calculations provided for certain energy efficiency measures within TRM	Guidance provided for calculating avoided costs/kWh from water saved	TRM	Additional information
Florida	No	No	No	N/A	Florida electric utilities do not consider the impact of reduced water demands in their conservation analyses.
Iowa	10% adder for externalities for electric programs and 7.5% adder for externalities for natural gas programs	Yes	No	Iowa Energy Efficiency Statewide Technical Reference Manual 2.0 (2017)	In their 2014–2018 energy efficiency plans, Iowa utilities used adders but did not quantify water savings separately. This may change in the 2019–2023 plans, which will be filed in 2017 and 2018, but currently there is no formal guidance from the board on how this should be quantified.
Maryland	Yes	Yes	Yes	Mid-Atlantic Technical Reference Manual 7.0 (2017)	All the EmPOWER Maryland utilities include water savings in cost effectiveness calculations and all the water calculations are based on algorithms and assumptions in the Mid-Atlantic TRM. EmPOWER Impact Evaluation Guidance (2017) directs utilities to use a weighted average of published publicly combined volumetric water and sewer rates as a proxy for avoided water supply cost: \$11.10 per thousand cubic feet for PEPCO and \$7.78 per thousand cubic feet for all other utilities.
Massachusetts	Yes	Yes	Yes	Massachusetts Technical Reference Manual (2015)	Avoided costs for water are based on a statewide average of customer water and sewer rates. It is implicitly assumed cost to deliver and energy usage are built into customer costs.
Michigan	No	No	No	Michigan Energy Measures Database (MEMD)	Utilities do not currently track nonenergy benefits from energy efficiency.
Minnesota	No	Yes	No	Minnesota Technical Reference Manual 2.1 (2017)	The Minnesota TRM lists some algorithms for quantifying water savings, however no IOUs include avoided costs of water in their cost-effectiveness screening.
Nevada	10% adder for externalities for electric programs	No	No	N/A. Relies on California Database for Energy Efficiency Resources, utility work papers, and other sources	No documented guidance on including water savings. NV Energy does however track water use associated with thermoelectric generation and calculates estimated generator-level water savings for demand-side energy efficiency measures based on proportional levels of kWh savings.

State	Avoided costs of water savings are quantified and included in benefit-cost testing	Deemed gallons saved values/calculations provided for certain energy efficiency measures within TRM	Guidance provided for calculating avoided costs/kWh from water saved	TRM	Additional information
New York	No	Yes	No	New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs—Residential, Multi-Family, and Commercial/Industrial (Technical Resource Manual 4) (2017)	Utilities may include the avoided cost of water in benefit-cost analyses; however there is no commission requirement to do so and no state guidance for inclusion of such nonenergy benefits related to water.
Oklahoma	No	No	No	N/A	Oklahoma Corporation Commission Rules 165:35-41-7 (d) call for utilities to report the amount of reduced emissions and water consumption experienced by the utility, including all assumptions and calculations details, in annual DSM reports. Reported water savings are at the generator level and based on NREL estimates of water consumption per kWh of energy consumed in the United States. Water savings are not included in cost-effectiveness tests.
Oregon	Yes	Yes	Yes	Regional Technical Forum	Deemed savings values provided by Northwest Regional Technical Forum.
Rhode Island	Pending	Yes	No	Utility-specific	The Rhode Island PUC approved a new Benefit Cost Framework in 2017 to be used in the Rhode Island Benefit-Cost Test. The framework specifically includes participant nonenergy benefits such as water and wastewater, though according to the PUC a methodology for calculating has yet to be developed.
Texas	No	No	No	Texas Technical Reference Manual 4.0 (2016)	The Texas TRM and PUCT energy efficiency rules do not account for water savings in benefit-cost analysis.
Vermont	Yes	Yes	Yes	Efficiency Vermont Technical Reference User Manual (2015)	Efficiency Vermont uses a \$10.63/ccf (1.42 cents per gallon) conversion to estimate avoided costs of water in its Societal Cost Test. No additional assumptions are made regarding electric savings from reduced water, aside from direct savings from the conservation of electrically heated water. However efforts are ongoing to identify upstream and downstream savings potential



