

# **Saving Upstream and Downstream Energy Through End User Water Conservation**

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## **ABSTRACT**

Past research shows that considerable energy is required to obtain, treat and distribute water supplies to end-use customers. In December 2007 the California Public Utilities Commission (CPUC) approved the Embedded Energy in Water Pilot programs, through which California's largest energy Investor-Owned Utilities (IOUs) were directed to develop jointly-funded partnerships with water agencies, implement specific water conservation and energy efficiency programs, and estimate embedded energy savings. This paper summarizes impact evaluation results for nine Pilot Programs (Pilots) that were implemented by Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric Company (SDG&E) from July 2008 - December 2009. Water and wastewater savings were typically measured via direct metering or analysis of water utility bills, and embedded energy savings were estimated based on the energy intensities of the water and wastewater systems that serve the Pilots participants. Across the nine Pilots, estimated annual embedded energy savings ranged from 0 kWh to over 178,000 kWh per year. In particular, PG&E and SDG&E detention facility projects that installed efficient toilets, urinals and toilet flush timers generated high energy savings. In addition, SCE's Leak Detection Pilot generated high energy savings by fixing distribution system leaks, and potential water/energy savings are much greater if more expansive leak detection campaigns are implemented. Lastly, recycled water retrofit projects can offer large potable water savings, but additional research is needed on the embedded energy in recycled water treatment (which offsets energy savings from potable water).

## **Introduction**

This paper presents high-level impact evaluation results for the Water Pilot Programs (Pilots) that were implemented by Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric Company (SDG&E). The Pilots were initiated in July 2008 and concluded December 31, 2009.

Past research shows that significant energy is required to obtain, treat and distribute water supplies to end-use customers. In October 2006, the Assigned Commissioner to the California energy efficiency proceeding issued a ruling soliciting Investor-Owned Utility (IOU) applications for an approximately \$10 million one-year pilot "to explore the potential for future programs to capture water-related embedded energy savings." More specifically, the ruling directed the four largest IOUs to partner with one large water provider to implement a jointly

funded program designed to maximize embedded energy savings per dollar of program cost.<sup>1</sup> The Pilots would focus on efforts that would:

1. Conserve water;
2. Use less energy-intensive water (gravity-fed or recycled versus groundwater, aqueducts or desalination); and
3. Make delivery and treatment systems more efficient.

The IOUs initially filed their proposed program designs in January 2007, and the proposed programs were further refined through a series of workshops and supplemental filings. In December 2007, the California Public Utilities Commission (CPUC) approved the Pilot programs (in D. 07-12-050), through which the four largest IOUs would develop partnerships with water agencies, undertake specific water conservation and efficiency programs, and measure the results. A third-party impact evaluation was also approved to inform the Commission in determining whether water conservation programs and/or measures should potentially be added to the utilities' energy efficiency portfolios.

## Programs Evaluated

Following are brief descriptions of the nine Pilots that were evaluated:<sup>2</sup>

1. **PG&E Large Commercial Customers** – This program offered audits to large commercial, industrial and institutional customers to recommend water efficiency improvements. The program also offered energy and water utility financial incentives to help offset the cost of improvements. Types of eligible improvements included: ozone laundry systems, winery and food processing changes, detention facility toilet and shower upgrades, and recycled water retrofit projects. For ozone retrofits in laundry facilities, program approved ozone installers performed the audits. For other water efficiency improvements, audits were conducted by local water agency (or city) staff or contractors.
2. **PG&E Low Income High Efficiency Toilets (Single-family)** – This program offered direct install, high efficiency toilets (HETs) to low-income customers living in single-family residences served by PG&E and partner water agencies (e.g., San Jose Water Company). Only toilets that flush at 3.5 gallons per flush (gpf) or greater were eligible for replacement.
3. **PG&E Emerging Technologies** – PG&E partnered with two water agencies to integrate real-time electricity consumption data from discrete water pumping zones into existing Supervisory Control and Data Acquisition (SCADA) systems. One water agency planned to utilize the energy data in a new water-pumping algorithm that would automatically control a

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<sup>1</sup> Embedded energy is defined as “the amount of energy needed to acquire, pump, treat, distribute, and operate water treatment and delivery systems for a given amount of water.” It excludes the savings directly associated with end-use applications.

