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Synergistic Energy and Water Conservation Strategies for the Commercial Sector

A 2010 Bren Group Project

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The Group Project is required of all students in the Master's of Environmental Science and Management (MESM) Program. It is a three-quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Final Group Project Report is authored by MESM students and has been reviewed and approved by:

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ABSTRACT

In this study we partnered with three hotels within Southern California Edison's (SCE) service territory to perform a combined energy and water audit to quantitatively capture water, electricity, and natural gas use, and the savings opportunities for the end-user. Our analysis demonstrates that integrated efficiency measures can result in a quicker payback period for each hotel than just electricity efficiency, and provide a basis for SCE and regulatory agencies to understand the combined savings potential from coordinated measures. Savings and recommended retrofits varied by hotel, but cost effective energy and water measures such as pool covers, faucet aerators, low flow showerheads, and efficient irrigation were consistently shown to offer large potential savings. Our project demonstrates the value of synergistic conservation strategies by quantifying the water, electricity and natural gas saved against typical programs which only calculate one type of resource savings. Our analysis can add value to SCE's existing electricity auditing process for technologies which require integrated planning. Furthermore, we encourage statewide coordinated energy and water conservation programs and policies as a cost effective method for reaching agency energy and water reduction goals, and make suggestions to progress collaborative conservation strategies among the various stakeholders in California.

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	**Title**
AB 32	Assembly Bill 32
AF	Acre Feet
BMP	Best Management Practice
BOR	Bureau of Reclamation
BTU	British Thermal Units
CAISO	California Independent System Operator
CEC	California Energy Commission
CEE	Consortium for Energy Efficiency
CII	Commercial, Industrial and Institutional
CIMIS	California Irrigation Management Information System
CPUC	California Public Utilities Commission
CUWCC	California Urban Water Conservation Council
DOE	Department of Energy
DWR	California Department of Water Resources
emPower SBC	Elective Municipal Program to Optimize Water Efficiency, Energy Efficiency, and Renewables
EMWD	Eastern Municipal Water District
ET	Evapotranspiration
FERC	Federal Energy Regulatory Commission
GHG	Greenhouse gas
gpf	Gallons per flush
gpm	Gallons per minute
GWD	Goleta Water District
HVAC	Heating, Ventilation and Air Conditioning
IOU	Investor Owned Utilities
kW	Kilowatt
kWh	Kilo-watt Hour(s)
MAF	Million Acre Feet
MWD	Metropolitan Water District of Southern California
NAICS	North American Industry Classification System
psi	Pounds per Square Inch
PTAC	Package Terminal Air Conditioning
SCE	Southern California Edison
SWP	State Water Project
UWMP	Urban Water Management Plan
WEEP	Water Energy Efficiency Program for Commercial, Industrial, and Institutional Customer Classes (CII) in Southern California
WUCOLS	Water Use Classification of Landscape Systems

EXECUTIVE SUMMARY

This project quantitatively demonstrates that combined energy and water saving strategies provide simultaneous benefits to businesses, utilities, and the environment. Despite the clear connection between the energy needed in the water cycle and the water needed to produce energy, the resources continue to be managed and planned separately and many opportunities to increase water and energy efficiency have yet to be captured (Mehan, 2009). What is currently needed is use of utility-specific data to inventory, characterize, and assess the primary types of water-related energy consumption by the end user and regional specific data on water sources and energy intensity. For our client Southern California Edison (SCE), we investigate whether integrated energy and water conservation measures could cost effectively aid them in reaching their efficiency goals. For SCE and three of their audited customers, we quantified the savings associated with additional cost effective energy and water efficient retrofits and management.

The process of heating, treating, transporting, and distributing water uses a tremendous amount of electricity and natural gas. Even more energy is required to collect and dispose of used water; meaning that energy is required at every step of the water use cycle. The California Department of Water Resources (DWR) estimates that meeting the water-related energy demand takes 19% of all of the electricity consumed in California, the single largest energy use in the state (Department of Water Resources, 2009). Similarly, the California Energy Commission estimates that statewide water-related natural gas demand is 32% of all non-thermal power generation gas use (Krebs, M., 2007). Water-related energy consumption is expected to increase substantially in the future due to population, urban growth and increased wastewater treatment (California Energy Commission, 2009b). Historically, conservation efforts have been enough to offset the increase in demand and total energy use has remained relatively stable. However, utilities like SCE must continue to aggressively adapt to the changing electricity needs of the population by a combination of energy efficiency efforts and infrastructure enhancements.

The 2003 California *Energy Action Plan* highlighted energy efficiency as the best available method of meeting the state's future energy needs. According to the state water plan, urban water use efficiency may prove to be the largest single supply available for meeting growth in both water and energy demand over time (California Energy Commission, 2009b). In an effort to reduce human-induced climate change, the 2006 California Global Warming Solutions Act mandated a reduction of statewide greenhouse gas (GHG) emissions to 1990 levels by 2020 (California Air Resources Board, 2009). Electricity generation, and electricity and natural gas end uses for residential and commercial purposes account for about 34% of all GHG emissions in California (California Air Resources Board, 2009). SCE actively supports the evolving statewide requirements by reducing GHG emissions from electricity provided to its customers by offering free electricity audits and increasing renewable energy generation.

With increasingly strict statewide targets for energy efficiency, improvements in SCE's audit process or scope will identify opportunities for additional electricity savings. Estimates from the Bureau of Reclamation argue that efficiency in various end uses in the Accommodation sector can yield substantial percentages of water, electricity, and natural gas savings (Bureau of Reclamation, 2009). To measure the total resource use from specific technologies, we partnered with three of SCE's hotel customers to perform a combined electricity, water, and natural gas audit. The hotels selected for this study are located in different cities of southern California and provide an interesting contrast of water and energy use and a unique mix of water sources. Two hotels are located in the cities of Goleta and Santa Barbara, which are both located in Santa Barbara County. The third hotel is located in Moreno Valley, which is located to the southeast of Goleta and Santa Barbara in Riverside County.

Using the water and energy use data we collected through our comprehensive audits, we analyzed the total resource savings associated with equipment upgrades or improved management practices. For all cost effective technological or behavioral retrofits, we report how each hotel could modify their current practices to save money and resources over the product lifetime. Additionally, using water source information provided by each individual water district we calculated the embedded energy used in delivering and treating the water consumed by the hotel. Through this approach we describe the opportunities that exist, and where there may be benefits for SCE and other utilities to improve resource efficiency for their hotel customers. Furthermore, we analyzed SCE's energy mix to estimate the energy related greenhouse gas reductions attained through conserving water at the end use.

Our combined energy and water audits were performed to quantify the total resource savings and see if value could be added to the savings SCE captures with their existing audit. Therefore, the results that we report include all potential resource savings, not just direct electricity. The resource savings from our combined energy and water audits are substantial for natural gas, water, and embedded energy. The total energy savings we calculated from the retrofits at each hotel adds 77% to 94% more total energy savings to the energy savings captured by SCE's retrofits. The savings from the retrofits we recommend offer more dollar savings for the hotel and cost less than the retrofits suggested by SCE. Our direct electricity savings, however, only add about 3% to 9% of kWh savings to the savings that SCE could capture at each hotel - signifying our results are more relevant to the natural gas and water utilities than to SCE. More broadly, a conservative estimate shows that an integrated audit could reduce natural gas, electricity, and water consumption by 27%, 4%, and9% respectively for the southern California accommodations sector. For energy embedded in the water cycle, the current regulatory environment does not allow electric utilities such as SCE to be credited for the energy savings and associated GHG reductions. We show how greater efficiency can be reached by quantifying the combination of all resource savings associated with a single conservation effort and identifying ways to credit the savings to specific utilities.

