



Municipal Water District of Orange County

18700 Ward Street
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Evaluation of Municipal Water District of Orange County's Water Smart Hotel Program



With EnviroSmart Solutions Group & Western Policy Research



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Acknowledgements

Acknowledgements

The team that evaluated the Municipal Water District of Orange County's (MWDOC) Water Smart Hotel Program included MWDOC's Water Conservation Department, EnviroSMART Solutions Group (ESG), and Western Policy Research (WPR). This study would not have been possible without the participation of the customers that allowed us to conduct interviews, the participating water retail agencies that provided data for the program evaluation, and WaterWise Consulting, Inc. for providing Water Smart Hotel Program information. It was a collaborative effort by all parties involved.

Valuable information and contributions were made by the following staff at the Municipal Water District of Orange County:

- Beth Fahl
- Joseph Berg
- Dr. Melissa Baum-Haley

The ESG staff members that contributed to this project included:

- Steven Chov
- Sue Pike

The WPR staff that assisted with the overall evaluation design and undertook the impact evaluation included:

- Dr. Anil Bamezai

The WaterWise staff that contributed valuable information included:

- Kelly Takai
- Juan Garcia

The agencies that provided funding for the Water Smart Hotel Program and Program Evaluation through grants:

- California Department of Water Resources
- United States Bureau of Reclamation

The agencies that provided rebates and incentives to assist with the Water Smart Hotel Program:

- Metropolitan Water District of Southern California
- Municipal Water District of Orange County

Special thanks go out to all retail agencies and customers that supported and participated in the Water Smart Hotel program and program evaluation.

Executive Summary

The Water Smart Hotel Program (Program) was developed by the Municipal Water District of Orange County (MWDOC) to offer hotels free indoor and outdoor water use efficiency surveys and to provide rebate incentives to encourage hotels to perform device retrofits. Hotels were targeted for this program because of their significant potential for water savings resulting from a vast array of plumbing fixtures, kitchens, restaurants, laundries, and large landscape areas. The water use efficiency surveys are customized to each hotel's characteristics, evaluate current water using equipment and water use trends, and provide recommendations for conserving water, including a cost benefit analysis of retrofit options and the rebates available. WaterWise Consulting, Inc. (WaterWise) was awarded the contract to perform these hotel water use efficiency surveys. As part of the water use efficiency surveys, WaterWise also provided follow up calls to encourage survey participants to take advantage of the available rebates. MWDOC's Program goals included completing 105 water use efficiency surveys and saving 531 acre feet of water per year. The Program is funded by grants provided by the Department of Water Resources (DWR) and the United States Bureau of Reclamation (USBR). The Program commenced in January 2008 and is expected to run through June 30, 2014.

A key requirement of the DWR and USBR grants funding the Program is that an evaluation be performed to determine the successes and challenges faced by the Program (Process Evaluation) and the actual water savings achieved by the Program (Impact Evaluation). To accomplish this task, MWDOC contracted with Envirosmart Solutions Group to undertake the Water Smart Hotel Program Evaluation (Program Evaluation). As part of this Program Evaluation, a random sampling of hotels was taken and separated into the following treatment groups: (1) hotels that participated in both the survey aspect and the rebate aspect of the Water Smart Hotel Program; (2) hotels that participated in only the survey aspect of the Water Smart Hotel Program; and (3) hotels that did not participate in the survey aspect of the Program, but did participate in the rebate aspect. A control group consisting of hotels that did not participate in either the surveys or the rebates was also developed.

A goal of the Process Evaluation was to interview a sample of 20 hotels in each treatment group to test the overall effectiveness of the Water Smart Hotel Program. Interviews were also conducted with the Program manager from MWDOC, as well as staff from WaterWise to gauge the successes and challenges of the Program. The Process Evaluation experienced difficulties in obtaining interviews with hotels in the treatment groups. Various methods were utilized in attempts to make contact with the hotels, such as phone calls, site visits, emails, and letters. Of the 171 hotels contacted to participate in the interviews, 31 hotels offered responses to the interview questions, resulting in an 18% response rate for the Program Evaluation. Not surprisingly, the majority of the hotels participating in the process evaluation interviews were hotels that actually participated in the Water Smart Hotel Program.

From Program launch, in November 2008, through June 2013, WaterWise has completed 54 surveys, which have identified potential water savings of 554 acre feet of water per year, assuming all recommendations are implemented. Over the same time period, 143 hotels implemented water savings practices tracked through the rebate component of the Program, yielding 503 acre feet based on industry accepted device water saving rates. Although the survey component of the Program has only resulted in

Executive Summary

51% of the goal so far in terms of the number of hotels surveyed, the water saving goal is already at 95% and on track to exceed this goal.

The purpose of the Impact Evaluation was to estimate the actual water savings; meaning realized water savings that could be discerned at the meter. A control group was introduced into the analytic framework to separate the impact of the coincident recession, or other external factors, from that of the retrofits. This would allow us to evaluate water use histories and determine savings due to retrofits, without any influence on water use resulting from the recession that began in late 2008. The Impact Evaluation provides characteristics of device retrofits that were made in the Program hotels, a distribution of hotel star ratings, and hotel size based on number of rooms.

Through the Impact Evaluation, it is estimated that the water use prior to the retrofits was 22.7 hundred cubic feet per day for the average retrofitted hotel in our sample. A savings of 18% translates into 4.1 hundred cubic feet per day or 3.4 acre feet per year per retrofitted hotel. High efficiency toilets were the most retrofitted devices among participating hotels, with a saturation level of 90%.

Introduction

The Municipal Water District of Orange County (MWDOC) officially launched the Program to the public in November 2008. The Program is offered to hotels and motels located within MWDOC's service territories, which includes 27 retail agencies. The purpose of the Program is to provide hotels with free indoor and outdoor water use efficiency surveys, along with rebate incentives to encourage hotels to perform device retrofits. The Program is funded through grant funds provided by the California Department of Water Resources (DWR) and the United States Bureau of Reclamation (USBR). As part of the Water Smart Hotel Program, the funding agencies require that a Program Evaluation be performed.

The indoor and outdoor surveys are performed by WaterWise Consulting, Inc. (WaterWise). For each indoor and outdoor water use efficiency survey, trained WaterWise staff evaluated and inventoried water using fixtures and appliances in all public restrooms, kitchens, common areas, and a sample of hotel rooms. Indoor water using fixtures include toilets, faucet aerators, showerheads, laundry facilities, and cooling towers. For the outdoor portion of the survey, irrigation equipment, including controllers and nozzles, are inventoried and evaluated for problems. After the data are gathered, WaterWise staff organize this data and allocates water usage per device to provide the hotel with a description of those areas using the most water. WaterWise prepares the information into a detailed survey report that includes a description of the hotel's water use history, a description of the hotel's water use trends, recommendations for water conservation and resultant monetary savings, and a listing of the rebates available to assist the hotel in making retrofits. Completed reports are delivered to the hotel, and WaterWise staff follows up with the hotel to provide additional guidance, if needed.

The purpose of this Program Evaluation was to perform (1) a Process Evaluation of the Program format and (2) an Impact Evaluation of water savings achieved by participants in the Water Smart Hotel Program. In addition to fulfilling a grant agreement requirement, MWDOC was looking to determine what successes and challenges came with implementation of the Water Smart Hotel Program. In 2012, MWDOC contracted with Envirosmart Solutions Group (ESG) to perform an evaluation of the Water Smart Hotel Program, and ESG teamed up with Western Policy Research (WPR) to perform the statistical impact analysis. WaterWise, the primary contractor performing the indoor and outdoor water surveys for the Water Smart Hotel Program, also assisted with and contributed information to the Program Evaluation.

The Process Evaluation included interviewing hotels and motels within MWDOC's service territory for information about their water using fixtures and appliances, as well as information about whether the hotels took advantage of the rebates available for retrofitting certain devices. These hotels and motels were chosen at random in order to ensure representativeness. Hotels to be interviewed were selected from three distinct groups: (1) hotels that participated in the Program surveys and made retrofits to their water using equipment; (2) hotels that participated in the Program surveys and did not make retrofits to their water using equipment; and (3) hotels that made retrofits to their water using fixtures without participating in the Program surveys. A non-participant group consisting of hotels that neither participated in the Water Smart Hotel Program nor made retrofits to their water using equipment was also added into the Program Evaluation. The design of the Process Evaluation also included interviews

Introduction

of MWDOC and WaterWise staff to obtain their feedback about the functioning of the Program.

Several goals were behind the Process Evaluation design, including:

- Understanding why surveyed hotels had not implemented the recommended retrofits;
- Determining what it would take to convert non-participants into participants;
- Determining the level of satisfaction with the programmatic surveys; and
- Detailing the hotel characteristics that could be useful in the impact evaluation.

The Impact Evaluation was conducted concurrently. For the water savings impact analysis, billing data were requested for all hotels that participated in a Water Smart Hotel Program survey and/or received rebates from said Program. Additionally, billing histories for a randomly selected list of non-participating hotels was requested from their respective retail water agencies. The Impact Evaluation also analyzed the characteristics of device retrofits that were made in the Program hotels, a distribution of hotel star ratings, and hotel size based on number of rooms.

Evaluation Need

A key requirement for receiving grant funding from DWR and USBR is the performance of a Program Evaluation to determine both the successes and challenges faced by the Program and the actual water savings achieved. Although the Program is still ongoing, the Program Evaluation began on October 4, 2012. The Program is set to conclude in June 2014. The results from this Program Evaluation will help determine what conservation practices are being utilized in hotels, those conservation devices that are in high demand, and will provide information on where water conservation programs should be focused in the future.

Program Evaluation Objectives

The goal of the Program Evaluation is to determine:

1. The successes and challenges in the Water Smart Hotel Program
2. Evaluate water savings from installed water conservation devices in hotels that participated in the Program.
3. Statistically analyze the impact of water conservation devices installed at hotels that participated in the Water Smart Hotel Program. It also evaluates hotels that participated in the survey component of the Water Smart Hotel Program, but chose not to install any water conservation devices, along with hotels that did not participate in any aspect of the Program.

Process Evaluation

Water Smart Hotel Program Summary

The Water Smart Hotel Program was developed to assist hotels located within MWDOC's service territory to reduce their water use. As plumbing fixtures in kitchens, restaurants, laundry facilities, and landscape areas at hotels have been determined to have a significant potential for water savings, the Program is also part of MWDOC's effort to implement the California Urban Water Conservation Council's (CUWCC) Best Management Practice for Commercial, Industrial, and Institutional facilities. With this Program, MWDOC set out to achieve a Program goal of completing 105 hotel surveys and saving 531 acre feet of water per year, or 5,310 acre feet of water savings over a 10 year period. The overall goal of 531 acre feet of water per year is a combination of the water savings goals from both the USBR and DWR grants.