<sup>2</sup> Southern California Gas Company implemented a Gas Pump Testing Pilot Program; however, this program was not evaluated, as the primary goal was to develop testing protocols to guide future testing programs, and not to save water or energy during the Pilots period.

subset of system pumps. The other water agency planned to have system operators manually change the pump operations in response to displayed energy consumption data. This program was not designed to conserve water, and instead focused on reducing energy consumption under different flow and pressure conditions.

4. **SCE Low Income High Efficiency Toilets (Multi-family)** – This program offered direct install, HETs to low-income customers living in multi-family residences served by SCE and partner water agencies. Only toilets that flush at 3.5 gpf or greater were eligible for replacement.
5. **SCE Express Water Efficiency** – SCE partnered with Metropolitan Water District of Southern California (MWD) to deliver pH controllers for cooling towers and Weather Based Irrigation Controllers (WBICs) to commercial customers with chilled water HVAC and/or large landscape irrigation systems. A pH controller is a programmable device that monitors and adjusts the chemistry of the system to reduce water that must be bled from cooling towers. WBICs achieve water savings by switching from manual irrigation to weather based controllers. SCE contributed marketing assistance to the program, and rebates were available through MWD.
6. **SCE Leak Detection** – For this program, detailed water audits that comply with International Water Association and American Water Works Association protocols were completed for three water agencies. These audits identify and validate different types of water volumes (e.g., authorized consumption, metering errors, leakage) that collectively add up to each agency's total water supply for the audit period. The program contractor also conducted proactive leak detection on a subset of each agency's supply system, and the agencies repaired all of the found leaks.
7. **SDG&E Managed Landscapes** – SDG&E hired a contractor to install proprietary equipment and software that converts conventional irrigation controllers into controllers that utilize daily evapotranspiration (ET<sub>o</sub>) and weather information to control automatically and dynamically the amount of water used for irrigation. SDG&E paid for the first year equipment and installation costs at each site, after which participants could sign an agreement with the contractor for continued services. Water savings incentives were also available from MWD, although this was not part of the core program design. The program was conducted in the San Diego region and targeted multifamily apartment complexes, condominiums, office parks, commercial properties, homeowner associations, and estate properties with at least four irrigated acres.
8. **SDG&E Recycled Water Retrofits** – This Pilot increased the use of recycled water by providing capital funding for planned retrofit projects that switched from a potable water source to a recycled water source.
9. **SDG&E Large Customer Audits** – For this Pilot, SDG&E provided capital funding to install water conservation measures at sites that had received prior water audits and where the customer had not yet acted to implement any of the identified measures. The second element of the Pilot developed and implemented new, integrated water/energy audits for large commercial, industrial and institutional high water users in San Diego County, expecting that some of these measures would be installed during the program period.

## Evaluation Goals and General Methods

The primary purpose of the evaluation was to identify and estimate the amount of embedded energy savings (kWh) associated with the water savings arising from the water efficiency measures in the Pilots.<sup>3</sup> During the evaluation scoping, the objectives were further refined and are listed below:

1. To learn if the Pilots do or can potentially result in significant *energy* savings;
2. To provide information that the CPUC and IOUs can use for water program cost-effectiveness and TRC calculations;
3. To provide information to enhance the CPUC's program planning tools for water and embedded energy savings; and
4. To develop and test evaluation methods.