State	Avoided costs of water savings are quantified and included in benefit-cost testing	Deemed gallons saved values/calculations provided for certain energy efficiency measures within TRM	Guidance provided for calculating avoided costs/kWh from water saved	TRM	Additional information
Wisconsin	Yes	Yes	Yes	Wisconsin Focus on Energy 2017 Technical Reference Manual	In 2015 the Wisconsin Public Service Commission authorized Focus on Energy to begin claiming credit for indirect energy savings (water and wastewater treatment) from water-reducing measures. Recommended energy use-per-gallon ratios are provided by Focus on Energy based on energy use surveys of Wisconsin water supply utilities and wastewater treatment facilities.

*Sources:* Arizona: R. Krouse, APS, pers. comm., December 7, 2017. Arkansas: Arkansas Public Service Commission (2016). California: K. Hardy, Energy Division, CPUC, pers. comm., December 5, 2017. Colorado: M. Pascucci, senior regulatory analyst, Xcel, pers. comm., November 29, 2017. Connecticut: L. Shea, manager, Regulatory, Planning, & Support, Eversource, pers. comm., December 12, 2017. Delaware: J. Loiter, Optimal Energy, pers. comm., November 29, 2017. District of Columbia: M. Walker, Regulatory Affairs, Vermont Energy Investment Corporation, pers. comm., December 12, 2017. Florida: T. Coston, economic supervisor, Florida Public Service Commission, pers. comm., November 30, 2017. Iowa: D. Tormey, director of communications, Iowa Utilities Board, pers. comm., December 5, 2017. Maryland: J. Loper, principal energy consultant, Itron, pers. comm., November 7, 2017. Massachusetts: T. Vigliotti, policy & evaluation analyst, National Grid, pers. comm., October 27, 2017. Michigan: K. Gould, Energy Waste Reduction Section, Michigan Public Service Commission, pers. comm., November 30, 2017. Minnesota: A. Fryer, conservation improvement program coordinator, Minnesota Department of Commerce, pers. comm., November 16, 2017. Nevada: K. McMaster, NV Energy, pers. comm., December 6, 2017. New York: K. Mammen, utility analyst, NYS Department of Public Service, pers. comm., December 4, 2017. Oklahoma: J. Bennett, energy policy advisor, Oklahoma Secretary of Energy and Environment, pers. comm., December 4, 2017. Oregon: F. Gordon, director of planning and evaluation, Energy Trust of Oregon, pers. comm., October 27, 2017. Rhode Island: T. Bianco, principal policy associate, Rhode Island Public Utilities Commission, pers. comm., December 4, 2017. Texas: M. Stockard, director of energy efficiency, Oncor, pers. comm., November 8, 2017. Vermont: M. Walker, Regulatory Affairs, Vermont Energy Investment Corporation, pers. comm., December 12, 2017. Wisconsin: J. Fontaine, Focus on Energy performance manager, Public Service, pers. comm., November 8, 2017.

Oregon's cost-effectiveness policy calls for utilities to "calculate cost savings and other non-energy benefits if they are significant and there is a reasonable and practical way for calculating them" (Commission Order No. 94-590 in Docket UM 551). The Regional Technical Forum (RTF), formed in 1999 by the Northwest Power and Conservation Council, is generally responsible for providing and updating reliable savings values for northwestern states. The RTF maintains a downloadable database of deemed savings values and calculation methods for common and specialized efficiency measures. These include annual water consumption estimates and, in some cases, embedded energy figures associated with water and wastewater treatment. Similar to Colorado utilities, Energy Trust of Oregon applies a 10% adder to capture the benefits of conservation, although water savings are calculated where easily quantified (Energy Trust of Oregon 2017).