In July 2007, DWR awarded a grant to MWDOC to implement a hotel water use reduction program. By December 2007, MWDOC and DWR finalized the scope of work for the Program. Thereafter, in July 2008 a Request for Proposals (RFP) to hire an implementation contractor was issued. Water Wise was selected through a competitive RFP process to market the program, perform the surveys, and prepare written survey reports. An Agreement and Scope of Work between MWDOC and WaterWise was finalized in November 2008. WaterWise's extensive experience providing indoor and outdoor water audits for large landscape, commercial, industrial, and institutional facilities assisted in the development of an indoor and outdoor water survey for the Water Smart Hotel Program. In December 2008, as the Water Smart Hotel Program was set to launch, the State of California Pooled Money Investment Board froze the execution of new grant contracts and payments on existing grants. Although funds had been frozen, MWDOC's Board of Directors chose to move forward with the Program and cover the costs until the freeze on funding was over, and MWDOC officially launched the Water Smart Hotel Program to provide hotels within MWDOC's service area with indoor and outdoor water use surveys, along with rebates for device retrofits. In June of 2009, MWDOC applied for and received funding from the CalFed Water Use Efficiency Grant offered by USBR. The freeze on DWR funding ended in February of 2010.

Data collection and reporting tools were created to MWDOC's specifications, and rebate funding levels were established. By using grant funds, the Program rebates are enhanced beyond the standard offerings of the Metropolitan Water District of Southern California (Metropolitan). Table 1 provides a detailed description of the rebates for water conservation fixtures and appliances that are offered by MWDOC, Metropolitan, and any other known rebate opportunity at that time.

Table 1. Water Conservation Fixture and Appliance Rebates

Equipment	Metropolitan So Cal WaterSmart Commercial Rebate	MWDOC Water Smart Hotel Rebate	Other Possible Rebate Opportunities
HET Retrofits (Verified 3.5+ gpf to 1.28 gpf Pre-retrofit survey required)	\$100	\$150	
HET Retrofits (1.6 gpf to 1.28 gpf)	\$100	\$50	
Zero & Ultra-low Water Urinals (ZWU –ULWU) (0 – 0.25 gpf)	\$200	\$100	
Cooling Tower pH Controllers	\$1,750	\$1,800	Southern California Edison The Gas Company
Connectionless Food Steamers	\$485 per compartment	\$100 per compartment	Southern California Edison The Gas Company
Weather-Based Irrigation Controllers	\$25/station	\$25/station	
Central Computer Irrigation Controller	\$25/station	\$25/station	
Rotating Nozzles for Pop-up Spray Heads Retrofits	\$4	\$0	
Large Rotary Nozzles	\$13 per unit	\$0	
In-Stem Flow Regulators	\$1 per regulator	\$0	
Ice Making Machines	\$1,000 per machine	\$250 per machine	Southern California Edison The Gas Company

MWDOC, WaterWise, and the retail agencies were all proactive in marketing the Program. Components of marketing for the Water Smart Hotel Program involved local retail agencies sending out letters and postcards to hotels informing them of the availability of site specific surveys and enhanced rebates through the Program. WaterWise also contributed to marketing the Program by conducting cold calls to gain customer interest. Additionally, hotels were informed about the Program through word of mouth and vendor referral. When a hotel was interested, WaterWise staff pre-screened the hotel to determine if it qualified to participate in the Program. WaterWise then scheduled an appointment with the hotel to evaluate the indoor and outdoor water using equipment, informing MWDOC and the retail water agency of the survey date. A trained WaterWise employee would conduct the survey, and a customized report was prepared to provide the hotel with (1) specific recommendations to improve water use

efficiency and save money and (2) to promote the rebate funding for any recommendation listed. MWDOC and WaterWise delivered and reviewed the report with the participant. The local retail water agency was also invited to this report delivery meeting. After report delivery, follow up phone calls were made to see if the hotels needed any assistance in implementing the recommendations or accessing the rebate funding.

Program Effectiveness

Since the launch of the Water Smart Hotel Program in 2008, over 200 hotels have been solicited to participate in the survey program. Of the hotels that were contacted, a total of 54 hotels have participated as of May 2013, yielding a 25% participation rate. The hotels that were targeted were divided into three groups: (1) small hotels consisting of 0 to 50 guestrooms; (2) medium hotels consisting of 51 to 250 guestrooms and: (3) large hotels consisting of 251 or more guestrooms. In order for a hotel to qualify for the Program, it has to have been constructed before 1992. If the hotel was constructed after 1992, it is required to have 10,000 square feet or more of irrigated landscape. Inns and motels were allowed to participate in the Program if they met the Program qualifications. Marketing for the Program involved a group effort by MWDOC, MWDOC's retail agencies, and WaterWise staff. Some retail agencies promoted the Water Smart Hotel Program by sending out marketing letters out or visiting their high-water-using hotel customers. MWDOC staff assisted with the development of all marketing materials. WaterWise staff marketed the Program via promotional brochures and by conducting cold calls via phone and in-person to promote the Program.

The Water Smart Hotel Program's goal was to survey 105 hotels and achieve 531 acre feet of water savings per year. As of the date of the Process Evaluation, WaterWise has surveyed 54 hotels, which is 51% of the initial goal for the Program. Program success potential was measured by water savings identified through the hotel surveys. For those 54 surveyed hotels, WaterWise has reported a total potential annual water savings of 554 acre feet of water per year, which could result in 104% of the Program goal set by MWDOC, assuming all of the recommendations were implemented. Table 2 shows the number of hotels surveyed by year throughout the length of the Water Smart Hotel Program. Figure 1 illustrates the total potential water savings quantified during the course of the Water Smart Hotel Program.

Table 2. Number of Hotels Surveyed Annually

Year	Number of Hotels Surveyed
2008	0
2009	11
2010	18
2011	9
2012	8
2013	8

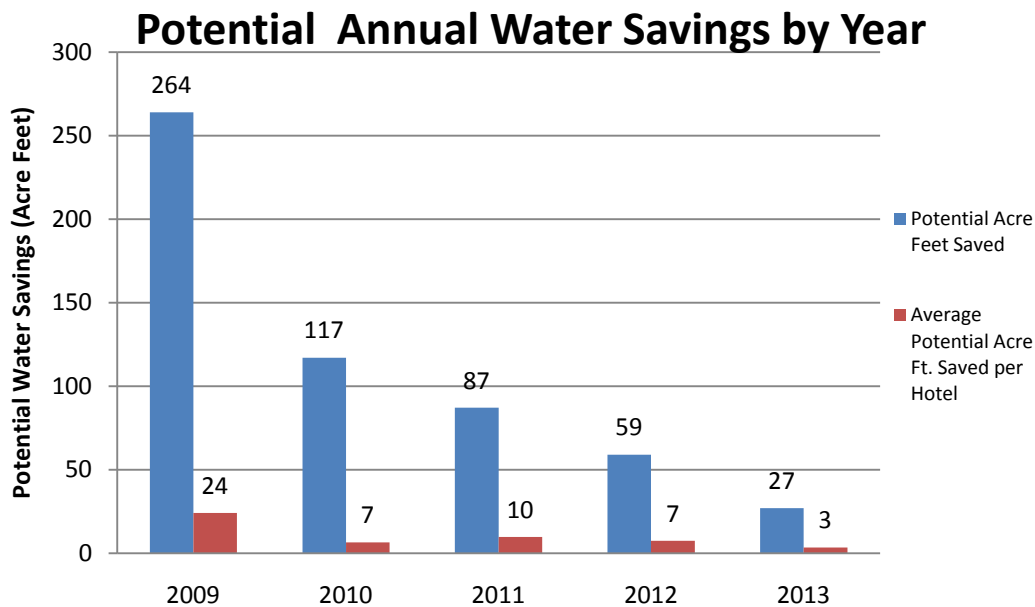


Figure 1. Total annual potential water savings and average potential annual water savings per surveyed hotel.

Program Models

The following three program models - logic, process theory, and impact theory - provide an overview of the steps taken for the Program. The logic model for the Hotel Program is displayed in Figure 2. From this model, the left most column displays inputs, which are stated as investments and include the agency staff, stakeholders, and vendors. The logistical investment includes marketing materials and surveys. The middle column lists the Program outputs. The outputs of what is actually done are: promote and conduct surveys, deliver reports, and offer rebates. The output column also lists the recipients of the program: hotels within MWDOC’s service area. The right column displays the outcomes by short, medium, and long term impacts. The short term outcomes result from learning and include:

awareness, knowledge, attitudes towards water efficient devices, site water use reduction, implementation of recommendations, and utilization of rebate opportunities. The medium term outcomes result from actions including behavioral and practice changes. A behavioral change would be participating in MWDOC’s Water Smart Landscape Program, which is a free water management program/tool that enables a site to track irrigation water use against a customized budget. Practice changes include continued maintenance and implementation of the recommendations over time. The long term condition changes are market transformation and a sustained decrease of indoor and outdoor water use at the hotel sites. Important components to the logic model are the assumptions and external factors. The assumptions are that contractors are willing to use new technologies and continue to drive customers to participate in the rebate programs. The external factors include site wants, policy changes, other messaging, other rebate programs, and weather trends.

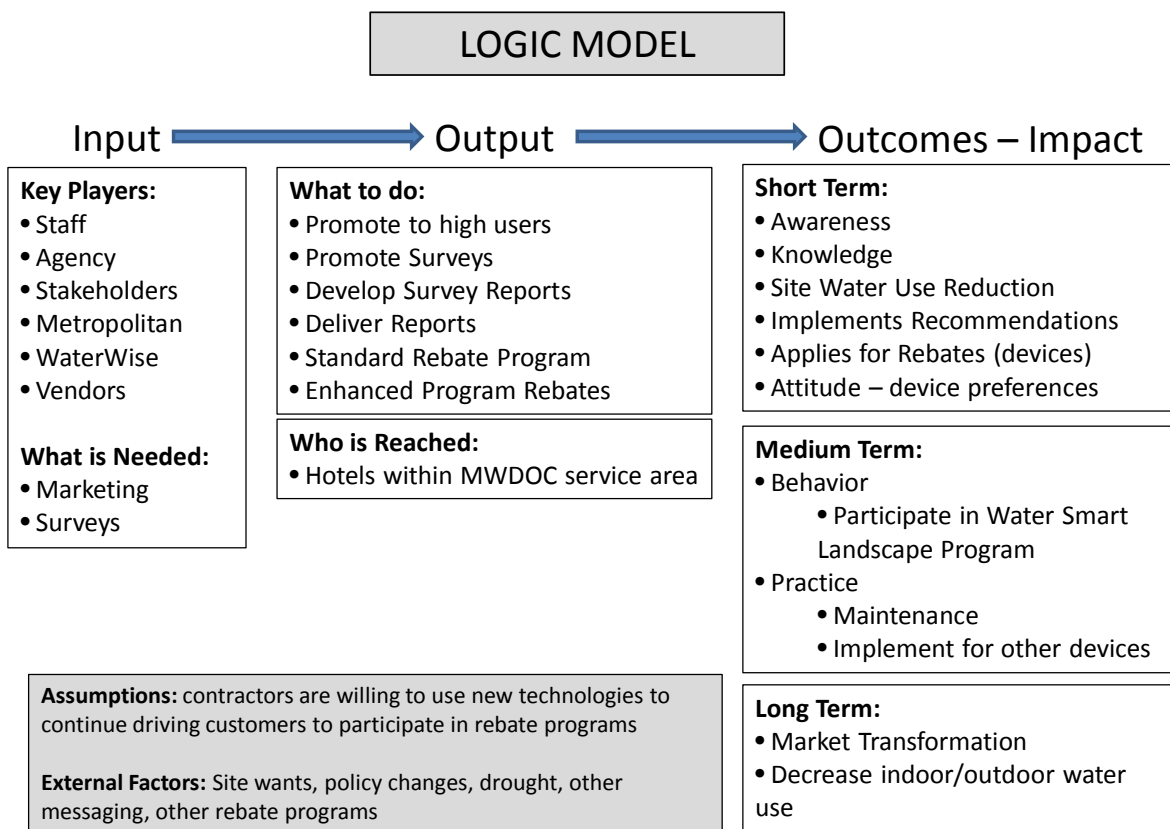


Figure 2 Logic Model for the Hotel Program

The impact model (Figure 3), traces the path of the Program and the subsequent outcomes. The Program is advertised in three ways: 1) MWDOC contracted with WaterWise for direct Program marketing, 2) Metropolitan markets the SoCal WaterSmart (a.k.a. Save-A-Buck Program), and 3) contractors encourage participation. Sites participating in the full Program receive surveys; however, sites can directly apply for rebates through the SoCal WaterSmart portal. Following the purchase and installation of the devices, rebates are provided. Rebate levels vary and include Program enhancement. Toilets, for example, receive a \$100 rebate from Metropolitan and a \$50 enhancement from MWDOC (check processed through SoCal WaterSmart). Sites with a verified (through a Program survey)

conversion of 3.5 gallons per flush to 1.28 gallons per flush can receive an additional \$100 “super enhancement” rebate from MWDOC (check processed through MWDOC). Confounding factors include site wants, policy changes, an increase in water costs, changes in technology, and introduction of other programs.