We encourage utility collaboration to inform businesses of the water end uses which provide energy savings, and offering rebates for common technologies. In scenarios where water, natural gas, or electricity savings potential are high, utilities should cooperate to offer joint rebates that may further entice efficient upgrades. Another integrated approach could come from the state, with the California Public Utilities Commission (CPUC) requiring gas, water and electric utilities to work to collectively meet statewide energy and water conservation goals and GHG reduction targets. Additionally, if the price of water and energy are raised enough to reflect the true cost of consumption, efficiency becomes more affordable for the end user. A better understanding of not just the direct savings possible, but how indirect water and energy savings occur will allow connections between energy and water to become clearer to policy makers and regulators. Actions by the CPUC, or another state agency, could then direct utilities to increase incentives for actions that show the greatest sum of savings. Achieving larger cost effective savings then benefits the business and utilities’ bottom lines, as well as society’s effort to meet energy reduction and water conservation targets.

INTRODUCTION

In three parts, this report progressively illustrates the significance of synergistic energy and water conservation in the commercial sector through three integrated energy and water case studies at hotel facilities. The reader should note that our three case study hotels are generically called Goleta hotel, Santa Barbara hotel, and Moreno Valley hotel throughout this report by their own request. Our methods for analysis were designed to add value to SCE's existing auditing procedure by capturing the energy related to water consumption by the end user. This analysis allows us to thoughtfully provide a basis for advocating combined energy and water management in Southern California. Our focus is targeted at quantifying how reductions in water use save and both direct and embedded energy and natural gas, but we often refer to *combined resource efficiency* or *total resource savings*. These terms are used throughout the report to describe management strategies which achieve a combination of water, electricity, natural gas, and the corresponding monetary savings. Through identification of the problem and thorough research and investigation, this study accurately analyzes and provides recommendations for how to increase the potential total resource efficiency in the hotel sector among the various stakeholders. Part I provides background information and explains both the need and the potential for water and energy conservation efforts for hotels in Southern California and for the entire hotel sector. Additionally, this part examines the energy intensity of the water cycle in Southern California, as well as highlights the regional differences. Furthermore, this section introduces both the difficulties and incentives which state agencies, utilities and businesses experience today while working toward efficient resource management. Part II begins by establishing the basis for data collection methods and analysis for each end use category targeted by our integrated energy and water audit. We then detail the methods by which we calculated the embedded energy in the water distribution and treatment processes and greenhouse gas (GHG) reduction estimations. Part III offers a range of water efficiency strategies for the specific hotels and for the sector as a whole. The results of our audits are aggregated by hotel, and presented as a series of figures and comparisons demonstrating the value of combined utility savings – which provide the basis for our recommendations. Through these efficiency measures, we also quantify the integrated utility savings that SCE and other utilities would receive. We present conclusions regarding policy recommendations, and a framework by which electricity, water and gas utilities can collaborate to obtain state support and ensure that the potential for total resource efficiency is achieved.

PART I: PROJECT BACKGROUND AND SIGNIFICANCE

The Synergy

Water and Energy Nexus

California uses a complex system of dams, aqueducts, and pumped groundwater to store, transport, and meet the water needs of the state – roughly equal to about 38 million acre feet (MAF) per year. The process of heating, treating, transporting, and distributing water uses a tremendous amount of electricity and natural gas. Even more energy is required to collect and dispose of used water; resulting often in energy being used at every step of the water use cycle (Figure 1).

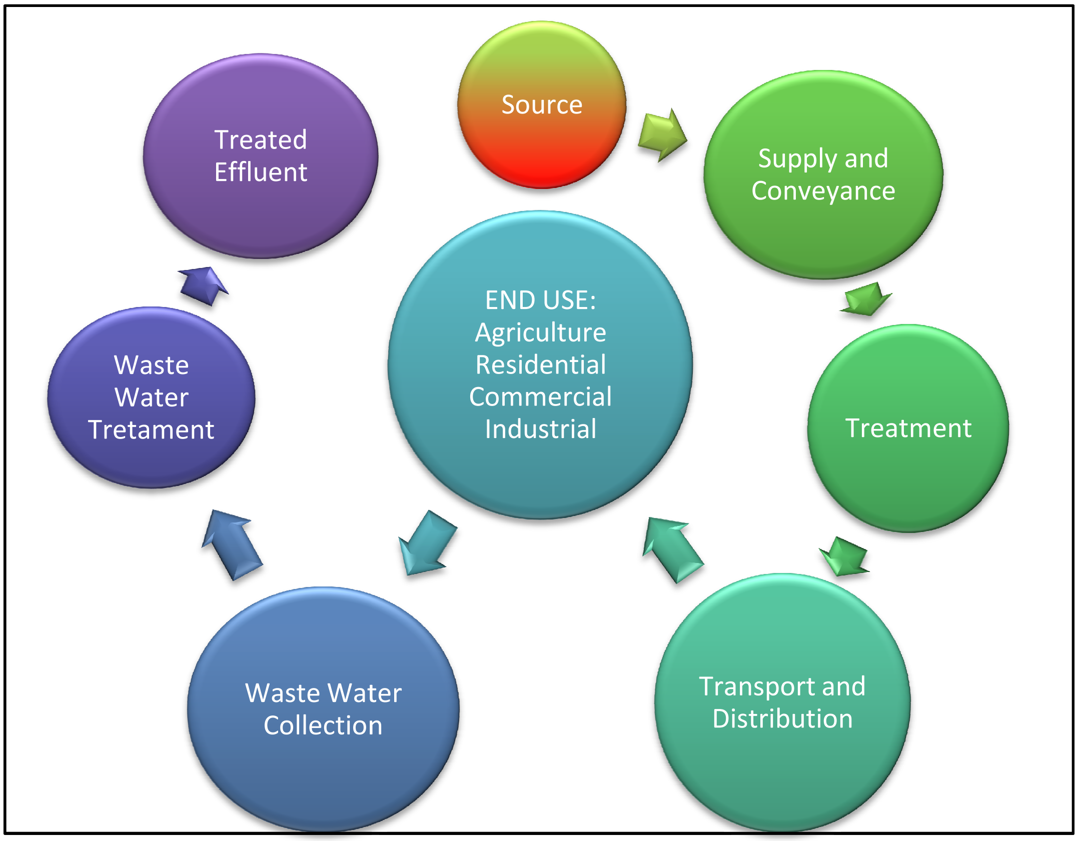


Figure 1 Water use cycle in California
Source: (Wilkinson, 2008)

The California Department of Water Resources (DWR) estimates that meeting the water-related energy demand takes 19% of all of the electricity consumed in California, the single largest energy use in the state (Department of Water Resources, 2009). In comparison, the California Energy Commission estimates that statewide water-related natural gas demand is 32% of all non-thermal power generation gas use (Krebs, M., 2007). The most recognized water and energy nexus is hydroelectric power generation, but other forms of energy generation use water as well. Other water-intensive energy generating methods include coal, nuclear, geothermal and bioenergy. Much of the water consumed for energy generation via conventional thermoelectric powerplants is used for cooling (Dennen, Larsen, C. Lee, J. Lee, & Tellinghuisen, 2007). Despite the clear connection between the energy needed in the water cycle and the water needed to produce energy, the resources continue to be managed and planned separately and many opportunities to increase water and energy efficiency have yet to be captured (Mehan, 2009). However, California's water and energy planners are starting to see the need for an integrated management approach when it comes to securing the water and energy supplies for California's future (Department of Water Resources, 2009).

Water Consumption by the Commercial End-Use

While significant energy is embedded in transporting, treating, and distributing water, these may not be the areas of greatest energy intensity. Energy consumption in the water use cycle by the end user accounts for roughly four times the electricity and 92 times the natural gas needed to deliver and treat water. Water end use can be split into two broad categories: irrigated agriculture and urban use. Eighty percent of the 14 trillion gallons of water used in California during a normal year is used by agriculture (Rosenblum, 2009). The remaining 20% is allocated for urban uses that are classified as residential, commercial, or industrial. Residential customers account for 48% of the electricity consumed in association with urban water use. Commercial and industrial uses account for a respective 30% and 20% of the electricity consumed in water-related energy use (Figure 2).