The evaluation had two primary components. The first was to **measure end use water savings**. Most of the evaluations utilized direct water metering of individual measures or housing units (e.g., for SCE HETs) for 2 to 4 weeks before and after the installations. Some evaluations, such as the SDG&E Recycled Water and Managed Landscapes Pilots, utilized monthly pre/post water billing data instead, adjusted for relevant factors (e.g., weather changes). The evaluation of PG&E's Emerging Technologies Pilot utilized regression analysis of energy consumption controlling for flow volumes and pressure changes (The impact evaluation cited in the *References* section of this paper includes detailed discussions of the water measurement techniques that were used.).

The second component was to **calculate embedded energy savings calculations**. This effort required determining the overall energy intensity of the water and wastewater systems that serve the Pilots participants, then multiplying these energy intensities by the water/wastewater savings.<sup>4</sup> For each Pilot project, the study team identified the relevant retail water and wastewater service providers and sent a survey to these agencies to obtain detailed information about water and wastewater flows and energy requirements. Some agency energy data were obtained from the CPUC's concurrent Embedded Energy in Water (EEW) Study 2, which collected similar data from a wide range of water and wastewater providers. A recycled water survey was also developed and sent to the cities with Pilot projects that offset potable demand with recycled water. Data on the energy intensity of various wholesale water agencies were obtained from similar surveys, CPUC EEW Study 1, and other previous studies. While IOU energy savings are of particular interest to the IOUs and the CPUC, the evaluation also tabulated energy savings from other energy providers, as these can be significant. The evaluation was not scoped to measure or estimate changes in end-user energy consumption, which may have occurred if customers installed or changed on-site equipment to implement the water conservation measures, or hot water demand was reduced, for instance.

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<sup>3</sup> Therms savings were also estimated, but were found to be very low and are not reported in this paper.

<sup>4</sup> Energy intensity is defined as kWh per million gallons of water provided or treated. Average system-wide intensities were developed to reflect that future projects could occur in different parts of each system's service territory.

## Summary of Key Findings

Most of the program evaluations provided useful information about embedded energy savings to inform future analyses of cost-effectiveness and program continuation. That said, collecting water and energy data from the water agencies was challenging for both the water agencies and the evaluation team. Water agencies that were involved in conceptualizing the programs from an early stage expected that production and energy data would eventually be required in some form. Other water retailers, however, were not initially aware that they would need to provide data, even if their water wholesaler was a Pilot program partner. In particular, wastewater and recycled water agencies that operate independently of water wholesalers and retailers did not know of the need for energy data until contacted by the evaluators. Despite these challenges, the evaluation team was able to obtain usable data from many of the water agencies that served participating Pilots customers.

**Table 1** summarizes the annual potable water, wastewater and IOU embedded energy savings that were measured for each of the Pilots. For each program, the table also lists the number of project sites or measures that were evaluated, and the energy portion of the project implementation budget for each program, although program cost-effectiveness was not assessed. Notable data limitations are described below the table.

**Table 1.** Summary of Annual Water and Wastewater Savings, and IOU Energy Savings

<b>Pilot Program</b>	<b>IOU Budget<sup>1</sup></b>	<b>Project Sites, Measures</b>	<b>Annual Water Savings (gallons)</b>	<b>Annual Wastewater Savings (gallons)</b>	<b>Total IOU Embedded Energy Savings (kWh/Yr.)</b>
PG&E Large Commercial Customers <sup>2</sup>	\$700,000	11 sites	33,719,230	16,478,711	<b>55,189</b>
PG&E High Efficiency Toilets (SFR) <sup>3</sup>	\$200,000	478 toilets	5,098,320	5,098,320	<b>14,328</b>
PG&E Emerging Technologies	\$341,000	2 water agencies	NA	NA	<b>0</b>
SCE High Efficiency Toilets (MFR)	\$200,000	276 toilets	1,329,768	1,329,768	<b>5,712</b>
SCE Express Water Efficiency <sup>4</sup>	\$133,000	3 pH controllers	6,351,000	6,351,000	<b>9,385</b>
SCE Leak Detection	\$300,000	3 water agencies	82,923,912	NA	<b>178,143</b>
SDG&E Managed Landscapes <sup>5</sup>	\$250,000	13 sites	51,772,695	NA	<b>21,275</b>
SDG&E Recycled Water Retrofits <sup>6</sup>	\$250,000	4 sites	31,847,172	NA	<b>75,205</b>
SDG&E Large Customer Audits <sup>7</sup>	\$496,000	4 sites	82,081,336	82,081,336	<b>155,512</b>