A number of states' TRMs include deemed unit savings for annual gallons of water saved for certain energy efficiency measures. This enables program administrators to calculate dollar values of avoided costs within cost-benefit screening. For example, Massachusetts, Connecticut, and Rhode Island make reference to the Department of Energy's (DOE's) *Energy Cost Calculator for Faucets and Showerheads* (DOE 2017). In Massachusetts, utilities such as National Grid rely on the *Massachusetts Technical Reference Manual* to calculate gallons of water savings from a variety of measures. The Massachusetts TRM calculates the avoided cost of water from a statewide average of the customer's cost for water and sewer. Customer costs include energy costs associated with water delivery and treatment, but this does not consider subsidies from tax revenues.

Maryland's EmPOWER program coordinates and funds the state's residential and commercial energy efficiency programs. EmPOWER administrators rely on calculations within the *Mid-Atlantic Technical Reference Manual* (NEEP 2017a) as well as *EmPOWER Energy Efficiency Programs Strategic Evaluation Guidance* for evaluating energy and water savings provided by efficiency programs (EmPower 2017). All EmPOWER Maryland utilities calculate participant water saving within the Total Resource Cost (TRC) test. Strategic evaluation guidance lists combined volumetric water and sewer rates to be used in these calculations for approximating avoided water supply costs.

The Illinois TRM (ICC 2017) includes water impact algorithms for a wide range of commercial, industrial, and residential measures (e.g., ENERGY STAR® dishwashers, prerinse spray valves, low-flow faucet aerators, low-flow showerheads, ozone laundry systems, clothes washers, thermostatic restrictor shower valves, and commercial gas and electric steam cookers). Although the Illinois TRM provides methodologies for capturing these water savings, avoided costs of water are included on a limited basis when performing the TRC test for energy efficiency programs. Nicor Gas, for example, includes dollar benefits associated with the value of avoided water based on gallons saved and a weighted average calculation of retail water costs in the utility's service territory (Nicor Gas 2016). SB 2814 (the Future Energy Jobs Act), signed in December 2016, updated the statutory definition of the TRC test to explicitly include "avoided costs associated with reduced water consumption, and avoided cost associated with reduced operation and maintenance costs."

The Vermont TRM also provides water savings algorithms and default values for commercial and in-unit clothes washers, clothes washer retrofits, low-flow showerheads,

and faucet aerators (Efficiency Vermont 2015). A 2012 order from the Public Utility Commission directed that “water and operations and maintenance savings should continue to be directly quantified, where appropriate separate from the 15% adder” currently applied to account for other nonenergy benefits (State of Vermont Public Service Board 2012). In 2017, Efficiency Vermont increased efforts to save water by working with selected drought-impacted communities in coordination with the Vermont Rural Water Association. Their goal was to determine the electric efficiency benefit of addressing water leaks at the community level (Efficiency Vermont 2017). As of late 2017, a study is ongoing to identify the potential statewide energy savings potential associated with reduced water use.

In December 2015, the Arkansas Public Service Commission called for updating the state’s TRC test to include the benefits of public water and wastewater savings. The commission directed the independent evaluation monitor to develop an algorithm for calculating the value of such savings resulting from electric and gas utility efficiency programs (APSC 2015). Beginning in 2016 with the release of Version 6.0 of the Arkansas Technical Resource Manual, Protocol L2 began listing marginal retail water rates and average residential and commercial sewage rates (both on a per-gallon basis) to determine a statewide average proxy value for all avoided water usage benefits. Rates provided in the TRM are based on research into six Arkansas water districts. Program administrators may use alternative water costs if they believed them to be more appropriate for their respective service territory. The TRM stipulates that these rates are to be revisited at the beginning of each three-year program cycle (APSC 2016).