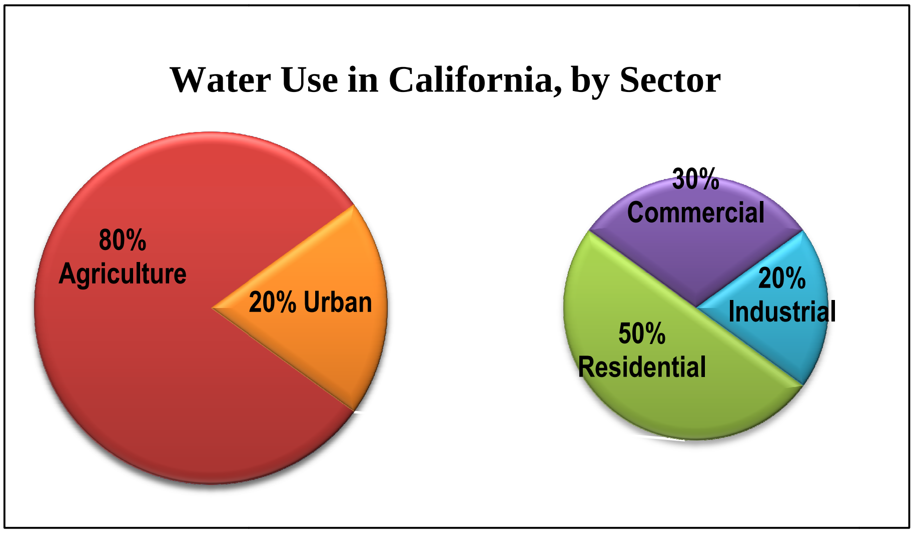


Figure 2 Water related energy consumption by end users for all of California
Source: (Rosenblum, 2009)

Potential Conservation in Residential and Commercial Sector

Depending on your location, there are often many incentives in place to encourage efficiency of residential water and energy use. Proven measures that conserve energy or water when installed in the residential sector include: programmable thermostats, compact fluorescent light bulbs, and lowering the thermostat on the hot water heater to 120° F (United States Department of Energy, 2009f). Reducing residential hot water use effectively conserves both water and energy. These efficiency measures are inexpensive and easy to install, leading the California Energy Commission (CEC) to estimate that a commitment to residential energy and water efficiency could become the largest "new" water source in California (California Department of Water Resources, 2005). The scope of the CEC report is limited to residential water related energy use; however a major urban sector that lacks evaluation and integrated management to realize combined water and energy conservation is the commercial sector.

There are many opportunities to introduce energy and water efficiency measures within the commercial sector. Processes like heating and cooling, pressurizing, and air conditioning are all large water and energy uses; and stand out as targets for considerable reductions. Commercial landscaping also has considerable potential for reducing water use, given the growing social acceptance of native and drought tolerant landscaping. The energy-water nexus is beginning to be documented and researched. However, what is currently needed is use of utility-specific data in order to build an inventory, characterization, and assessment of the primary types of water-related energy consumption divided by type of water source, system, function, and end use. There is a need for data to be collected in order to develop the detailed methodologies on which cost effective programs can be based for combined energy and water efficiency (Mehan, 2009).

The Water Energy Efficiency Program

A recent report prepared for the Bureau of Reclamation (BOR) called 'Water and Energy Efficiency Program for Commercial, Industrial, and Institutional Customer Classes (CII) in Southern California' (WEEP) highlights the potential opportunities for combined water and energy efficiency within the commercial sector (Bureau of Reclamation, 2009). The WEEP report systematically and comprehensively identified the CII sectors that are the most intensive users of water and energy. The report includes wide-scale, generalized recommendations for how the identified CII customers can realize combined energy and water efficiency. Based on the suggestions made by the WEEP report, we focused on the energy, water, greenhouse gas (GHG), and monetary savings opportunities for a case study within one specific resource-intensive commercial sector. The scope of our case study, data collection, data analysis, and report focused on the Accommodations sector. The largest opportunities for combined energy and water savings within the Accommodation sector were identified as: swimming pools, laundry, plumbing fixtures, lighting, cooling, landscape, and food service (Bureau of Reclamation, 2009). We focused our case studies and baseline data around these services that have the most potential for combined energy and water savings.

Regional Differences of Energy Intensity for Water Supply and Conveyance

Southern Californians obtain water from a variety of sources: local surface water, local groundwater, and imported surface water. Imported water is often a combination of several sources that all have unique embedded energy costs. For example, the State Water Project (SWP) is an aqueduct that carries water south along the west side of the San Joaquin Valley and requires more energy for transport than any other California aqueduct (Garrison, Wilkinson, & Horner, 2009). The Colorado River supplies much of eastern Los Angeles and San Diego with drinking water and is also energy intensive relative to local sources. A region that predominately relies on SWP or the Colorado River consumes more energy than a region that mainly draws from local surface or groundwater for their drinking water supplies.

For our project, we designed a combined energy and water auditing framework that can be applied to different regions across California. To demonstrate specific water-related energy savings for our case studies it was important to understand the unique water source mix and water production process used in each location. The additional amount of energy saved from including water conservation in an energy audit varies depending on the location’s water source mix. Combined water and energy savings will also depend on the water district’s embedded energy in the transport, treatment, distribution, and waste treatment of that water. To compare the relative difference in regional energy embeddedness of water, our study investigated energy embeddedness for two hotels in Santa Barbara County in the cities of Santa Barbara and Goleta, as well as one hotel in Riverside County in the city of Moreno Valley (Figure 3). Each city is provided water by a different water district: The City of Santa Barbara, Public Works, Goleta Water District (GWD), and Eastern Municipal Water District (EMWD) all use a distinctive mix of water sources to meet their community’s water demands.

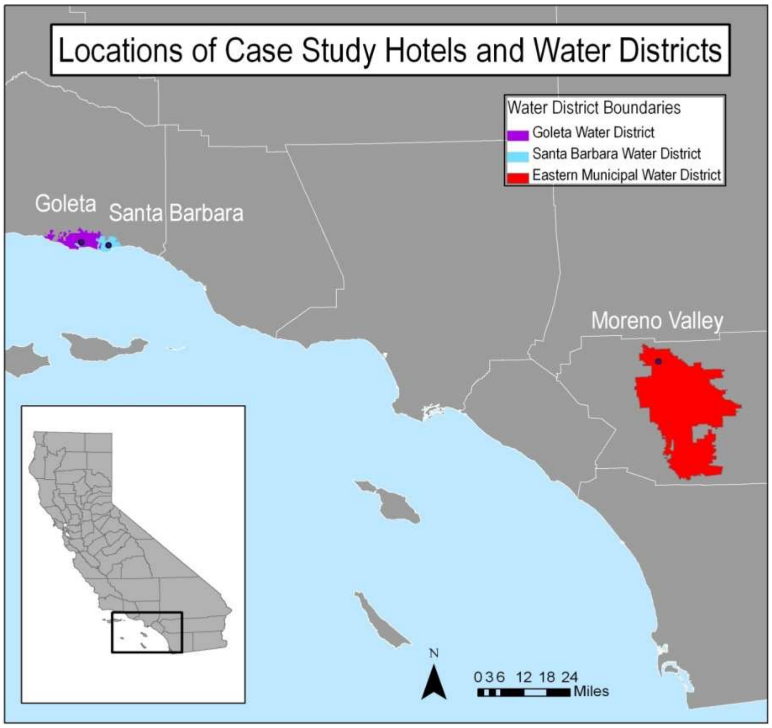


Figure 3 Location of case study hotels and water districts
Source: (National Atlas, 2009)

Santa Barbara

The water resources division of the City of Santa Barbara, Public Works provides water to about 95,000 citizens in Santa Barbara (City of Santa Barbara Public Works Department (b), 2005). Santa Barbara uses several sources of water: surface water, groundwater, imported water, and recycled water. The surface water originates from the nearby Santa Ynez River, is stored behind Cachuma and Gibraltar Reservoirs, and is delivered through two separate tunnels to Goleta and Santa Barbara. Surface water is gravity fed to the city's treatment and distribution centers. Groundwater is primarily from two hydrogeologic units; one located near downtown Santa Barbara, and one near upper State Street (Water Resources Division, Public Works Department, 2008)(Water Resources Division, Public Works Department, 2008)(Water Resources Division, Public Works Department, 2008)(Water Resources Division, Public Works Department, 2008)(City of Santa Barbara Public Works Department (b), 2008). Imported water is from the SWP. In a typical year about 83.66% of the water supplied in Santa Barbara is surface water, 5.6% is groundwater, 5.65% is imported, and 5.10% is recycled (Figure 4). El Estero is the Waste Water Treatment Plant serving Santa Barbara and typically treats about 321.2 million gallons of wastewater per year (City of Santa Barbara Public Works Department (b), 2005).