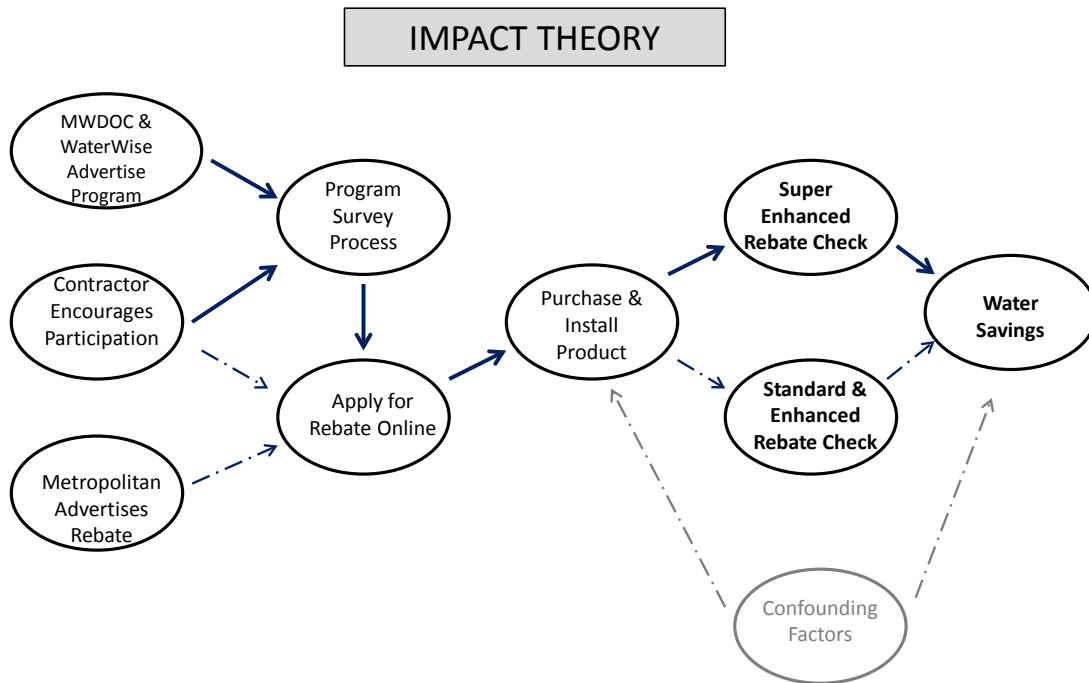


Figure 3. Impact theory model for the Hotel Program.

Process models (Figures 4 and 5) are more detailed than an impact theory model (Figure 3). The process model outlines the expected pathways and gaps. From this model, the role of Program personnel is also highlighted. The model splits the diagram into two parts: the Program’s organization plan and the Program’s utilization plan. The organization plan takes into account the tasks of the Program staff and affiliates to administer the rebates and surveys. In the two figures, below the alternative paths that could be taken are illustrated. In Figure 4, the site applies directly for the rebate through SoCal WaterSmart. Alternatively, in Figure 5, the site participates in the surveys prior to engaging with SoCal WaterSmart. The utilization half of the diagram traces the path of the participants from seeing the solicitation through increase in device installation.

The dashed lines in the model represent the pathway that results in gaps from confounding factors. The gaps will result in the following consequences: the site is not eligible based on location or age; the new device is not eligible; the device is recommended, but the rebate is not applied for; or the rebate is applied for, but the device is not installed.

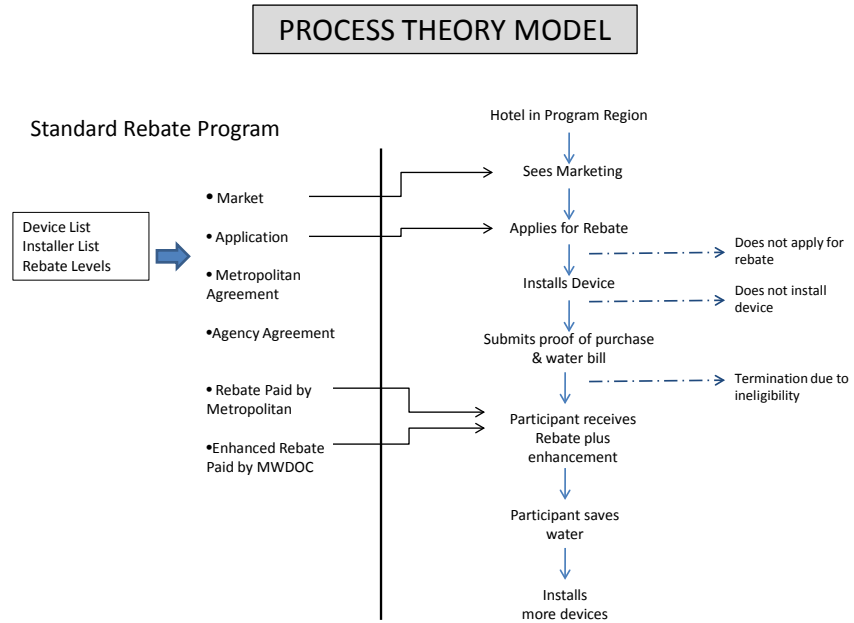


Figure 4. Process theory model for the Hotel Program when participants only participated in the SoCal WaterSmart Program.

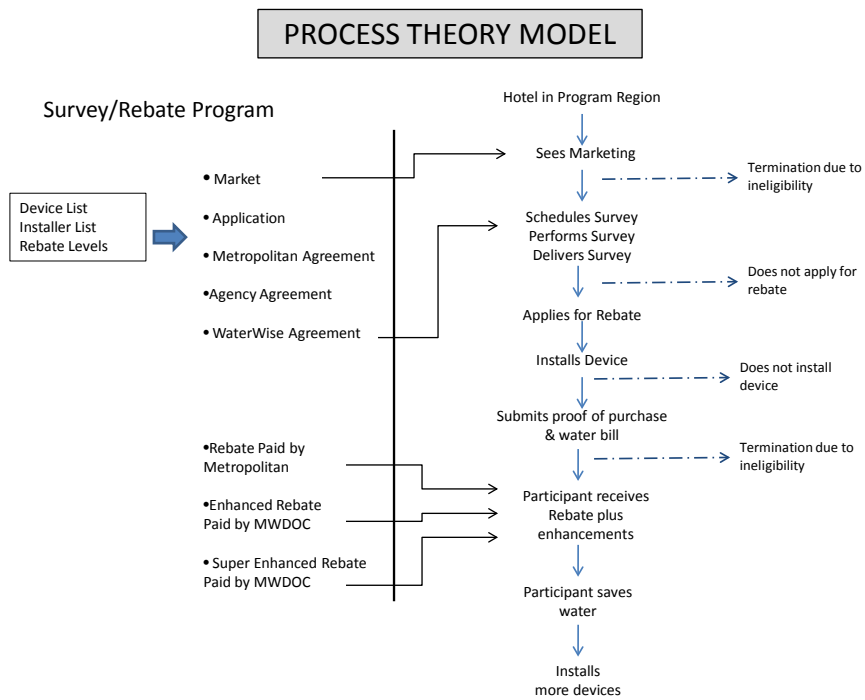


Figure 5. Process theory model for the Hotel Program when participants participated in the MWDOC Survey Program.

Process Evaluation Methodology

The primary objective of the Program Evaluation was to determine the success rate of the Water Smart Hotel Program and measure the amount of water saved throughout the course of the Program. The following information describes the detailed methodology of the Process Evaluation.

Hotels were split into three treatment groups for the purposes of this study. The three treatment groups consisted of:

- Group 1 - Hotels that participated in the Water Smart Hotel Program surveys, made retrofits to their hotel, and received rebates.
- Group 2 - Hotels that participated in the Water Smart Hotel Program surveys, but did not implement any of the recommended retrofits or receive rebates.
- Group 3 - Hotels that did not participate in the Water Smart Hotel Program surveys, but received rebates through SoCal WaterSmart for retrofits.

Representative samples of hotels were taken among the different treatment groups. A control group of hotels that did not participate in the Water Smart Hotel Program surveys or receive any rebates was also interviewed in order to provide a comparison group.

As part of this study, hotels in each treatment group were informed via letter that they would be contacted to participate in the Program Evaluation. Using the Program marketing data that was obtained from WaterWise, ESG compiled a list of hotels that would be sent the letters. The letters inviting hotels to participate in our Process Evaluation survey were then sent at random.

Interview questions were developed and approved by MWDOC staff for each of the treatment groups. The interview questions were formed specifically to identify reasons for participating in the Program, the retrofits that were made, the rebates that were received, hotel occupancy rates, etc. Questions varied based on the specific treatment group. The questionnaire was kept as short as possible, but still comprehensive enough to provide quantifiable information for the study.

As part of the Program Process Evaluation, interviews were conducted with MWDOC and WaterWise in order to better understand the Water Smart Hotel Program. Information was collected regarding the number of sites surveyed since the beginning of the Program, Program challenges, marketing, potential water savings, rebates, etc. Gathering this information was just as important as gathering information from hotels. The information gathered from MWDOC and WaterWise proved useful in describing the Program's history, reporting potential water savings, and understanding the successes and challenges that were faced during program implementation.

Review of Surveys/Interviews

After the hotels in each treatment group were sent invitation letters, staff, using various methods, began contacting management and facilities personnel at the hotels. Initially hotels were contacted by phone, but once participation in interviews began to ebb, other methods were used to make contact. These methods included in-person contact, leaving voicemail messages requesting a return call, and sending emails with the interview questions to those hotels that requested to be emailed. Table 4

Process Evaluation

shows the number of hotels contacted for interviews per treatment group, along with the number of hotels that actually participated in the interview versus hotels that agreed to participate and did not or that did not respond to our request for an interview. Treatment Groups 1 and 2 were combined due to our attempts to obtain 20 responses from each treatment group for the purposes of this Evaluation. All hotels in each treatment group were contacted up to five times each in an attempt to reach our goal of 20 responses per treatment group. Instances occurred where ESG staff was able to make contact with hotel or facility managers and were told to provide the interview questions via email. Table 3 shows, by treatment group, the number of hotels contacted and a breakdown of the number of hotels that participated in the interviews and number of hotels that did not participate.