The California Public Utilities Commission has also been engaged in multifaceted efforts to join energy and water utilities to address the energy–water nexus. Since 2010, the commission’s Water Action Plan has included a focus on water–energy nexus conservation programs. This has led utilities to design programs for determining the avoided costs of water and water savings and including them in cost-effectiveness calculations. In 2013 the CPUC commenced a rulemaking to develop a comprehensive cost-effectiveness framework for analyzing water and energy savings from energy efficiency programs. The following year, working with Navigant Consulting, Inc. and GEI Consultants, the CPUC released a Water–Energy Calculator and Avoided Water Capacity Cost Model (CPUC 2015b).

The California Water–Energy (WEN) Calculator and Avoided Water Capacity Cost Model comprises 29 worksheets within a single Excel workbook. The model prompts users to input systemwide as well as measure-specific information, including annual water savings, measure life, hydrologic region, and end-use sector (urban or agricultural). Outputs include both IOU and non-IOU embedded electric energy (kWh) as well as results of both Total Resource Cost and Program Administrator Cost tests. These consider benefits such as avoided marginal embedded energy costs, avoided water capacity costs, and environmental benefits. The model includes additional costs, such as rebate, installation, incremental equipment, and program administration. In 2015, the CPUC directed administrators of water–energy partnership programs to use these tools to demonstrate tangible benefits to their energy ratepayers (CPUC 2015a). However, in recent conversations, stakeholders indicated more work is needed to refine the calculator for formal use in program design.

An important next step for enabling calculation and approval of incentives for embedded water–energy savings is to connect the WEN Calculator with the cost-effectiveness tool (CET, formerly known as the E-3 Calculator) that California energy utilities currently use. In August 2017 the utilities submitted a *Water Energy Nexus Cost Calculator Plan of Action*. It considered several possible approaches for integrating the calculators before formally recommending that IOUs calculate embedded energy in kWh output from the WEN Calculator and input this into the CET to calculate the TRC (Joint IOUs 2017).<sup>6</sup> This was not the original intent of the WEN Calculator as it does not directly use its cost-effectiveness functionality. In December 2017 however the CPUC approved this course of action moving forward (CPUC 2017). In October 2017 utilities began monthly reporting of embedded energy savings using the California Energy Data and Reporting System (CEDARS) (CPUC 2017a).

In conversations with the CPUC and state IOUs, staff noted a variety of technical details that must be addressed before embedded water–energy savings can be claimed. These include distinguishing between IOU and non-IOU embedded energy. In particular, uncertainty persists regarding the ex ante process to approve embedded energy savings values for water measures, how to appropriately modify the CET to incorporate avoided water/wastewater capacity costs, and savings attribution for water–energy projects (SoCalGas 2017; PG&E 2017a). At present, IOUs generally do not claim any energy savings or avoided costs associated with water saved from energy efficiency programs, although water-related nonenergy benefits are considered in the valuation of low-income programs.

## Conclusions

Our review revealed a diversity of energy efficiency programs that provide and account for the avoided costs and indirect energy benefits of water savings. These include simple direct-install measures for residential and commercial customers, innovative multistakeholder partnerships addressing hard-to-reach customers, and efforts to utilize smart technologies to promote water-saving behavioral changes by accessing real-time consumption data. Water savings are formally calculated to a limited extent in some utility programs. This typically is in states where valuing energy efficiency as a resource and providing guidance for doing so is a significant focus of the utility commission. These valuations however are usually conservative estimates. Efforts are ongoing – most notably in California – to incorporate the full energy intensity of water into valuation of energy efficiency portfolios. More work must be done however before the full range of water benefits can be formally recognized to inform the proper attribution of claimed savings and distribution of incentives and funding toward water–energy programs.

Our key findings include the following.

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<sup>6</sup> Other options considered included (1) adding the energy utility TRC output from the WEN Calculator to the TRC output from the CET (this option was eliminated as TRCs are not additive) and (2) adding costs from the CET and WEN Calculator and adding benefits from the CET and WEN Calculator to calculate TRC as the ratio of costs to benefits. This was not ultimately recommended because of variations in costs and benefits calculations between the two calculators, including different assumptions and capabilities for considering base year.