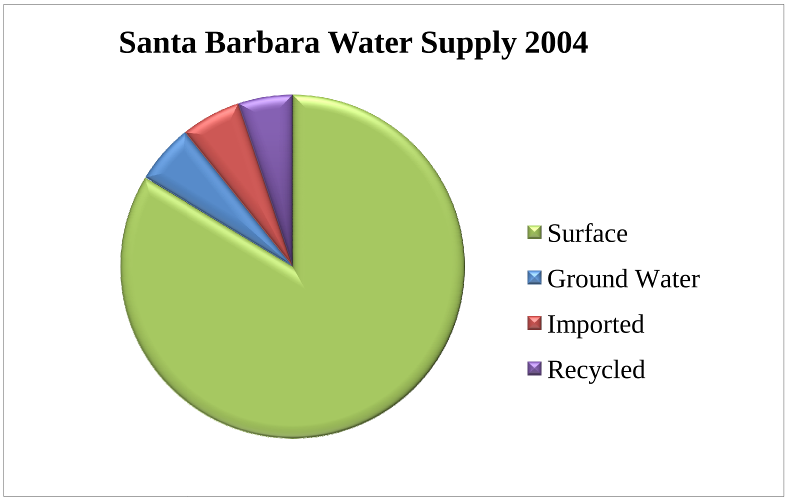


Figure 4 Santa Barbara water supply numbers from 2004 water year, groundwater numbers from 2008 water year
Source: (City of Santa Barbara Public Works Department (b), 2005)

Goleta

Goleta Water District uses 230 miles of pipeline to deliver water to 75,000 people in Goleta, and to the University of California, Santa Barbara (Goleta Water District, 2005). Goleta Water District delivers water from several sources: surface water, imported water, recycled water, and minimal amounts of groundwater. The surface water comes from the Cachuma Reservoir and the SWP is the source of imported water for Goleta. Goleta Water District has the adjudicated right to produce up to 2,350 acre feet (AF) per year of groundwater. From 2000 to 2004, however, a total of 8 AF was produced (Goleta Water District, 2005). According to the 2005 Goleta Urban Water Use Plan, Goleta produced 64.68% from the Cachuma Project, 28.30% from SWP, 0% from groundwater, and 7.03% from recycled water during the 2004 water year (Figure 5). The Waste Water Treatment Plant for Goleta is the Goleta Sanitation District, which treats about 64.75 million gallons of wastewater per year.

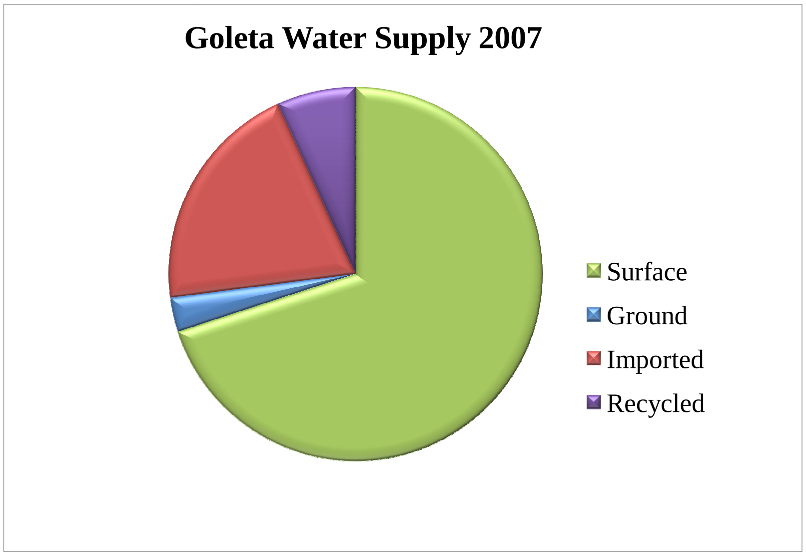


Figure 5 Goleta water supply for 2004 water year
Source: (Goleta Water District, 2005)

Moreno Valley

Eastern Municipal Water District (EMWD) provides water for the 165,328 people of Moreno Valley. About 75% of the potable water used in Moreno Valley originates from imported sources and 25% of the potable water comes from groundwater and recycled water (Eastern Municipal Water District, 2005). The imported water that EMWD uses is from the State Water Project and the Colorado River Aqueduct. There are eight different groundwater management basins in the EMWD. In the 2004 water year 78.52% of the water supplied was imported, 17.26% was groundwater, 3.45% was desalinated groundwater, and 0.77% was recycled water (Figure 6). Wastewater for this region is treated at Hemet/San Jacinto, Moreno Valley, Sun City, and Temecula Valley Water Reclamation Facilities.

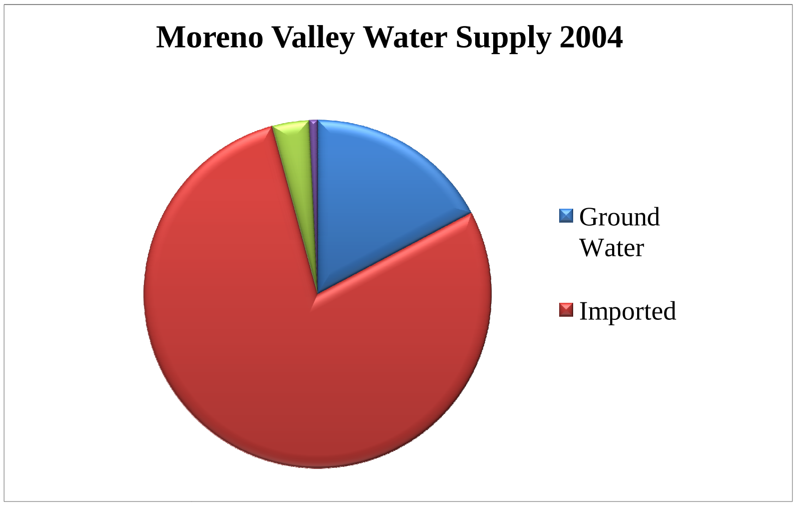


Figure 6 EMWD water supply for 2004 water year
Source: (Eastern Municipal Water District, 2005)

Energy and Water Demand Projections

California Population

Currently, nearly 37 million people live in California, and the population is projected to grow by 40% to 60 million people by 2050 (State of California, Department of Finance, 2007). County level projections predict that the three fastest growing counties – Los Angeles, San Bernardino and Riverside (all located in Southern California Edison (SCE) territory) – are expected to expand by 8.6 million people alone by mid-century (State of California, Department of Finance, 2007). SCE already serves more than 14 million people who live and work in 180 cities, and provides electricity to 5,000 large and 280,000 small businesses (Southern California Edison, 2009b). SCE will need to expand upon their existing 16 utilities and 4,990 transmissions circuits to support the electricity needs of Southern California in 2050. Historically, conservation efforts have been enough to offset the increase in demand and total energy use has remained relatively stable. However, utilities like SCE must continue to aggressively adapt to the growing electricity needs of the population by a combination of energy efficiency efforts and infrastructure enhancements. As the demand for electricity increases, electric utilities are trying to find ways to avoid large capital expenditures such as building transmission towers and power generation facilities by supporting energy efficient strategies for their customers. Through a loading order developed by the CPUC, investor owned utilities (IOUs) are required to seek efficiency first, build renewable energy second, and then expand efficient fossil fuel generation last (California Public Utilities Commission, 2009). This policy not only requires efficiency be emphasized over all other methods to meet the energy needs of the state, but makes efficiency in the financial best interest of IOU's prior to seeking to expand renewable or traditional generation (California Public Utilities Commission, 2009).