Table 3 Number of Hotels Contacted

Response by Type	Groups 1 (No. of Hotels)	Groups 2	Group 3 (No. of Hotels)	Control Group (No. of Hotels)	Total (No. of Hotels)
Participated in interview for Process Evaluation	19	2	1	9	31
Offered to respond to interview by email, but did not participate	9		0	23	32
Hotels that said they would call back, but did not participate	2		0	16	18
Hotels that did not respond to interview requests	10		58	22	90
Total Number of Hotels Contacted	42		59	70	171

Overall, the interview effort yielded an 18% response rate. Of the total 171 hotels contacted, 31 participated in the interview. However, of the hotels that were contacted for Treatment Groups 1 and 2, 50% of the hotels allowed ESG staff to conduct interviews for the Process Evaluation. Treatment Group 3 had the lowest participation levels at a 2% participation rate. The Control Group had a 13% participation rate. However, out of the number of hotels contacted in the Control Group, 55% said they would participate in the interview via email or a return call, but did not.

Follow up calls and emails were made to these hotels, with no success. As ESG staff continued to call hotels for participation in the Process Evaluation interviews, hotel managers indicated that they were too busy to participate. Some hotels thought the interviews were being used as an attempt to sell products. There were also hotels that showed no interest in participating in any conservation programs whatsoever.

For the hotels that did participate in the interviews, hotel managers or facilities staff members answered the interview questions to the best of their knowledge, but were unable to answer the entire set of interview questions as exact information was not on hand at the time. When asked what additional assistance the hotels would like from their water utility, seven hotels in Groups 1 and 2 requested assistance with irrigation equipment, faucets, showerheads, urinals, and dual flush toilets. Treatment Group 3 and the Control Group were asked the same question and did not request any assistance. From this it can be inferred that the participation in the Program survey resulted in a sense of trust or ease when reaching out for water use efficiency knowledge for the hotels that were interested in water conservation.

Table 4 illustrates the hotel manager’s or facilities staff’s awareness of the Water Smart Hotel Program, as well as the rebates that were accessed by the hotels in each treatment group that participated in the Process Evaluation. The participation percentages are based on the responses from the 31 Process Evaluation participants. Appendix B contains the interview questionnaires that were created for each treatment group.

Table 4 Conservation Program Interview Response

Objectives	Group 1	Group 2	Group 3	Control Group	Participation Percentage
The hotels aware of the Water Smart Hotel Program	19	2	1	4	83% (26/31)
Participated in Toilet Rebates	14	0	0	3	55% (17/31)
Participated in Weather-Based Irrigation Controller Rebate	2	0	0	0	6% (2/31)
Participated in a rebate, but did not remember which rebate	3	0	0	4	19% (7/31)
Number of hotels willing to participate in a future conservation program	n/a	n/a	0	1	10% (1/10)
Number of hotels that would like additional conservation rebates and incentives	5	2	0	0	23% (7/31)

Impact Analysis

The previous sections discussed the functionality of the Program through a Process Evaluation. The Impact analysis focuses on the other important question, “how much water has the Program saved?” To judge the Program’s efficacy, all parties that have funded this Program require an answer to this question. MWDOC additionally needs these savings estimates for inclusion in its long-term water supply plan.

For the Impact Analysis, it was important to obtain water use history data for the hotels in each of the treatment groups. Evaluating water use histories provided useful information on water use and savings for hotels that made retrofits versus water use for hotels that have not make any retrofits. The water history data also provided valuable information on the effects of the recession on water use at the hotels that participated in the Program Evaluation.

A statistical analysis of the collected data was performed in order to provide insight into the characteristics of hotels that participated in the Water Smart Hotel Program, determine if a reduction of water use was due to conservation measures or affected by the recession, and establish the types of water conservation equipment that were retrofitted among hotels that took advantage of the rebates.

Penetration of the Water Smart Hotel Survey Program

There are roughly 448 hotels and motels in MWDOC’s service area (Table 5). This information is only available in the form of aggregate counts by city. By the Fall of 2012, 45 of these had participated in the Water Smart Hotel Program surveys.¹ These 45 surveys were implemented between February 2009 and April 2012. A total of 127² hotels have also received one or more rebates. The earliest retrofits qualifying for rebates are reported to have occurred in January 2008 and the latest in March 2012. The rebate program began 13 months prior to the survey program. In some service areas, the survey program was not offered at all so the number of hotels receiving rebates is much greater than those that participated in the Water Smart Hotel Program surveys. Furthermore, according to the rebates database maintained by MWDOC, only 22 of the 45 surveyed hotels appear to have accessed rebates. Does this mean that the remaining surveyed hotels have not acted on the recommendations of the Water Smart survey? Could they have undertaken retrofits without applying for rebates? Addressing this question was one of the objectives of the process evaluation surveys (not to be confused with the original Water Smart Hotel Program surveys), but we have not been able to achieve a high response rate to these process evaluation surveys to successfully address this and other related questions.

While rebate and other data about the Water Smart Hotel Program were available from MWDOC, the billing histories had to be requested from each of the participating retail agencies. Of the 448 hotels in MWDOC’s service area, we were able to compile a master list with street addresses for only 273 hotels

¹ Since then additional surveys have been completed. Through June 2013, the survey count increased to 54, as reported earlier.

² Through June, 2013, a total of 143 hotels implemented water savings practices tracked though the rebate component of the Program with 11,648 devices rebated, yielding 503 acre feet based on industry accepted device water saving rates.

Impact Evaluation

and motels. This master list was created from data provided by MWDOC and WaterWise Consulting, the implementing vendor for the Water Smart Hotel Program. The master list includes both hotels that participated in the Water Smart Hotel Program (surveys, rebates, or both) and those that were contacted by WaterWise Consulting during the marketing of the Water Smart Hotel Program, but that chose not to participate. Hotels for whom WaterWise Consulting was unable to obtain clean location and contact information, and to whom they never marketed the Water Smart Hotel Program, were excluded from the process and impact evaluations.

Table 5. Hotels by City in MWDOC's Service Area

City	# of Hotels	Agency
Aliso Viejo	3	Moulton Niguel Water District
Anaheim	125	City of Anaheim
Brea	9	City of Brea
Buena Park	17	City of Buena Park
Costa Mesa	34	Mesa Water District
Cypress	12	Golden State Water Company
Dana Point	11	South Coast Water District; small portion in City of San Juan Capistrano
Foothill Ranch	3	Irvine Ranch Water District
Fountain Valley	3	City of Fountain Valley
Fullerton	10	City of Fullerton
Garden Grove	20	Cit of Garden Grove
Huntington Beach	16	City of Huntington Beach
Irvine	19	Irvine Ranch Water District
La Habra	3	City of La Habra
La Palma	2	City of La Palma
Laguna Beach	22	Laguna Beach County Water District; small portion in South Coast Water District
Laguna Hills	3	half El Toro Water District; half Moulton Niguel Water District
Laguna Niguel	2	Moulton Niguel Water District
Laguna Woods	1	El Toro Water District
Lake Forest	6	half El Toro Water District; half Irvine Ranch Water District
Los Alamitos	1	Golden State Water Company
Mission Viejo	3	half Moulton Niguel Water District; half Santa Margarita Water District
Newport Beach	19	City of Newport Beach; small portion Mesa Water District; small portion Irvine Ranch Water District
Orange	17	half City of Orange; half Irvine Ranch Water District; small portion Golden State Water Company
Placentia	3	Golden State Water Company; small portion Yorba Linda Water District
Rancho Santa Margarita	0	Santa Margarita Water District; small portion Trabuco Canyon Water District
San Clemente	19	City of San Clemente
San Juan Capistrano	6	City of San Juan Capistrano
Santa Ana	35	City of Santa Ana
Seal Beach	3	City of Seal Beach
Stanton	5	Golden State Water Company
Tustin	3	City of Tustin; small portion Irvine Ranch Water District
Villa Park	0	Serrano Water District
Westminster	8	City of Westminster
Yorba Linda	5	Yorba Linda Water District; small portion of Golden State Water Company
TOTAL	448	

SOURCE: MWDOC.

Sample Characteristics

Eleven retail water agencies sent us usable billing data for 88 hotels out of the master list of 273 hotels. These include the City of Fountain Valley, City of Garden Grove, City of Huntington Beach, Irvine Ranch Water District, Laguna Beach County Water District, Mesa Water District, City of Newport Beach, City of Santa Ana, South Coast Water District, City of Tustin, and the City of Westminster. Billing data for 4 hotels (over and above the 88) could not be used because the data did not extend back enough in time, or suffered from missing read dates, or were not provided in clean spreadsheet format.

Table 7 and Table 8 show how our sample of hotels compares with the population of 273 hotels from which it was selected. The sample was not selected using random sampling, but instead represents the compilation of all the billing data provided to us.

Our analytic framework also includes a control group, necessary for separating the impact of retrofits from that of the coinciding recession, which began in late 2008. Without this, the framework could lead to inflated savings estimates. Control group hotels are those that neither participated in the Water Smart Hotel Program surveys nor obtained any rebates, but were informed about the Water Smart Hotel program by WaterWise. Our analysis sample of 88 hotels includes 16 such hotels.

Table 6 Type and Number of Device Retrofits

	Population		Sample	
	Number	Percent	Number	Percent
Survey, no retrofit	22	8.0%	7	8.0%
Survey, retrofit status unclear	3	1.1%	3	3.4%
Retrofit Group	127		62	
HET only	106	38.8%	49	55.7%
ULFT only	1	0.4%	--	--
HEU only	1	0.4%	1	1.1%
Smart Controller only	2	0.7%	--	--
Smart Controller + Nozzles	6	2.2%	6	6.8%
HET + HEU	2	0.7%	1	1.1%
HET + Smart Controller	3	1.1%	3	3.4%
HET + Nozzles	1	0.4%	--	--
HEU + Nozzles	1	0.4%	1	1.1%
Other	4	1.5%	1	1.1%
No survey, no retrofit (Control Group)	121	44.3%	16	18.2%
TOTAL	273	100.0%	88	100.0%

Table 6 classifies hotels by the combination of plumbing fixtures and devices that were retrofitted and subsequently rebated. Hotels had several indoor and outdoor retrofit options available to them, including: (1) high-efficiency toilets (HETs) rated at 1.28 gallons per flush; (2) ultra-low-flush toilets (ULFTs) rated at 1.6 gallons per flush; (3) high-efficiency urinals (HEUs) rated at 0.5 gallons per flush or waterless; (4) weather-based smart irrigation controllers; (5) rotating spray nozzles; and (6) a few other options such as water brooms and one high-efficiency washer in the case of one hotel.

The vast majority of the cases involve HET retrofits, either alone or in combination with other fixtures. We were able to separately estimate savings for this HET subgroup in addition to overall savings. Retrofit combinations that account for less than 10% of the sample are too infrequent to permit reliable estimation of water savings independent of overall savings.