<sup>1</sup> Does not include implementation budgets of partner water agencies. Actual program expenditures may be less than these approved budgets.

<sup>2</sup> Does not include IOU embedded energy savings for three water retailers (serving three projects) that did not provide data. Does not include IOU embedded energy savings for two large recycled water projects; no data were provided by the recycled water provider. Does not include IOU embedded energy savings for three wastewater agencies (serving four projects) that did not provide data.

<sup>3</sup> The wastewater agency serving the vast majority of program installations did not provide embedded energy data.

<sup>4</sup> The water retailer for the one customer site did not provide embedded energy data. Water and energy savings are artificially high due to poorly maintained cooling towers. The full report includes estimated water/energy savings for 3 properly maintained cooling towers.

<sup>5</sup> Does not include energy savings from two retail water agencies (serving two sites) that distribute imported treated water from a wholesaler.

<sup>6</sup> Does not include energy savings from one city (serving one project) that did not provide potable water or recycled water data. Embedded energy savings are from *all* sources (not only SDG&E). Two other projects were installed late in the program period and were not evaluated.

<sup>7</sup> Does not include energy savings from one city (serving one project), which did not provide potable water or wastewater data.

SDG&E's Large Customer Audits Pilot generated relatively high IOU energy savings from both water and wastewater savings, while SCE's Leak Detection Pilot generated high energy savings by fixing distribution system leaks. PG&E's Large Commercial Customers Pilot also generated high IOU energy savings by reducing wastewater treatment, which accounted for 75 percent of total energy savings (details not shown). In contrast, PG&E's Emerging Technologies Pilot did not save any IOU energy from water pumping changes.

Following are some of the key findings from the nine Pilot program evaluations:

1. Leak Detection programs initially appear to offer the greatest energy savings potential (at relatively low cost) among all the Pilot programs. In particular, the energy savings documented for SCE's program are based on leaks that were *actually* repaired during the program period; *potential achievable* water (and energy) savings were estimated to be much higher by the program implementation contractor.
2. PG&E and SDG&E detention facility projects that installed efficient toilets, urinals and toilet flush timers generated high water and energy savings. Future programs may seek to focus on these types of projects, pending detailed cost-effectiveness analyses. (For these projects, SDG&E contributed capital funding whereas PG&E offered rebates based on water savings.)
3. Recycled water retrofit projects can offer large potable water savings, but additional research is needed on the IOU embedded energy in recycled water treatment (which offsets energy savings from potable water). In areas where recycled water treatment does not require significant IOU energy, it may be possible to design cost effective programs based on potable water savings.
4. For the other Pilots, the program costs are likely to exceed the energy benefits, even where embedded energy savings are incomplete (e.g., wastewater for PG&E HETs). That said, additional research would be required on actual program spending, potential economies of scale, measure lifetimes and potential end-user energy savings. Cost-effectiveness could be increased by reducing energy utility program funding levels and/or targeting programs to the most energy intensive water systems.

## **Program-Specific Findings**

### **PG&E Large Commercial Customers Pilot Program**

This Pilot generated high potable water savings through recycled water retrofit projects for a private company and a school site (for athletic field irrigation), however, additional

research is required to understand the embedded energy in the tertiary treatment of recycled water; no data were provided for this evaluation.<sup>5</sup> In addition, there may be high free ridership if recycled water costs significantly less than potable water in the local service territory. This Pilot also achieved high water savings through a detention facility project that installed low-flow toilets with electronic flush valves/timers.