Commercial Electricity Demand Projections

A study by researchers at the Institute of Transportation at the University of California, Davis based future electricity projection demand scenarios on historical energy use data, demographic, economic and technological assumptions from 2005-2050 (McCarthy, Yang, & Ogden, 2006). Then the energy use intensity of the commercial sector was aggregated as a product of commercial floor space which determined the annual energy consumption over time. At current efficiency and demand rates, the baseline demand for electricity increases by about 56% by mid-century. Under a maximum demand scenario, this increase could as much as double the current levels (McCarthy et al., 2006). However, if the commercial sector operates under a high efficiency scenario, total energy consumption could decrease to levels lower than they are today, even with an expanding population. The projections show that a high-efficiency baseline scenario that involves aggressive efficiency improvements across the sector can result in a 25% decline compared to current baseline conditions by 2050 (McCarthy et al., 2006). By understanding how demographic and technological growth factors affect electricity demand, utilities can ensure their plan meets the needs of the future.

In 2009, the CEC reported a forecast of electricity demanded by each end use sector in SCE's service territory (Figure 7). According to this demand forecast, commercial electricity consumption accounts for about 37% of the total electricity generated by SCE (California Energy Commission, 2009b).This consumption rate is followed closely by the residential sector at 32%, industrial at 18%, and the remaining 13% is attributed to mining, agriculture, transportation, communication, utilities and street lighting. Even as the absolute energy consumption for each of these sectors is expected to rise as the population increases, these percentages remain relatively stable when projected to 2020 (California Energy Commission, 2009b).

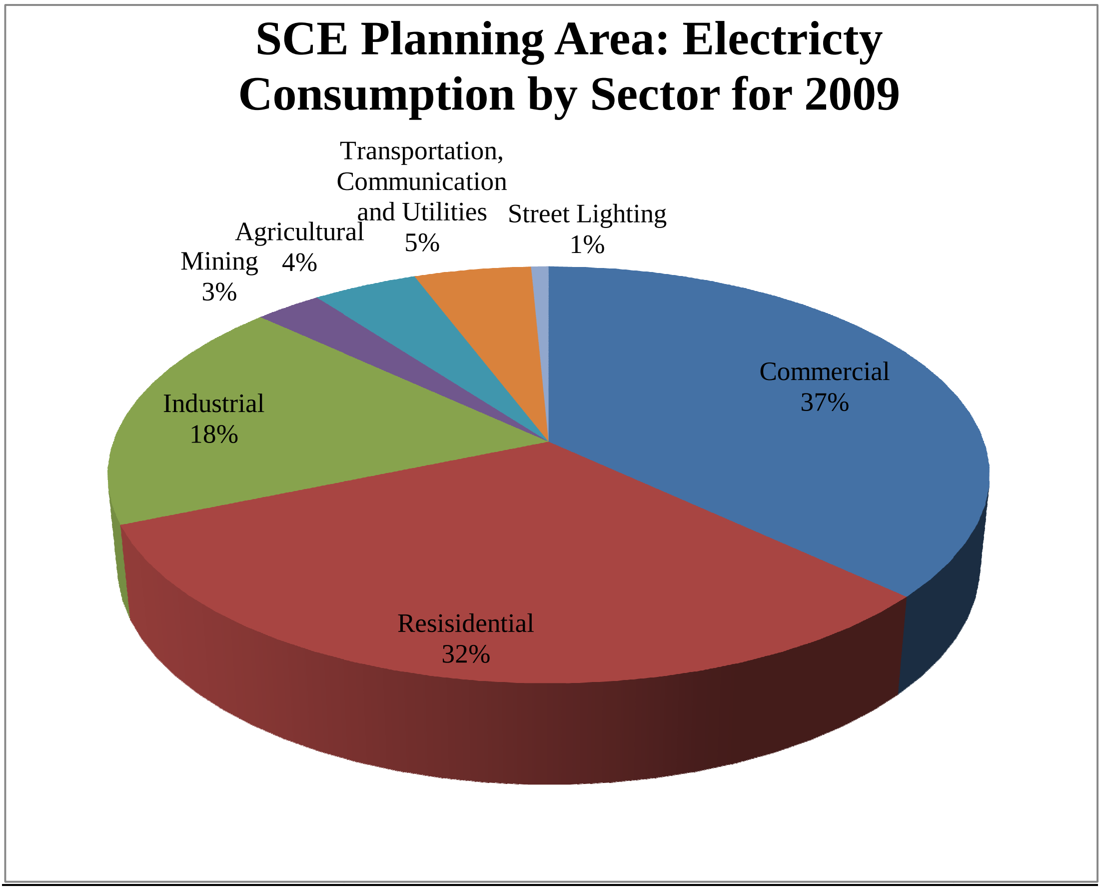


Figure 7 SCE planning area: electricity consumption by sector for 2009
Source: (California Energy Commission, 2009b)

Meeting Future Energy Needs

The 2003 California Energy Action Plan highlighted energy efficiency as the best available method of meeting the state's future energy needs. The CEC and CPUC are responsible for setting efficiency targets for both investor owned and publicly owned utilities under Assembly Bill 2021, which requires a statewide goal of reducing electricity consumption by 10% in ten years. In the 2005 Water Plan Update from the DWR, it is estimated that statewide urban water use is expected to increase by 67% by 2030 (California Energy Commission, 2009b). Therefore, water-related energy consumption is expected to increase substantially during this time due to population, urban growth and increased wastewater treatment (California Energy Commission, 2009b). In Southern California, energy demand is high and transmission systems are already strained during times of peak demand. According to the State Water Plan, urban water use efficiency may prove to be the largest single supply available for meeting growth in both water and energy demand over time (California Energy Commission, 2009b).

Water Demand Projections

While water demand is projected to rise, supplies are expected to become increasingly limited in the future. Drought events are projected to increase in intensity and duration by the second half of the 21st century (Burke, E., Brown, S., & Christidis, N., 2006). These strains on water supply come at a time when contributions from California's most significant out of state resource, the Colorado River, has been formally scaled back from a peak of 5.2 MAF per year to the legal limit of 4.4 MAF now that other states in the basin are taking their full allotment (California Performance Review, 2002). These reductions have caused energy-intensive water deliveries from the wet mountains of Northern California to the farms and cities south of the Delta to rise from an average of 4.6 MAF between 1990 and 1999 to over 6 MAF between 2000 and 2007, a nearly 30% increase (Bacher, Dan, 2009). While other sources of water include the Owens Valley, local groundwater, recycled water, and desalination; none of these come close to matching the large volumes of projected shortages – highlighting the need for aggressive water efficiency measures.

Meeting Future Water Demand

As part of the California State Water Plan process, the Pacific Institute prepared a projection of supply and demand under different efficiency scenarios (P. H Gleick, Cooley, & Groves, 2005). Even with an increasing statewide population, the Pacific Institute's High Efficiency Scenario shows that water use in 2030 could be 20% below water use in 2000 (P. H Gleick et al., 2005). They argue that the sooner those aggressive water efficiency improvements are made in all sectors the easier it will be to meet the needs of the future. Shown in Figure 8 below, the *Current Trends* scenario includes a modest 15% increase in efficiency, while the *Less Resource Intensive* scenario assumes nearly 40% water use efficiency in both residential and CII sectors – but no advancements in technology. This scenario also assumes additional conservation programs and a more price-sensitive water demand than is currently presumed.