Table 7. Distribution of Hotels By Star Rating & Number of Rooms

Star Rating	Number and Percent by Star Rating				# of Rooms	Number and Percent by # of Rooms			
	Population		Sample			Population		Sample	
<=2	49	17.9%	21	23.9%	<=100	49	17.9%	23	26.1%
2.5-3.5	68	24.9%	29	32.9%	101-200	40	14.7%	16	18.2%
4 or 5	12	4.4%	8	9.1%	>=201	28	10.3%	14	15.9%
Missing	144	52.7%	30	34.1%	Missing	156	57.1%	35	39.8%
TOTAL	273	100.0%	88	100.0%		273	100.0%	88	100.0%

Table 7 compares our sample to the population that it represents, on two dimensions: (1) the hotel’s star rating; and (2) total number of rooms. Although, information on both dimensions is missing for a large fraction of the population and sample, our sample exhibits a good mix of hotels by both the star rating and number of rooms. A greater proportion of hotels within the sample can be categorized either by their star rating (65.9%) or number of rooms (60.2%) compared to the population as a whole, where this information is available less than half the time. If the missing categories are ignored, however, the distribution of hotels in the sample and the population appear broadly comparable.

Conceptual Framework

Evaluations aim to quantify the impact of an intervention (Program) on a group of subjects by comparing outcomes after the intervention to what the outcomes would have been in the absence of the intervention. Participant outcomes in the absence of the intervention are fundamentally unobservable—they have to be inferred either through pre-intervention longitudinal data, or through the behavior of a control group.

A complicating factor, however, is the economic recession that coincides with this Program. Since a weak economy may also have caused a drop in hotel visits, it can potentially lead to an overstatement of water savings attributed to the Water Smart Hotel Program. The presence of a control group certainly helps to reduce this possibility, but does not eliminate it completely since the control and retrofit groups

are not matched by design, as would be the case if both had been sampled at random. Therefore, one cannot assume that both groups have been equally impacted by the recession.

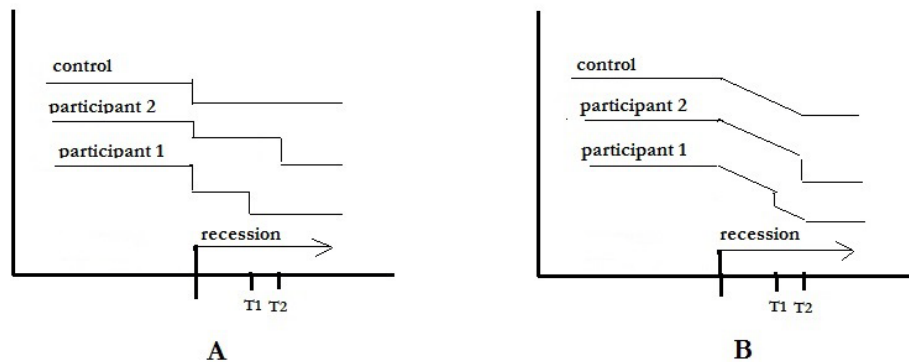


Figure 6. Impact of Recession on Water Savings Evaluation

Figure 6 describes the situation relevant to the present study. A hotel retrofit program is implemented when water use is below the historical norm. The control group available to assess the impact of the recession is not well matched to the retrofit group. However, since participant sites are retrofitted at different points in time (i.e., T1, T2, and so on), it is possible to test whether water use is stable or continuously adapting to the recession.

Figure 6-A shows the relatively easy case where water use adjusts to the recession very quickly, remaining stable thereafter. In such a case, comparing post-intervention water use to the recession-period water use yields the net impact of the retrofits. The net impact can obviously vary across sites since their characteristics differ. Reliability of impact estimates depends upon how rapidly each site adapts to the recession. If water consumption drops quickly at the beginning of the recession and remains stable afterward, impact estimates are likely to be reliable. If, however, sites adapt to the recession gradually (Figure 6-B), impact estimates are likely to be sensitive to assumptions about the recession's beginning. Such an empirical property is testable, thus providing a convenient technique for assessing the reliability of the savings estimates.

Billing histories indicate that we have both types of situations in our sample. Figure 7 shows a hotel where water use dropped sharply once all toilets were retrofitted with HETs. The impact of the recession is barely evident in these data. Savings can be estimated quite reliably. Many other hotels in our sample exhibit this pattern.

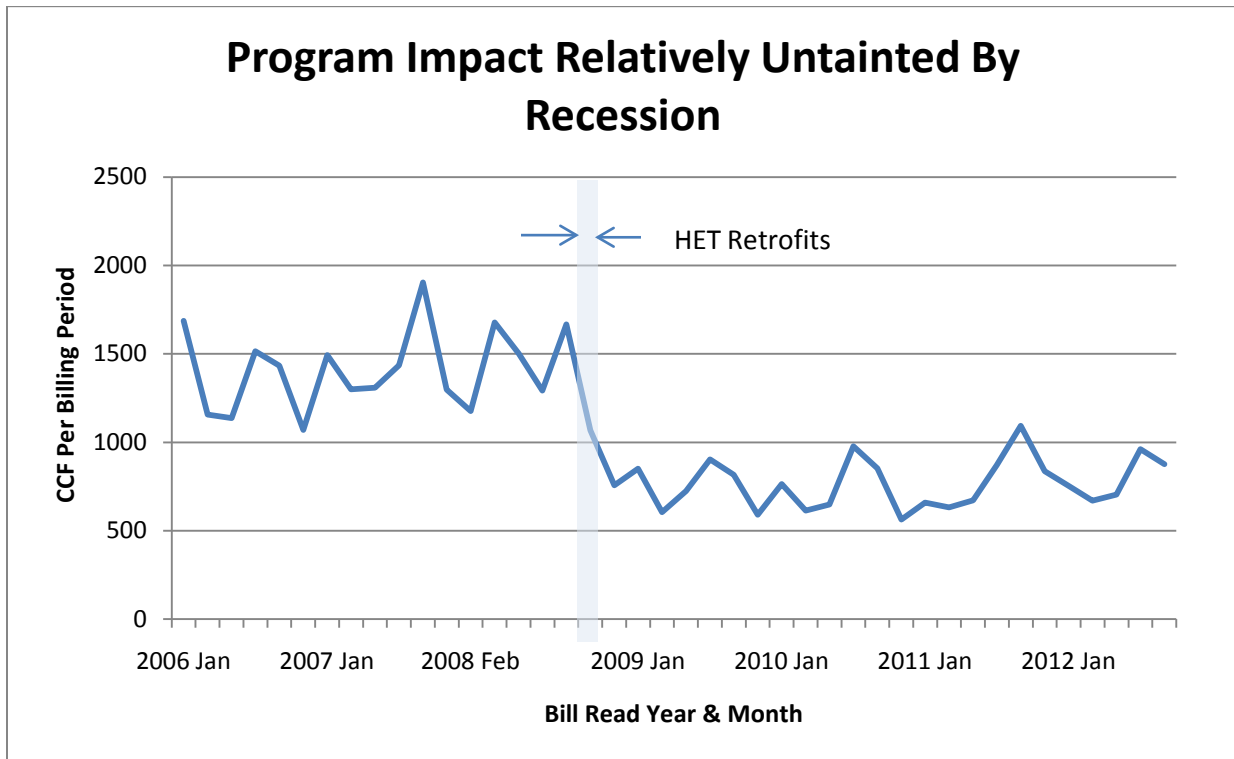


Figure 7. Hotel with Low Recession, High Program Impact

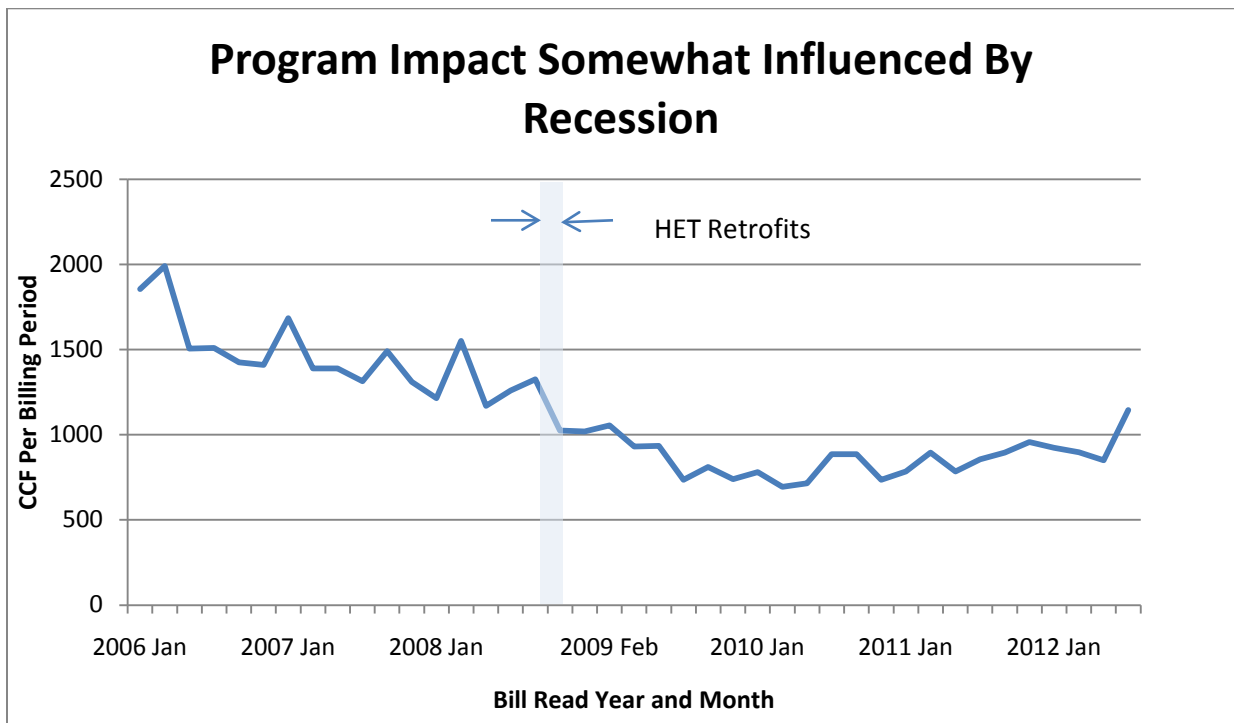


Figure 8. Hotel with High Recession, High Program Impact

But our sample also includes cases (Figure 8) where the pre-retrofit and post-retrofit demand patterns are not as sharply delineated as they are in Figure 7. In Figure 8, water use drops after the HET retrofits, but along a trend line that appears to be a continuation from the pre-retrofit period. Water demand eventually bottoms out in fall 2009 and stays at this new low level. It has taken almost a year after the retrofits to reach this point. Why? That is hard to say without a lot of detailed site data. If the entire post-retrofit history is used to estimate water savings, it will produce a slightly different estimate than if only the post-bottom point history from fall 2009 is used. In the absence of detailed data to inform these analytic choices, one is forced to rely on sensitivity analyses. There is no doubt that the impact of HET retrofits in this hotel is real because the post-retrofit history continues to remain significantly below the pre-retrofit history. However, reliable estimation of the magnitude of the impact is another matter, discussed in greater detail in Appendix C.