Seven of the 11 program participants were ozone laundry customers, and free ridership for these projects was probably low, as several eligible customers turned down the opportunity to participate (due to company spending limits in the poor economy), even while the combined PG&E and water agency rebates covered a significant portion of the installation cost. While one ozone laundry project generated negative water savings (for unknown reasons), the other six realized positive savings, illustrating the importance of evaluating a sufficient number of sample sites. One project, a high-efficiency commercial dishwasher, generated large negative water savings because a new trough drain installed at the same time was inadvertently left open each morning before the dishwasher began operations (requiring the dishwasher to intake more water). While this type of problem is easily rectified, a larger sample size would provide more reliable savings estimates.

### **PG&E High Efficiency Toilets Pilot Program**

The calculated embedded energy impacts for the PG&E HETs program were modest but also incomplete, as wastewater treatment data were not provided to the evaluation team. Embedded energy savings from reduced wastewater treatment would need to be measured or estimated in order to understand the full impacts of this type of program. In addition, some higher-volume non-retrofit toilets remained in the single-family homes, and it is not clear how people used the different models because non-retrofit toilets were not metered.

Leakage was observed to be a prevalent problem with the new toilets and is reducing potential water and energy savings by over 20 percent. Furthermore, this evaluation revealed that future HET programs should not rely on the manufacturer rated flush volumes without additional testing, since the observed flush volumes were higher in this case.

Additional research needs to be conducted prior to implementing a more comprehensive program. In particular, given the low-income target population, it is not known if property owners will install these measures on their own without program assistance; this evaluation found that almost one-third of the existing toilets in the single family homes were already low-flow models. Although program cost effectiveness was not assessed, utility cost-effectiveness could potentially be improved by requiring the property owners to pay a portion of the installation costs.

### **PG&E Emerging Technologies Pilot Program**

PG&E's Emerging Technologies Pilot did not result in measured energy savings, as one water agency did not actually implement the planned automatic pumping control algorithm during the program period, and system operators at the other participating water agency did not utilize new SCADA screen displays of real-time energy consumption to manually improve the

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<sup>5</sup> Wastewater that is going to be re-used undergoes additional, tertiary treatment to reduce nitrogen, phosphorus, and other contaminant concentrations, and this treatment requires additional energy.

energy efficiency of pumping. While these strategies may have resulted in energy savings in other places, this was not observed during the Pilots period.

### **SCE High Efficiency Toilet Pilot Program**

The total annual IOU embedded energy savings for the SCE HETs program (5,712 kWh/year) are modest compared to the other programs, in part because relatively few HETs were assessed (276), and also because the energy intensity of the affected wastewater agency is very low (132 kWh/MG).

As with PG&E's HET program, potential water and energy savings are being reduced by leakage. Daily water savings of about 20 gallons/household were found in this evaluation, and would be closer to 30 gallons/household if most of the leaks were repaired (the largest leaks in particular). This evaluation also found that some of the new toilets flush at higher volumes than the manufacturer's ratings.

The owner of the apartment buildings had utilized the program installation contractor to install new toilets at several other company owned sites previously - it is not known if these were low-flow toilets or if rebates were obtained. Additional research is needed to better understand if low-income property owners will install these measures on their own without program assistance. Similarly, it may be possible to increase utility cost-effectiveness by requiring property owners to pay a portion of the installation costs.

### **SCE Express Water Efficiency Pilot Program**

SCE's Express Water Efficiency Pilot yielded only one pH controllers project, which retrofit three cooling towers at one industrial customer site. Importantly, the water and embedded energy savings shown in Table 1 should not be extrapolated to other sites or programs, as the cooling towers were operated atypically during both the pre- and post-retrofit periods. In particular, two water bleed controllers were not functioning in the pre-retrofit period, and the towers were being bled manually, resulting in unusually high water use. After the retrofits, the concentration ratios of the three towers were still below the normal target level, reducing potential water savings. Based on operational data from the three towers and data from more typical, properly maintained systems (before and after retrofits), actual water savings at other sites may be closer to 25 percent of those documented in the table.