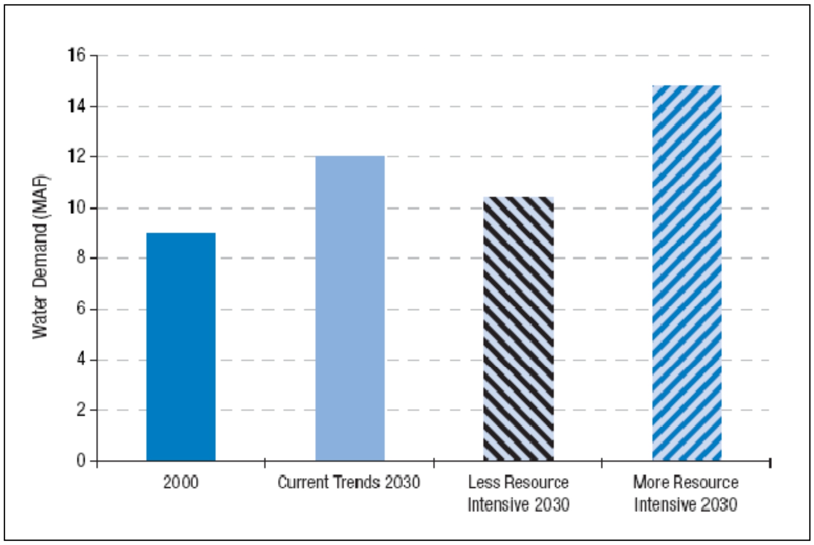


Figure 8 Urban water demand from DWR's estimate for 2000 and 2030 as projected in the three DWR scenarios

Source: (P. H Gleick et al., 2005)

Population growth and income both play a large role in predicting future water demand. While urban water demand is expected to increase across all three major regions of California (north, central, and south), the largest increase in absolute terms is expected to be in the southern region. Figure 9 below, illustrates that in a high efficiency scenario, a water demand increase in the north can be offset by more efficiency in the central and southern regions. Urban water conservation will prove to be the most useful in the south, because the urban population is much higher than in the rest of the state.

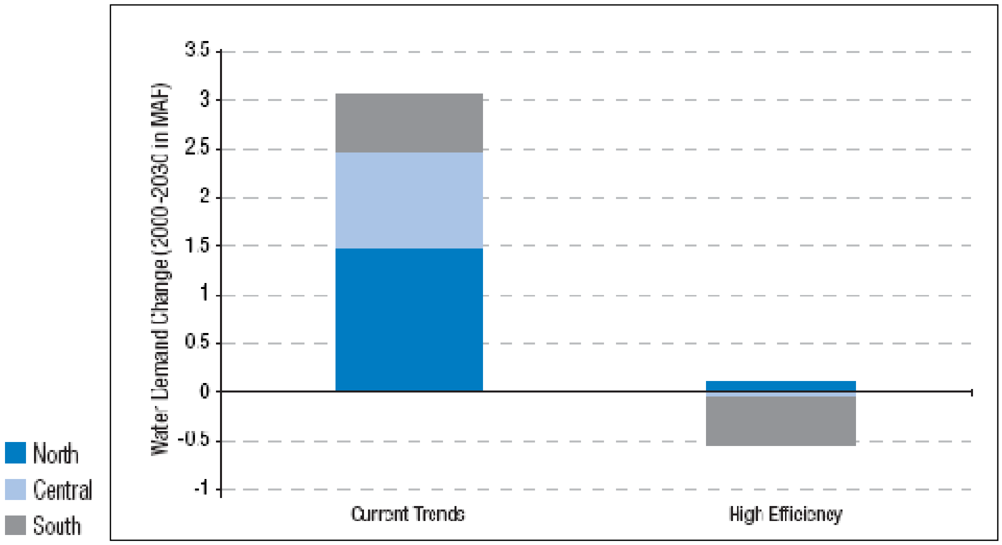


Figure 9 Changes in urban water demand (2000-2030) by geographic region for the current trends and high efficiency scenarios

Source: (P. H Gleick et al., 2005)

Climate Impacts of Energy and Water Consumption

Greenhouse Gas Emissions from Electricity Generation

It is extremely unlikely that global climate change over the past 50 years can be explained without attributing much of it to the observed increases in anthropogenic GHG concentrations (Parry, Canziani, Palutikof, van der Linden, & Hanson, 2007). In an effort to reduce human-induced climate change, the 2006 California Global Warming Solutions Act, Assembly Bill 32 (AB32) mandated a reduction of statewide GHG emissions to 1990 levels by 2020 (California Air Resources Board, 2009). Electricity generation, combined heat and power, and electricity and natural gas end uses for residential and commercial purposes are accountable for about 34 % of all greenhouse gas emissions in California (California Air Resources Board, 2009). Therefore, AB32 specifically monitors efforts taken by power generators to reduce their emissions.

Increased renewable energy use, such as solar and wind power, will result in fewer emissions than more traditional methods of electricity generation from coal, nuclear and natural gas. However the largest potential to reduce GHG emissions may be from reductions in overall energy use and increased efficiency measures (Kutscher, C.F., 2007). Forty-three percent of all U.S. carbon emissions can be attributed to residential, commercial and industrial buildings (Kutscher, C.F., 2007). Among the various strategies to encourage energy efficiency for buildings include improved appliance and equipment efficiency standards, and utility-based financial incentives programs (Kutscher, C.F., 2007). We argue that due to the electricity embedded in the water cycle, the large commercial sector in Southern California has a great potential to make sizeable reductions in GHG emissions from also implementing water conservation strategies across various businesses.

Climate Change Impacts on Water and Electricity Resources

Studies have shown that climate change only amplifies the difficulties of managing water in California because warmer winter temperatures have led to changing precipitation patterns and reduced water availability throughout the year (Stewart, I.T., Cayan, D.R., & Dettinger, M.D., 2004). Water availability in California is largely dependent on weather, availability of groundwater, and the storage system constraints of capturing snowmelt from the Sierra Nevada Mountains (Stewart, I.T. et al., 2004). As warmer winter temperatures affect the timing and amount of precipitation that falls as snow, it also hinders the ability to capture spring run-off (Stewart, I.T. et al., 2004). Since that very runoff affects the reliable water supply needed throughout the arid summer months, climate change impacts on precipitation patterns have become a particular interest for the CDWR when designing the State Water Plan.

An unreliable supply of fresh water through the year can have many adverse impacts on California's economy. The effects can include: reduced water allocated to agriculture; diminished ability to produce hydroelectricity; disrupted marine ecosystem dynamics; and increased risk of wildfire (California Climate Change Center, 2009). As water supplies are stressed, the price may cause a shift to full-cost water pricing that will effect industry and business water-use practices, and lead to more rigid water regulations (Morrison, J., Morikawa, M., Murphy, M., & Schulte, P., 2009). Therefore, efforts to become more energy and water efficient can help facilitate the mitigation of climate change through decreased GHG emissions from the energy sector and lessen the global warming impacts on water resources. While even aggressive efficiency actions taken by California will only have a very small impact on GHG emissions worldwide, they will allow California to prepare for a more uncertain future.

Climate change projections for California depend significantly on near term worldwide actions to limit anthropogenic GHG contributions. Regardless of these actions, climate change models predict increases in summertime air temperatures which will cause an increase in total and peak electricity demand as shown in Table 1 (Franco & Sanstad, 2006). While there will be slightly higher winter temperatures, the increase in electricity use for summer cooling is projected to exceed reductions in reduced winter heating (Franco & Sanstad, 2006). Coupled with increased populations, especially in the fast growing interior counties, future demand increases for electricity in the summer months to maintain comfort and human health could be substantial.