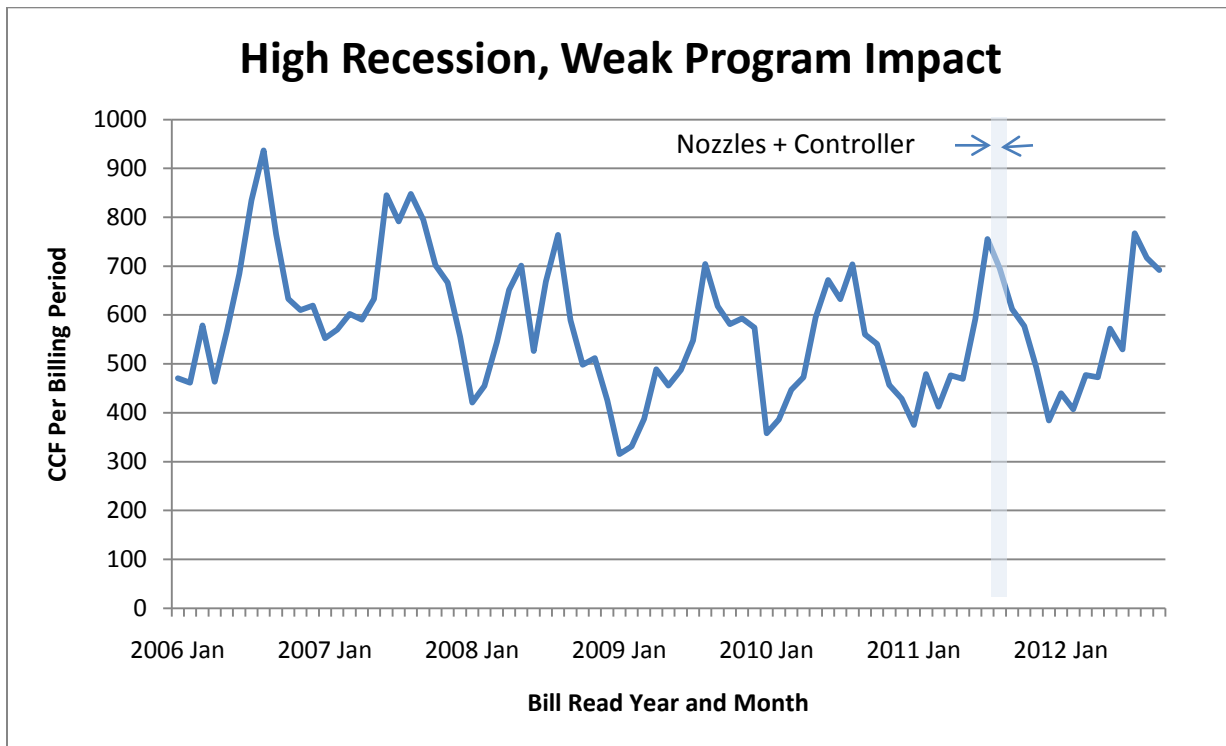


Figure 9. Hotel with High Recession, Weak Program Impact

Figure 9 shows another example where instead of HET retrofits, this hotel undertook some actions to improve their irrigation system, such as upgrading nozzles and installing a weather-based smart controller. The billing history suggests that business in 2009 was impacted by the recession, but it is difficult to discern any impact of the retrofits in 2012.

As mentioned earlier, most of the retrofits undertaken under the auspices of the Water Smart Hotel Program have been HETs. Based on our limited data, it also appears that those hotels that have undertaken these HET retrofits have by and large changed out all their toilets. We have information

about total number of rooms only for 24 hotels of the 53 that have engaged in HET retrofits. In this subset, it appears that over 90% of all toilets have been replaced with HETs. Given this high level of HET saturation, it is to be expected that hotels that undertook HET retrofits ought to show greater savings than those that have retrofitted a few devices or fixtures here and there, such as a few urinals or a smart controller, etc.

Appendix A discusses in greater detail the specification, testing, and sensitivity analyses of the estimated models. The methodology takes the billing data structure with staggered read dates across customers as is, without any tampering such as interpolation into calendar months. Instead, to account for weather, our methodology matches weather exactly to the time period that is covered by a read, by working with daily weather data. Weather is captured using daily rainfall adjusted reference ETo from CIMIS.

Results

Among hotels in our sample that have undertaken retrofits, roughly 85% (that is, 53 among 62 hotels) have either retrofitted HETs alone or in combination with other fixtures. Accordingly, we were able to estimate savings for two primary groups: (1) hotels that retrofitted HETs alone or in combination with other devices; and (2) hotels that retrofitted devices and fixtures other than HETs. In the latter, it is not possible to disaggregate any further because of small sample size.

Table 8 Water Savings By Retrofit Group

Type of Retrofit Group	Percent Reduction in Demand
Hotels with HET retrofits, alone or in combination with other fixtures	22% †
Hotels with retrofits other than HETs	5% ‡
All retrofitted hotels	18% †

†Statistically significant at 1% level. ‡Statistically insignificant.

We estimate that hotels that engaged in large-scale HET retrofits have reduced their water demand by 22% (statistically significant at 1%). As mentioned earlier, most hotels that focused on retrofitting HETs seem to have done it on a large scale. Where we have information on total rebated HETs and total number of rooms in a hotel, we estimate that in such hotels HET saturation is over 90%. Thus the finding of significant water savings is not surprising.

For hotels that did not retrofit HETs, we estimate they reduced water consumption by 5%. This result is not statistically significant, however. That does not mean that retrofit of other fixtures and devices, such as urinals and smart controllers did not save water, only that we have too few cases in our sample to reliably estimate savings for these types of hotels.

Overall, hotels in the sample have reduced their water demand by 18% (statistically significant at 1%). These are conservative estimates selected from the many different model specifications we used to assess the impact of the recession on our savings estimates. Even so, they translate into large amounts of water savings. We estimate water use prior to the retrofits was 22.7 CCFs per day for the average

Impact Evaluation

retrofitted hotel in our sample. A savings of 18% translates into 4.1 CCFs per day or 3.4 acre-feet per year per retrofitted hotel.

We also examined if hotels that participated in the Water Smart Hotel Program surveys without evidence of participation in the rebate program had perhaps acted on their own to implement recommendations made to them in the Water Smart surveys, but we could not detect any water savings for these hotels.

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Evaluation Conclusion

Of the 450 hotels in MWDOC's service area, over 200 hotels were contacted to participate in the Water Smart Hotel Program.

From Program launch, in November 2008, through June 2013, WaterWise completed 54 surveys, which have identified potential water savings of 554 acre feet of water per year, assuming all recommendations are implemented. Of the hotels which received surveys that were interviewed (n=21), there was a 90% implementation rate for installing the rebated devices. This shows real promise for the Water Smart Hotel Program and the potential water savings that could be achieved in hotels within MWDOC's service area.

Over the same time period, 143 hotels implemented water savings practices tracked through the rebate component of the Program. There were 11,648 devices rebated, yielding 503 acre feet based on industry accepted device water saving rates. From the Impact analysis, the water use at the hotels prior to the retrofits was 22.7 hundred cubic feet per day for the average retrofitted hotel in our sample. A savings of 18% translates into 4.1 hundred cubic feet per day or 3.4 acre-feet per year per retrofitted hotel.

Although the survey component of the Program has only resulted in 51% of the goal so far, the water saving goal is already at 95% and on track to exceed this goal. The Water Smart Hotel Program is currently ongoing and is set to conclude in June of 2014. A collaborative effort by MWDOC, WaterWise, and retail agencies is important in reaching the goals that were set forth by MWDOC.

Program Challenges and Successes

As with most programs, there are challenges encountered during implementation. Some of the challenges experienced with the Water Smart Hotel Program included Program funding, difficulties in getting hotels to participate in the Program, staffing issues with WaterWise, and marketing issues among retail agencies due to varying staff levels and workloads.

As the Water Smart Hotel Program was set to begin near the end of 2008, DWR program funding was frozen, and Metropolitan Water District of Southern California was faced with conservation program funding limitations as well. When this challenge with funding was presented to MWDOC's Board of Directors, they elected to continue on with the Water Smart Hotel Program and carry the costs of the Program until the funding freeze was over. In June 2009, MWDOC also applied for and received a CalFed Water Use Efficiency Grant from USBR to assist with Program funding. The freeze in DWR funds ended shortly thereafter, in September 2009.

Staffing changes at WaterWise were another challenge that was faced throughout the course of the Water Smart Hotel Program. MWDOC reported that program management at WaterWise had changed four times during the Program's term, which impacted Program momentum.

Customer participation was the biggest challenge for the Water Smart Hotel Program. Due to the 2008-2010 economy, hotels experienced low occupancy rates, had limited staff, and did not have time to

Conclusion

participate in the Program. Another issue with participation was the lack of name recognition for MWDOC and WaterWise with the hotels as neither was the hotel's water retailer. Credibility played a big role in participation from hotels. A marketing strategy was put in place to provide more information about MWDOC, the local water retail agencies, and WaterWise in order to enhance credibility with the hotels. MWDOC, WaterWise, and member agencies all worked together to market the Program, with a success rate of approximately 27%.

Process Evaluation

The Process Evaluation was faced with several challenges that extended the length of the Process Evaluation, including the organization of data and securing participation from hotels in the interview process. In spite of these challenges, we were still able to obtain useful data for the Process Evaluation.

One of the first challenges faced in the Process Evaluation was the organization of the raw tracking data from WaterWise. Since, due to unforeseen staffing issues, the Program experienced four changes in program management, there were slight variations among the tracking methods of each program manager. For example, there were inconsistencies with hotel names and contact information that had to be clarified before sending letters to hotels to inform them about the Process Evaluation. This was a result of multiple tracking logs for the Program. While organizing the varying tracking logs added a slight delay, this issue was fixed without any major problems.

Another challenge that was faced was with obtaining water history information from some of the retail water agencies within MWDOC's service area. As water history information was being requested, some retail agencies were unable to provide information due to privacy issues with their customers. Even though the Process Evaluation would not be divulging names of hotels, privacy was still a concern. We were able to make adjustments to this challenge by focusing our study on those retail agencies that were more able to provide us the information.

We were also met with a challenge involving customer participation from specific treatment groups. Of the three treatment groups and the control group, hotels that had actively participated in the Water Smart Hotel Program seemed to be more responsive to being interviewed for this study. However, both the treatment group that did not participate in the Water Smart Hotel Program, but received rebates to make retrofits to their hotel, and the control group that did not participate in the survey program or make retrofits to their hotel were less responsive to our requests.

Five attempts each were made to conduct interviews with the hotels in the retrofit-only group and the control group, with only 10 responses from the 129 hotels that were contacted in those groups. We used various methods to request participation from these hotels, including in-person contact, telephone contact, voicemail messages, and multiple emails. Often when we would get in contact with hotel management, we were told that the hotel was interested in participating and would like to answer the questions through email. However, we would never receive responses from these hotels after sending the requested emails to them. Of the 171 hotels contacted, 32 requested emails, 18 offered to call back at a better time, and 90 hotels did not have time to participate in an interview. The hotels that requested emails or offered to call back at a more convenient time did not ultimately participate in the

Conclusion

interviews. As difficult as it was to gain responses from these groups, it shows us that obtaining participation in the Water Smart Hotel Program and the Process Evaluation is no easy task. A new marketing strategy might be necessary to increase participation levels in future programs.