### **SCE Leak Detection Pilot Program**

SCE's Leak Detection Pilot warrants further consideration for inclusion in regular IOU programs, pending further analysis of cost effectiveness. According to secondary research completed for this Pilot, most water agencies in California do not proactively manage leakage and only react to found leaks, typically after they have become larger. Thus a program that offers proactive leak detection services could potentially generate large net water saving impacts. (The program may not need to offer comprehensive water audits, however, particularly if water agencies are already required to conduct these.) According to the secondary research, about 0.87 million acre-feet of water is lost each year through leaking water distribution pipes in California, and about one-third of this may be economically recoverable. The water savings documented for the three water agencies that participated in this Pilot, however, should not be extrapolated to a broader population of agencies, as these agencies have relatively low levels of leakage. Water



savings could be even larger if agencies with relatively more leakage can be encouraged to participate.

### **SDG&E Large Customer Audits Pilot Program**

This program had four customers install measures, and given the range of equipment installed it is difficult to draw broad conclusions about this program.<sup>6</sup> As with PG&E's Large Commercial Customers Pilot, significant water savings were achieved through low-flow toilets, flush valves/timers and other measures at a large detention facility. This project received significant capital funding from SDG&E through the Pilot, and would not have been completed without this funding. The customers that installed autoclaves and reverse osmosis upgrades and process changes also realized water savings. Two of these customers did not obtain any water saving incentives for installed measures, but may not have been willing to pay for the free comprehensive water/energy audits offered through the program.

### **SDG&E Recycled Water Pilot Program**

While this Pilot generated high potable water savings, it should not be added to regular program portfolios until more research is conducted. In particular, this program has a relatively high potential for free ridership, since local costs for recycled water are much lower than for potable water; the county water agency already had several planned retrofit projects to select program participants from. In addition, more research is required on the intensity of energy in tertiary recycled water treatment (i.e. the incremental energy beyond that needed for standard wastewater treatment). This program evaluation utilized past research on tertiary water treatment in San Diego, as more current detailed energy data could not be obtained for any of the recycled water agencies serving Pilots participants. Lastly, these Pilot evaluation findings should not be extrapolated to a larger program, due to the small sample size and because there was only a modest correlation between pre-installation ETo rates and potable water usage (this correlation was used to normalize water usage in the post-installation period). More importantly, recycled water retrofit projects may differ significantly in scope and by end use.

### **SDG&E Managed Landscapes Pilot Program**

The evaluation of SDG&E's Managed Landscapes Pilot suggests that water savings of 25 percent are generally achievable, and that these savings are probably due to the vendor's "smart" irrigation technology since no major site changes were noted in the post installation period. The low correlations between water use and the ETo data are presumably due to few ETo data points, microclimate effects, and/or vendor adjustments to how the ETo data are used by the proprietary software (perhaps even between sites, to develop partially customized watering schedules). Free ridership for this program was probably low, since the program paid for all of the customers' first-year service costs. However, we do not know how many of the participant sites plan to utilize the smart irrigation technology beyond the first free year of service. Additionally, the increasing imposition of mandatory water restrictions will significantly increase free ridership for these projects in the future.

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<sup>6</sup> Nine customers received initial water/energy audits at no cost to them.