Table 1 Estimated increases in annual electricity and peak load demands for the AlFi, A2 and B1 scenarios, relative to the 1961-1990 base period

Climate Model	Year	Emission Scenario	Annual Electricity (%)	Peak Demand (%)
Hadley3	2005-2034	A1fi	3.4	4.8
	2035-2064	A1fi	9.0	10.9
	2070-2099	A1fi	20.3	19.3
PCM	2005-2034	A2	1.2	1.0
		B1	0.9	1.4
	2035-2064	A2	2.4	2.2
		B1	1.7	1.5
	2070-2099	A2	5.3	5.6
		B1	3.1	4.1
GFDL	2005-2034	A2	2.9	3.6
		B1	2.5	4.1
	2035-2064	A2	5.0	5.0
		B1	4.2	5.0
	2070-2099	A2	11.0	12.1
		B1	5.8	7.3

Source: (Franco & Sanstad, 2006)

The Impacts of Water Shortage in California

Decreases in water availability are expected to impose adverse impacts in the commercial and industrial sectors in Southern California. Large-scale housing developments have already been affected by shortages in water supply due to the California state law that requires housing developers to provide a 20-year water supply plan as a condition for building. This law, California Water Code, Section 10631.1, was enacted in 2001 and is only the beginning of a set of water laws that require more stringent water conservation policies on development (Steinhaurer, J., 2008). Water shortages will also hurt energy providers that are already struggling to meet the demand of an ever-increasing population. Currently, California receives 14.5% of its electricity from hydroelectric power, a source that is decreasing in energy output

(California Energy Commission, 2009a). As a more limited water supply affects the ability of Southern Californians to meet their water needs, industrial and commercial businesses draw upon groundwater reserves and import water from farther away to meet demand. However, over-pumping of ground water and water importation uses even more energy and electricity, thus causing further stress to California’s natural resources.

Barriers for Potential Resource Efficiency

The underlying motivation of this project is to quantitatively demonstrate that combined energy and water saving strategies provide simultaneous benefits to businesses, utilities, and the environment. With easily accessible information, common goals, appropriate incentives, and unlimited funding, these benefits would be simple to achieve and projects like ours would prove unnecessary. The difficulties can range from administrative, financial, legal, and technical for both businesses and the utilities (Bureau of Reclamation, 2009). Recognition of the various barriers that the utilities and businesses face is the first step toward discovering solutions that overcome them.

Limitations for Businesses

The fifth volume of the recently completed WEEP report identified the limitations that businesses in the CII sector encounter. Broadly categorized, the barriers that commercial businesses face are: imperfect knowledge of conservation techniques or programs; limited availability of engineering and administrative support; and capital and financial limitations (Bureau of Reclamation, 2009).

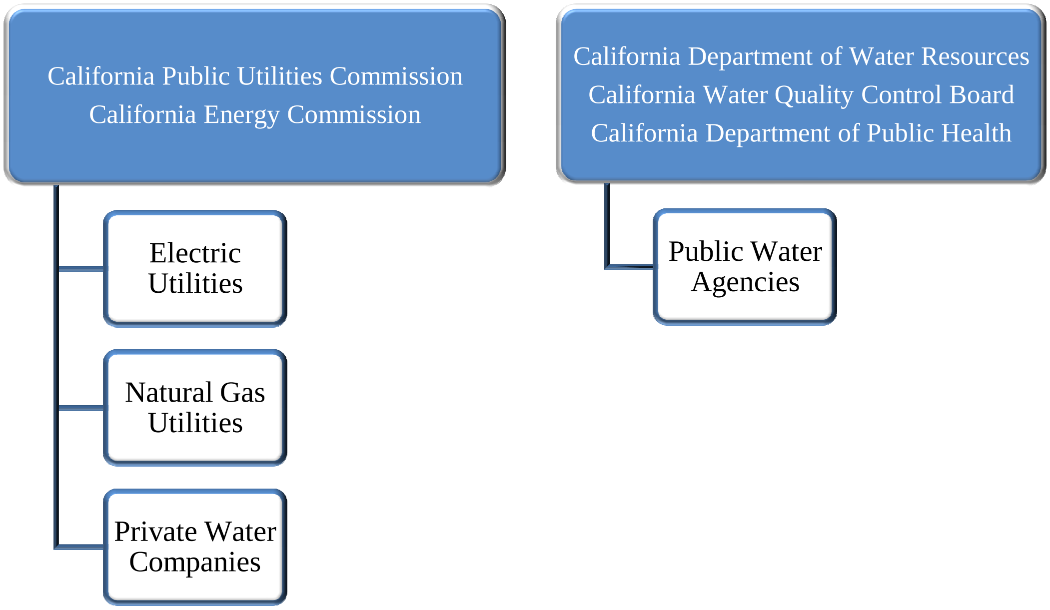
Many California utilities are aware of these barriers and produce useful information to help business customers understand energy or water conservation opportunities and rebates. Although many utilities and water districts post this information on their websites, informational seminars or technical assistance for businesses is limited. Since the utilities have few available technical staff to educate businesses about the complexities of energy and water conservation strategies, many businesses are not aware of their potential savings or available rebate programs (Bureau of Reclamation, 2009). Additionally, audits conducted by electricity and water utilities are helpful sources of information, but they are not typically comprehensive and do not always effectively communicate to the businesses how to move forward and implement conservation strategies (Bureau of Reclamation, 2009). And in some cases, business managers in the CII sector may be aware of more efficient equipment but lack the up-front capital or technical assistance needed to implement these technologies.

Utility Barriers & the Institutional Disconnect

Comparable to the barriers encountered at the consumer level, energy and water utilities face a set of restrictions which include: lack of knowledge of the quantified savings opportunities of combined energy and water conservation; institutional and political challenges; and securing funding for joint efficiency programs.

Since the nexus between energy and water is still a relatively new area of research, some uncertainty remains in determining the extent to which water conservation efforts relate to direct electric savings. In 2007, the CPUC approved a pilot project to study the degree to which water conservation programs could be a relevant part of the California energy utilities efficiency programs. Among the various goals of this project were to both identify geographically specific kilowatt-hour (kWh) savings per millions gallon estimates and also create a model for tracking and crediting cross-territory embedded electricity savings (California Public Utilities Commission, 2007). The results of the study to determine a statewide and regional water-energy relationship have not been published. Establishing the quantifiable scientific connection between electricity savings and water conservation is crucial to provide incentives for utilities to jointly manage energy and water use.

In addition to the utilities' inability to directly quantify the benefits related to combined energy and water conservation, the fact that they are not jointly regulated creates an institutional barrier between them. As a matter of public interest, regulations guide both energy and water policy and management. Regulations can be broad, or leave little room for interpretation for energy and water management. The regulatory agencies therefore play an important role but are not yet built to account for and oversee coordinated energy and water management across the state. While IOUs and private water companies work within a structure set mostly by the CPUC and CEC, public water agencies, making up the majority of urban water suppliers, are not regulated by either of these agencies (Figure 10). This lack of combined oversight acts as a barrier to policies which integrate resource management of water and energy. While some future legislation may bring public water agencies and other utilities under some centralized control such as the CPUC or DWR, this may have its own political and technical difficulties. Until then, voluntary coordination and smaller scale projects with mutual interests may be all that is possible.



California Public Utilities Commission
California Energy Commission

- Electric Utilities
- Natural Gas Utilities
- Private Water Companies

California Department of Water Resources
California Water Quality Control Board
California Department of Public Health

- Public Water Agencies

Figure 10 Relationship between regulatory agencies and energy and water utilities in California

Unlike SCE which has investors and centralized management, most water utilities are publically owned and largely managed at a local level. Water utilities have been very effective at attaining development and sanitation objectives. However, the WEEP report suggests that water utilities have not been as effective as electric utilities at attaining conservation goals because of barriers in terms of staffing, funding, and time necessary for water utilities to plan strategically (Bureau of Reclamation, 2009).

Tiered Pricing

For communities served by water districts which employ a tiered rate structure, conserving water presents even larger marginal cost savings for end-users. Tiered prices by design charge customers incrementally higher rates per unit as use increases. Rate increases occur as use exceeds a pre-determined level, encouraging customers to stay in lower use tiers. As the end-user decreases their water demand they can descend into lower cost tiers of use and pay lesser amounts for each gallon of water used. Tiered prices can especially help spur investment in water efficiency for commercial customers who understand the economics of business operations and the value of staying out of high rate tiers.