## **STATES AND UTILITIES**

We found that the leadership of utility regulatory commissions helped the states and utilities that are making the most progress in tackling the energy–water nexus. These commissions have the power to set utility priorities, convene stakeholders in service of those goals, and standardize guidance according to utility and other stakeholder input.

Technical and regulatory barriers remain however. Among the most notable of these is the frequent disjunction in policy levers between energy and water utilities. In addition to the divergent legislative and regulatory drivers they each face, they typically report to different levels of government. Most US energy providers are large investor-owned utilities regulated by their state, while water providers tend to be smaller public water systems with fewer resources at their disposal. Therefore partnering and coordination are a challenge.

Many utilities, particularly in California, continue to make progress in operating joint energy–water programs that leverage the respective strengths of the energy and water utilities to help fill service gaps and strengthen offerings. By combining programs and defining roles and responsibilities through a memorandum of agreement, these utilities have reduced administrative costs and should serve as a model for other utilities looking to do the same (California Sustainability Alliance 2015).

Some municipalities, particularly those where energy and water utilities report through the same governance structure and have small service territories with similar geographic scope, have particularly favorable conditions for coordinating joint energy and water programs. Since they have relatively few legal hurdles to resolve, stakeholders among which to build consensus, and data-sharing barriers, they can more easily set up a one-stop shop that simplifies customer engagement.

## **ACCOUNTING FOR WATER SAVINGS IN COST-BENEFIT TESTS**

We found that a comprehensive assessment of the energy embedded in water use can be highly complex depending on the scope and level of accuracy desired. The need to reach consensus on energy data assumptions and agree on the appropriate policies and guidance for valuing and claiming savings from reduced water consumption increases the challenge.

State TRMs and PUC guidance commonly provide deemed calculations for quantifying direct energy savings associated with water-saving measures. Calculations of nonenergy benefits, such as avoided costs of water, are less common but do occur in at least a dozen states. While several states and energy utilities are increasingly trying to calculate and incorporate these values in cost-effectiveness screening, successful implementation has been limited to a handful of examples, including Wisconsin, Los Angeles, and the District of Columbia. In most cases, the value of water considered in cost-benefit evaluations is narrowly informed by average water and sewer rates. These rates fail to account for the full embedded energy costs of water, partially due to cross-subsidization and inaccurate price signals that fail to encourage efficiency.

The most large-scale effort to calculate the full energy intensity of water is still ongoing among California IOUs. It uses the CPUC’s Water Energy Nexus (WEN) Cost Calculator to capture energy used to produce, deliver, and dispose of potable water. Ongoing challenges

to full implementation are differences in data assumptions between the WEN Calculator and the IOUs' CET and questions regarding attribution of IOU and non-IOU savings. As of 2017, integration of the WEN Calculator into valuation of utility program portfolios remains a work in progress as utilities continue to test it on selected measures. This was among the most technically challenging efforts we reviewed due to the number of stakeholders involved and the diversity and complexity of the state's water infrastructure. Once implemented however the WEN Calculator should serve as a valuable resource and reference point for other states and energy utilities seeking to track and value water savings from their efficiency programs.

We found that common residential and commercial direct-install measures, such as low-flow showerheads and faucets, account for the majority of claimed utilities' water savings because they are easy to measure. However, although they are less readily quantifiable, the greatest savings are being realized from large custom industrial programs, leak detection initiatives, and irrigation modernization programs. Thus while practices are well established for some measures, the need for additional data and data sharing of potential embedded energy savings for a wide range of technologies, as well as for examples of successful cost-effective programs, remains.

As more utilities think outside the box to implement projects aimed at understanding the less-explored dimensions of the energy-water nexus, policymakers and practitioners will apply promising new technologies and program designs to leverage water savings as a resource.

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