## Recommendations for Future Evaluations

This research produced a number of recommendations for future evaluation efforts, including:

1. **For ozone laundry projects/programs, develop ways to obtain occupancy and/or laundry pounds data consistently to normalize water use.** These data could not be obtained for this evaluation for a variety of reasons (e.g., evaluation activities timing, time constraints among hotel staff). Future studies should try to collect additional data to normalize water use and refine water/energy savings estimates.
2. **Conduct further research about pH controllers.** This evaluation focused on one project where the pH controllers were not properly maintained, which misrepresented likely water savings. While the evaluation was able to estimate achievable water savings, additional research is warranted, unless existing secondary research provides reliable estimates of water savings for this measure.
3. **For HET evaluations where direct metering is conducted, add metering to non-retrofit toilets.** This would provide additional information to understand if/how actual household toilet usage may change after the retrofits (i.e. if some toilet models are preferred).
4. **For HET evaluations where individual apartment units are metered, conduct on-site verifications to confirm the make and model of the installed toilets.**<sup>7</sup> This is needed to distinguish maladjusted toilets from un-replaced toilets. Furthermore, this would better allow evaluators to apply results from only fully retrofit units to partially retrofit units on a per-toilet basis, if this approach is preferred.
5. **Do not use manufacturer rated flush volumes for HETs.** Both HET studies found that actual flush volumes differed from these ratings.
6. **Ensure that water agencies planning SCADA improvements to save energy have supportive operating conditions and policies.** Program planners need to make sure that operator behavior change is in fact feasible in the specific operating environment; otherwise energy savings are unlikely to result.
7. **Conduct real-time field visits to verify repairs of leaks found during program-sponsored leak detection surveys.** Due to logistical and budgetary constraints, this could not be done for this evaluation, but should be considered for future evaluations if energy savings will be claimed.
8. **Conduct detailed research on proposed “smart irrigation” technology and implementation to understand when and why typical control algorithms may be customized.** This could help refine future estimates of expected water savings, as this evaluation found some unexpected changes in pre/post soil moisture correlations and vendor may frequently make controller adjustments.

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<sup>7</sup> For the evaluation of SCE’s HET program, Aquacraft’s Flow Trace software was used to distinguish toilet flushes while metering at the individual apartment level.

9. **Systematically inform *all* of the agencies from which embedded energy data will be required for evaluation purposes.** For this evaluation, some retail water agencies did not provide embedded energy data, and important regional wastewater and recycled water agencies did not provide data. If embedded energy data are required for future studies or programs, the sponsoring agencies could make data submission a prerequisite for programs partnering.
10. **Conduct further research about recycled water, particularly embedded energy for tertiary treatment and retail costs to consumers.** These projects have a relatively high potential for free ridership, since costs for recycled water in some areas are lower than for potable water (in other areas they are similar). In addition, more research is needed on the intensity of energy in tertiary recycled water treatment. This evaluation was unsuccessful in collecting new detailed energy data from three recycled water agencies serving Pilots participants. Throughout much of California, especially Southern California, the energy requirements for potable water are high. Thus, recycled water is likely to yield significant energy savings. The energy implications of replacing potable water with recycled water, however, will vary among water agencies.
11. **Evaluate larger samples if possible.** The evaluated project samples were generally small due to limited programs participation. For some project types such high efficiency commercial dishwashers, pH controllers, and boiler water reuse, there was only one Pilots participant and only one project was evaluated.
12. **Incorporate changes in end-user energy consumption into cost-effectiveness calculations.** Although this evaluation was not tasked with measuring or estimating end-use energy changes, these changes could be significant and offset a portion of the embedded energy savings. Cost effectiveness analyses and/or future studies should attempt to quantify these impacts, to understand the true net energy savings from water conservation programs.

## Acknowledgements

Agencies and utilities that sponsored this evaluation effort are: California Public Utilities Commission, Pacific Gas and Electric, Southern California Edison, San Diego Gas and Electric and Southern California Gas Company.

Evergreen Economics staff (formerly employees of ECONorthwest) were assisted in this research by: SBW Consulting, Aquacraft Inc. Water Engineering and Management, Pacific Institute and Eskinder Berhanu and Associates.

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