Although participation levels for the Process Evaluation were not optimal, ESG and WPR chose to move forward with the data that was obtained. Out of the 450 hotels in MWDOC's service area, WaterWise contacted over 200 hotels, an approximate 25% success rate. ESG contacted 171 hotels to participate in the Process Evaluation and achieved an 18% success rate. New strategies in marketing should be developed for similar future programs.

Impact Analysis

The Impact Analysis was complicated by the ongoing economic recession, which roughly coincides with the time period that the Water Smart Hotel Program has been in operation. In spite of these problems, the Impact Evaluation suggests that hotels that have undertaken plumbing fixture and device retrofits, such as HETs, HEUs, weather-based irrigation controllers, etc., are saving significant amounts of water as a result. We estimate savings of 18% or 3.4 acre-feet per retrofitted hotel per year. HET retrofits far outstrip other fixtures and devices, and the overall savings estimate largely reflects the impact of HET retrofits. Furthermore, hotels that have retrofitted HETs have usually done so on a large scale. For those hotels where we had data about both total number of rooms and total HETs installed, it appears HET saturation may be in excess of 90%. The overall Program impact thus largely stems from HET retrofits.

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Appendix A—Letter to Water Smart Hotel Program Participants

Hotel Name

Address

Dear Hotel Manager/Facilities Manager,

This letter has been sent to you because you have either participated in or have been contacted about participating in the Municipal Water District of Orange County's (MWDOC) Water Smart Hotel Program.

As the Water Smart Hotel Program is coming to an end, MWDOC is interested in evaluating the success rate of the program with the local hotels in MWDOC's service region. MWDOC has informed your local water retailer about the evaluation and that we will be conducting interviews with the hotels in their service area over the next few weeks. MWDOC is currently working with Envirosmart Solutions Group (ESG) to perform the evaluation of the program. As part of the evaluation of the MWDOC Water Smart Hotel Program, we would like to ask for your participation in a brief phone interview with a representative from Envirosmart Solutions Group. The phone interview will take approximately 5-10 minutes of your time.

Your participation is greatly appreciated and will help with future decisions for water conservation in the hotel industry. Thank you for your time and we look forward to speaking with you.

Sincerely,

Steven Chov

Appendix B—Interview Questions

Treatment Group One

1. How did you hear about the Water Smart Hotel Program?
2. Were you satisfied with the data collected and results of the survey report provided?
3. Did you implement the recommended changes from the report provided by WaterWise Consulting?
4. If so, what water using fixtures were retrofitted?
5. Did you participate in any incentive or rebate programs provided by MWDOC, Metropolitan Water District, or City programs? If so, which programs?
6. If you did not make any recommended changes, what was the reasoning for it?
7. What additional assistance would you like from your water utility to help you become more water efficient?
8. What is your hotel's star rating?
9. In which year was your hotel constructed?
10. Can you provide us with your hotel occupancy rate by year from 2004 to 2012?

Treatment Group Two

1. How did you hear about the Water Smart Hotel Program?
2. Were you satisfied with the data collected and results of the survey report provided?
3. Did you implement the recommended changes from the report provided by WaterWise Consulting?
4. If so, what water using fixtures were retrofitted?
5. Did you participate in any incentive or rebate programs provided by MWDOC, Metropolitan Water District, or City programs? If so, which programs?
6. If you did not make any recommended changes, what was the reasoning for it?
7. What additional assistance would you like from your water utility to help you become more water efficient?
8. What is your hotel's star rating?
9. In which year was your hotel constructed?
10. Can you provide us with your hotel occupancy rate by year from 2004 to 2012?

Treatment Group Three

1. Our records indicate that you obtained rebates to improve water use efficiency in your hotel. How did you hear about the Water Smart Hotel Program?
2. What rebate program did you participate in and through which agency?
3. Which water using fixtures or appliances did you retrofit and obtain rebates for?
4. Did you make any additional modifications to improve water-use efficiency in your hotel that were not eligible for rebates?
5. When were the rebated retrofits made as well as the non-rebated retrofits to your hotel?

Appendix B

6. If the hotel was contacted by an installer to make retrofits, did you use the same installer that initially contacted you to complete the retrofits?
7. Would you participate in a free indoor water use survey if it was offered by your local water agency in the future? (Yes/No)
8. If no, what assistance would you like from your local water agency or provider to become for your hotel to become more efficient?
9. How many guest rooms are in your hotel?
10. Are there any water efficient toilets in the hotel? If so, how many?
11. Are there any low flow showerheads installed in the hotel? If so, how many?
12. Is there an onsite laundry present? If so, how old are the laundry machines?
13. How many kitchens does the hotel have?
14. Does the hotel have efficient pre-rinse spray valves? If so, how many?
15. What is your hotel's star rating?
16. In which year was your hotel constructed?
17. Can you provide us with your hotel occupancy rate by year from 2004 to 2012?

Control Group

1. Your water wholesale provider, Municipal Water District of Orange County (MWDOC), offers a water conservation program called the Water Smart Hotel Program to promote water efficiency in hotels: Are you aware of this program, or any other water conservation programs in your area?
2. Have you participated in any water conservation programs in the last 7 years? If yes, can you tell us the name of the program? If no, why did you not want to participate in these programs?
3. Did you retrofit any plumbing fixtures or water using appliances? If yes, can you tell us which fixtures were retrofitted?
4. When were these retrofits made?
5. Would you participate in a free indoor water use survey if it was offered by your local water agency in the future? (Yes/No)
6. If no, what assistance would you like from your local water agency or provider to become for your hotel to become more efficient?
7. How many guest rooms are in your hotel?
8. Are there any water efficient toilets in the hotel? If so, how many?
9. Are there any low flow showerheads installed in the hotel? If so, how many?
10. Is there an onsite laundry present? If so, how old are the laundry machines?
11. How many kitchens does the hotel have?
12. Does the hotel have efficient pre-rinse spray valves? If so, how many?
13. What is your hotel's star rating?
14. In which year was your hotel constructed?
15. Can you provide us with your hotel occupancy rate by year from 2004 to 2012?

Appendix C—Model Specification and Estimation

Conceptual Model

A logical way of modeling staggered billing data is to conceive the model at a daily level and then scale it up to the meter-read level. Equation (1) expresses logarithmically transformed daily consumption (U_{it}) for customer (i) at time (t) as a function of the daily weather index (W_t), say, the evapotranspiration rate, customer characteristics (X_i), daily intercept terms (α_t) and random error (ε_{it}). This model is very flexible insofar the intercept terms and weather coefficients are conceptually allowed to vary on a daily basis. Intercept terms are necessary because intervening human factors make consumption's relationship with weather somewhat sticky. Irrigation decisions, to some extent, are based upon experience and "gut feel." A weather index alone is therefore unlikely to fully capture variation in consumption by time of year.

$$\begin{aligned} \ln(U_{it}) &= \alpha_t + \beta_t W_t + \eta X_i + \varepsilon_{it} & (1) \\ \text{where } \varepsilon_{it} &\sim N(0, \sigma^2) \end{aligned}$$

Daily consumption is logarithmically transformed because water consumption is generally distributed with a long right-hand tail. And usually, even after accounting for customer heterogeneity and seasonality, model error does not exhibit a normal distribution. A couple of explanations can be offered for skewed model error. First, the most seasonal component of consumption—irrigation—is a discrete event, even when scheduled according to scientific principles. A landscape is supposed to be irrigated when daily evapotranspiration has depleted the soil water content below a certain threshold (Snyder and Sheradin, 1992). When daily evapotranspiration is low and uncertain, or rainfall is received periodically, average daily consumption may exhibit a rightward skew. Second, landscape professionals often set irrigation schedules by varying a preset baseline schedule in proportion to changes in the evapotranspiration rate. Errors are therefore proportionally magnified or diminished.

Averaging consumption across the (N) days included in a read taken at time (T) yields the meter read-level model (Equation 2). Throughout, summation operators are subscripted backward in time because meter read-dates signal the end of a consumption period. If consumption days (N) vary markedly across reads, averaging insures error homoscedasticity at the meter-read level when daily error is homoscedastic. Of course, in spite of averaging, meter read-level error will be heteroscedastic if daily error itself is heteroscedastic, in which case (2) should be estimated using generalized least squares. Autocorrelation is a different matter, however. Because of error averaging, autocorrelation at the meter-read level should be low to nonexistent even if daily error is highly autocorrelated. It can be mathematically shown that if daily autocorrelation is as high as 0.9, even then observed autocorrelation will only be 0.092 for 30-day cycle reads, and 0.025 for 61-day cycle reads (Bamezai, 1997).

$$\frac{1}{N} \sum_{t=T}^{T-N} \ln(U_{it}) = \sum_{t=T}^{T-N} \alpha_t \frac{1}{N} + \sum_{t=T}^{T-N} \beta_t \frac{W_t}{N} + \eta X_i + \frac{1}{N} \sum_{t=T}^{T-N} \varepsilon_{it} \quad (2)$$

Appendix C

$$\text{where } \frac{1}{N} \sum_{i=T}^{T-N} \varepsilon_{it} \sim N(0, \sigma^2)$$

Estimation of (2) as it stands requires the creation of at least 365 daily indicator variables (equal to $1/N$ for days included in the read) for capturing the daily intercepts and another 365 interactions of these indicators with the daily weather index to capture the daily weather response. For days not included in a specific meter read, the corresponding daily indicators and their interactions take on the value of zero. Such an enormous estimation exercise is unlikely to succeed not only because of the immense computing resources required, but also because of multicollinearity among many of the daily indicator variables. Meter reads must be available for every day in the year to provide the variation necessary for estimating these daily parameters, but read-dates are often clustered by design. Thus, for estimation purposes, it is necessary to impose some simplifying restrictions on these daily parameters.

One option is to assume that the daily intercepts (α_t) and the weather response coefficients (β_t) are equal for all days in a given month. Doing so reduces the estimation problem down to 12 monthly intercepts, 12 weather coefficients, and other customer characteristics included in the model. It is not necessary to place the same restrictions on (α_t) and (β_t). For example, the daily intercept terms (α_t) may be fit with piece-wise linear or cubic splines (Suits et al., 1978; Robb, 1980), while the weather coefficients (β_t) may be assumed constant for either all days in a month or all days in a season. The daily intercepts may also be captured using Fourier harmonics (Bamezai, 1996).

Because monthly restrictions are perhaps the most obvious choice with billing data that follow a 30-day cycle, the implication of these restrictions is developed in greater detail. Equation (3) shows what these restrictions imply for meter reads that span a total of (N) days, with (m) days falling in one month and (n) days in the next.

$$\frac{1}{N} \sum_{i=T}^{T-N} \text{Ln}(U_{it}) = \alpha_m \frac{m}{N} + \alpha_n \frac{n}{N} + \beta_m \sum_{i=T}^{T-m} \frac{W_t}{N} + \beta_n \sum_{i=T-m-1}^{T-m-n} \frac{W_t}{N} + \eta X_i + \frac{1}{N} \sum_{i=T}^{T-N} \varepsilon_{it} \quad (3)$$

To estimate (3) it is necessary to allocate the total number of days covered by a meter read to each calendar month. In other words, 12 monthly variables must be created of which 2 take on the values (m/N) and (n/N) for any given read, the rest being zero. Similarly, the daily weather index during a read interval must also be split into month-specific aggregates. Once again, 12 weather variables are required of which only at most 2 take on a nonzero value for any given read. Meter reads taken bimonthly can be handled just as easily in the above framework, the only difference being that such reads are likely to span 3 instead of 2 months.

Construction of the dependent variable in (3), however, still poses a minor problem. The dependent variable is equal to the sum of logarithmically transformed daily consumption. But billing histories yield only the sum of daily untransformed consumption which, after a logarithmic transformation, does not equal the desired dependent variable (Equation 4).

$$\frac{1}{N} \sum_{i=T}^{T-N} \text{Ln}(U_{it}) \neq \text{Ln}\left(\frac{1}{N} \sum_{i=T}^{T-N} U_{it}\right) \quad (4)$$

The above inequality, however, can easily be resolved by leaning on well-known properties of a lognormal distribution.

If $Ln(U_{it}) \sim N(\mu_t, \sigma^2)$

$$\text{then } E\left(\frac{1}{N} \sum_{t=T}^{T-N} Ln(U_{it})\right) = \frac{1}{N} \sum_{t=T}^{T-N} \mu_t \quad (5)$$

Similarly

$$Ln\left(E\left(\frac{1}{N} \sum_{t=T}^{T-N} U_{it}\right)\right) = Ln\left(\frac{1}{N} \sum_{t=T}^{T-N} e^{\mu_t + \frac{\sigma^2}{2}}\right) = \frac{1}{N} \sum_{t=T}^{T-N} \mu_t + \frac{\sigma^2}{2} + Ln\left(\frac{1}{N} \sum_{t=T}^{T-N} e^{\varepsilon_t}\right) \quad (6)$$

where $\varepsilon_t = \mu_t - \frac{1}{N} \sum_{t=T}^{T-N} \mu_t$

Under most plausible scenarios of the rate of change in average daily consumption (μ_t) over the course of 30 or 61 days, the last term in (6) converges to zero. In other words, the two quantities cited in (4) differ approximately by a constant (that is, half of the daily variance), hence are readily substitutable.

Approximating Nonlinearity and Reducing Measurement Error

If data and model diagnostics indicate that the weather index (say, the evapotranspiration rate) should either be logarithmically transformed or that higher powers should be included as well, the framework developed in (1) through (6) can easily include such possibilities. One such case is discussed below for illustration.

Assume daily consumption is a quadratic function of weather instead of a linear function (Equation 7).

$$Ln(U_{it}) = \theta_t + \omega_t W_t + \psi_t W_t^2 + \eta X_t + \varepsilon_{it} \quad (7)$$

where $\varepsilon_{it} \sim N(0, \sigma^2)$

Under the assumption of monthly restrictions, estimation of (7) now requires 12 additional variables to capture the weather index's second power. But, by applying a linear approximation to (7), both the computational burden and the impact of measurement error can be minimized. The daily weather index is first re-expressed in terms of deviations from the daily mean, but then higher powers of the deviations are dropped (Equation 8).

$$Ln(U_{it}) = \theta_t + \omega_t (\bar{W}_t + \Delta W_t) + \psi_t (\bar{W}_t + \Delta W_t)^2 + \eta X_t + \varepsilon_{it} \quad (8)$$

$$\Rightarrow Ln(U_{it}) \approx \alpha_t + \beta_t \Delta W_t + \eta X_t + \varepsilon_{it}$$

where $\alpha_t = \theta_t + \omega_t \bar{W}_t + \psi_t \bar{W}_t^2$

$$\beta_t = \omega_t + 2\psi_t \bar{W}_t$$

After the linear approximation, the essential structure of (8) is identical to (1). By working with daily deviations in the weather index, however, an approximate nonlinear weather specification is implicitly assumed without any increase in the computational burden. Bamezai (1997) demonstrates the validity of this approximation. Two additional benefits also accrue from the above approximation. First, the daily intercepts (or monthly if so constrained) provide a direct measure of average consumption on a particular day (or month) in a normal weather year—the differenced weather index is centered at the mean by construction. Second, a systematic time bias in the weather index’s mean caused by lack of information about plant material by customer is likely to influence the deviations significantly less. A differenced weather specification (8) therefore simultaneously minimizes the impact of systematic measurement error while capturing an approximate nonlinear weather response. Even if weather response is linear, a differenced weather index is preferable to an undifferenced index: either index will yield identical results in the absence of measurement error, but the former is likely to be more accurate in the presence of measurement error.

Weather Index Construction

For the analyses that follow, weather variation is captured through a rainfall adjusted evapotranspiration-rate index (Equation 9). The evapotranspiration rate measures a plant’s total water demand. It is necessary to subtract effective rainfall from the evapotranspiration rate to accurately predict net irrigation demand. The daily evapotranspiration and rainfall data are obtained from CIMIS.

$$W_t = \max[0, (ET_t^R K_t^C - P_t u)] \quad (9)$$

where

W	daily weather index (inches)
ET^R	daily reference evapotranspiration rate (inches)
K^C	crop coefficient
P	daily precipitation (inches)
u	effective proportion of precipitation

CIMIS’s ET^R represents the water demand of 4- to 6-inch-tall, cool-season grass transpiring at its maximum rate. In reality, plant height, plant roughness, plant age, ground shading, and other factors, all influence actual evapotranspiration needs of a plant (Snyder, 1993). If plant material is known, (fixed or time-varying) crop coefficients can be incorporated into Equation 9 to correct the reference evapotranspiration rate. For example, Meyer and Gibeault (1987) provide estimates of monthly crop coefficients for cool season turf. Half of daily rainfall is assumed to be effective as per CIMIS’s recommendation, but when effective rainfall exceeds total evapotranspiration demand, net evapotranspiration demand is floored at zero. As mentioned earlier, the science underlying irrigation is essentially a stock and flow problem (Snyder and Sheradin, 1992). Soil moisture content (stock) must be maintained within a certain threshold. Evapotranspiration (flow) reduces the stock on a daily basis, effective rainfall intermittently adds to it, with irrigation acting as the balancing lever. A weather index constructed using a stock and flow framework is likely to be a better predictor of irrigation demand—the most weather-sensitive portion of total demand.

The CIMIS station in Irvine (station #75) was used for depicting weather in Orange County.

Model Results

Water reductions achieved through the Water Smart Hotel Program were estimated by analyzing pre- and post-retrofit billing histories, controlling for weather and other unobserved time-invariant differences (fixed effects) across the various hotels. The time period when retrofits actually occurred is excluded from the models. Some of these accounts were on a monthly, others on a bi-monthly, billing cycle. The model relates the logarithm of average daily consumption to a vector of covariates including monthly indicators, yearly indicators, weather deviation variables, and an indicator variable for each hotel that captures differences in average use across different hotels. Weather effects were pooled across contiguous months where estimated coefficients appeared insignificantly different, leading to three distinct seasons in a year. The final model also incorporates a heteroscedasticity correction based upon methods discussed by Carroll and Ruppert (1988).

As mentioned earlier, the overlap between the Water Smart Hotel Program and the economic recession that began in the fall of 2008 leads to difficulties in savings estimation because either the pre- or post-retrofit period is tainted by the effects of the recession. Not all hotels are equally affected by this. We showed an example in Figure 1 where the program's impact was clear with no significant confounding caused by the recession. There are many other hotels with similar patterns in our sample, but not all.

Several sensitivity analyses were attempted to bracket the impact of the recession. To test whether retrofit dates were accurate, we varied the length of the excluded retrofit window to assess its impact on savings. The retrofit window is excluded from the models. A longer window is likely to produce a cleaner comparison of the pre- and post-retrofit billing histories in case the intervention dates are recorded with error. We also attempted alternative methods for capturing the impact of the recession following some of the ideas that were first developed by Bamezai (1996) to evaluate a public facilities retrofit program in San Diego implemented during the early 1990s drought. For example, we interacted each hotel's indicator variable with a recession indicator that takes on a value of 1 after September, 2008, zero before that. These interactions capture how each hotel's water use responded to the recession individually. Including these interactions reduces the estimated program impact. We also included additional interactions between each hotel's indicator and a second recession indicator that takes on a value of 1 after January, 2010, zero before. These second set of interactions capture how hotels may have been behaving differently from 2010 onward compared to late 2008 and 2009. These second set of interactions reduce the estimated impacts some more. We also varied the point in time when the second recession indicator kicks in to assess whether that makes any difference. Some of these specifications produced higher savings estimates, some lower. We have selected to go with a specification that produced a very conservative estimate of water savings just to be on the safe side.

Table C-1 displays the estimated model, without the hotel indicators and their interactions with the first and second recession indicator, both for brevity and because these coefficients are not of primary interest. The estimated coefficients that are shown behave in expected ways. For example, within any given year water use peaks in the months of July and August, as captured by the monthly indicators. Deviation from normal weather has the greatest impact during winter and spring than summer and fall. And, the year indicators suggest that water use was very stable over time until 2007, but has dropped since then, bottoming out in 2010. Since 2010, however, hotel water demand has started to creep back up, although it is still below the historical norm.

The coefficient on the post-retrofit indicator captures the drop in water use from all the retrofits. Overall, water savings amount to 18.1% ($e^{(-0.200)}-1$), and this estimate is highly significant. If this model is re-estimated to separately quantify savings achieved by hotels that retrofitted HETs alone or in

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combination with other devices, and hotels that did not retrofit any HETs but only other devices, we find that the former group reduced their consumption by 22.6%, and the latter by 5.1%. The former is highly significant, but the latter is not. That does not mean that non-HET retrofits did not save water, only that we have too few such cases in our sample to estimate savings reliably. Hotels that participated in the Water Smart Hotel Program survey but did not access any rebates also have not saved any water.

Table C-1 Estimated Model for Overall Savings

Dependent Variable – Ln(Use Per Day)

Covariate	Coefficient	Std. Err.	t-statistic
Post retrofit indicator, equals 1 for reads after retrofits, zero otherwise	-0.200*	0.017	-11.7
Post-survey (no retrofit) indicator, equals 1 for reads after Water Smart survey, zero otherwise	-0.014	0.029	-0.5
January indicator	0.005	0.018	0.3
February indicator	0.038*	0.015	2.5
March indicator	0.112*	0.015	7.3
April indicator	0.164*	0.014	11.4
May indicator	0.175*	0.015	11.9
June indicator	0.263*	0.015	17.7
July indicator	0.379*	0.016	23.9
August indicator	0.368*	0.015	23.9
September indicator	0.264*	0.015	17.3
October indicator	0.150*	0.015	10.0
November indicator	0.081*	0.016	5.0
December indicator (omitted for comparison)	--		
December-March weather deviation	1.281*	0.374	3.4
April-May weather deviation	0.690	0.359	1.9
June-November weather deviation	-0.036	0.252	-0.1
2001 indicator	0.222*	0.070	3.2
2002 indicator	0.259*	0.065	4.0
2003 indicator	0.263*	0.065	4.0
2004 indicator	0.246*	0.064	3.9
2005 indicator	0.273*	0.063	4.3
2006 indicator	0.290*	0.063	4.6
2007 indicator	0.256*	0.063	4.1
2008 indicator	0.196*	0.062	3.2
2009 indicator	0.107	0.060	1.8
2010 indicator	-0.112*	0.012	-9.5
2011 indicator	-0.074*	0.011	-6.5
2012 indicator (omitted for comparison)			
Constant	1.963*	0.039	50.8
R-Square	0.46		

NOTE: *Significant at 5 percent level or better. Estimated fixed effects and interactions with recession indicators are not shown, but are included in the model.

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