By enacting tiered pricing, economic signals are sent to customers to reduce water use if the cost of water exceeds their willingness to pay. Already required by the CPUC for IOUs selling electricity, natural gas, and water, tiered rates for public water agencies allow customers to better recognize the true cost of water and adjust their behaviors according to their own view of affordability. Properly designed tiered pricing structures encourage conservation, and when carefully adjusted to account for changes in use, revenue, and expenditures, tiered rates can avoid revenue shortfalls for water agencies even with reduced sales.

All three of our case study hotels are served by water districts with tiered rates. However, tiers for our Goleta and Santa Barbara hotels do not have large increases in rates with higher use, limiting the effectiveness of the economic signal tiers can send (Figure 11). For the Moreno Valley hotel, a shift to an aggressive tiered rate structure occurred in 2009. Because this hotel has separate water meters for indoor use and landscaping, only the landscaping is subject to tiers 2-4, creating a strong incentive to conserve outdoors while reinforcing an economic barrier to conserving water on the indoor account.

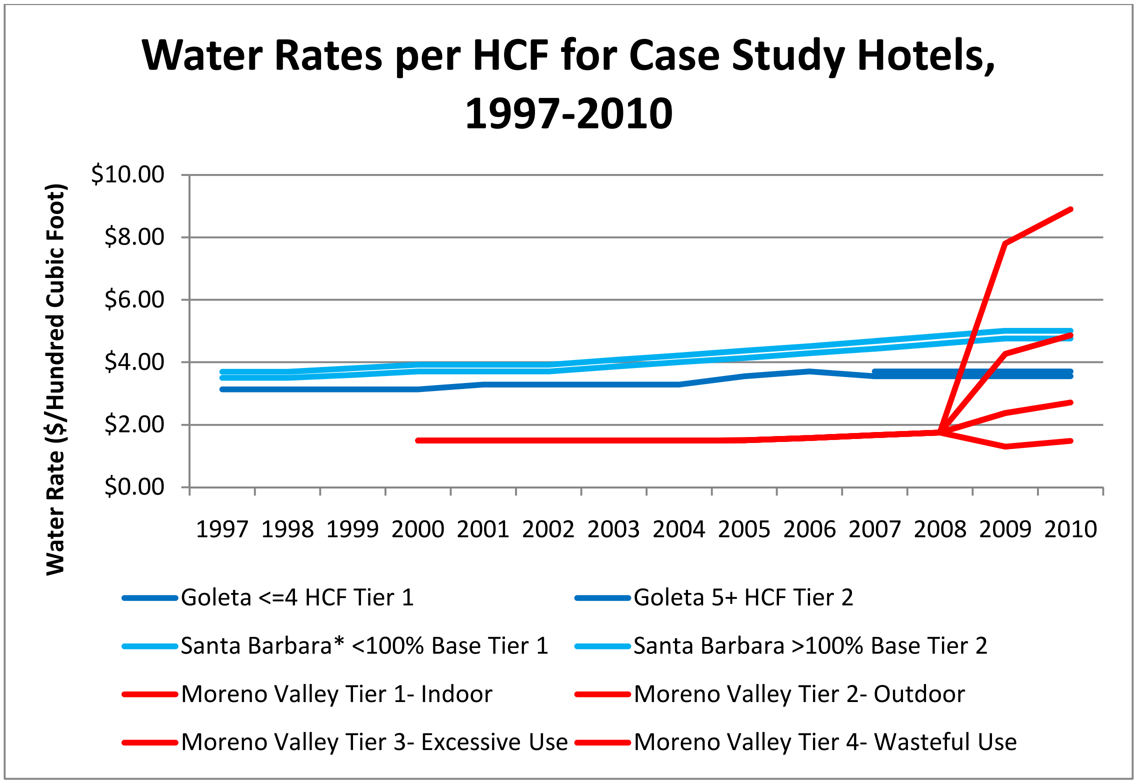


Figure 11 Water rates for case study hotels, 1997- 2010
Source: (Eastern Municipal Water District, 2010; Santa Barbara County Water Agency, 2009c)

On top of tiered prices, regulated energy utilities also have sales that are decoupled from their revenue stream. Energy utilities in California have two charges, the first is for volume of electricity or natural gas delivered and the second is for operational costs including transmission, distribution, maintenance, salaries, etc. (American Gas Association, 2009). The utilities can only charge their actual cost for the volume of energy delivered and earn profit only from the operational component. Further, the CPUC must approve of rates the utility can charge to ensure conservation is emphasized. Decoupling profits from the amount of commodity sold ensures the utility is “financially indifferent to its volume of sales”, freeing it to prioritize long term planning and policy (Mehan, 2009).

Without tiered or decoupled water rates, it is difficult to expect water districts to push water conservation that reduces their own revenues, except during droughts and periods of limited supply. While many water districts do have conservation rate structures that discourage waste, there is still less incentive to encourage conservation than with fully decoupled rates. For this reason, the conservation goals of energy and water utilities are understandably different.

Southern California Edison Incentives

Southern California Edison is one of the largest electricity providers in the nation, serving more than 13 million people across 50,000 square miles of southern, central, and coastal California (Southern California Edison, 2009a). SCE generates over a third of the power it delivers, coming from large nuclear, natural gas, hydroelectric, and solar generation facilities. SCE also maintains an expansive transmission and distribution system to guide the reliable flow of electricity to its customers. As an IOU, SCE must be responsive to shareholders and its parent company, Edison International, but is also closely regulated by the CPUC and the Federal Regulatory Commission (FERC) (Southern California Edison, 2009b).

Under current conditions, Edison finds itself attempting to maintain its core business and meet evolving requirements to increase renewable energy generation while helping to reduce the GHG emissions from electricity provided to its customers. SCE recognizes these goals and actively supports the California's energy reduction targets by working to assist their customers to become more energy efficient. Through the combination of direct energy efficiency measures and an increase in renewable energy production, SCE is poised to reduce its GHG emissions to 1990 levels by 2020. As the first priority in California's electricity loading order, the CPUC requires that energy efficiency goals be satisfied prior to meeting electricity demand through demand response, renewables, and distributed generation (California Energy Commission, 2005).

Partnerships

Public oversight from state agencies such as the CPUC, CEC, and California Independent System Operator (CAISO) partly drive SCE's efforts in assisting customers to use electricity more efficiently. The CPUC approves rate changes and rules relating to customer charges which guide SCE's policies and strategies for meeting customer electricity demand and the adoption of renewable energy and efficiency goals. By providing a forecast of energy needs and licensing of new power plants, the CEC also plays an important role for SCE in promoting efficiency (League of Women Voters of California, 2005). The CAISO provides the management of statewide electricity transmissions, which ensure integrity of the entire grid during peak demands periods. In order to effectively manage the electricity grid CAISCO requires that partnerships exist between utilities and their large customers to shave power use at peak times. Within this complex arrangement of planning and regulation, SCE has developed many programs to meet the energy and environmental goals of the state.

Energy Efficiency Programs

In order to capture a broad range of energy efficiency opportunities, SCE manages many programs that will reduce electricity demand, increase renewable energy production, and provide customers with information to save energy and money. Customer oriented initiatives include improving distributed power through incentivizing solar electric generation and the installation of efficient combined heat and power generators. Other program such as SmartConnect will install all new "smart" electric meters, allowing customers to better manage electricity use (Southern California Edison, 2010a). Perhaps the most important programs are those that provide information and rebates to assist customers in implementing energy efficiency projects.

Business Incentives & Services Program

SCE provides direct incentives to residential and business customers for the purchase of energy efficient equipment (Southern California Edison, 2010b). From lighting to HVAC and even food preparation equipment, SCE's incentives are designed to reduce the initial cost to the consumer of common appliances and electronics. Other programs that SCE offers to small business customers include a direct install program which provides free energy savings analysis and products such as efficient refrigeration technologies, fluorescent lighting and LED lighting (Southern California Edison, 2010c). Other available programs help with energy efficiency during remodeling save money during the summer peak period, and educate customers about energy efficiency and saving money (Southern California Edison, 2010b).

To further meet the demands of the commercial sector, SCE employs trained Account Executives to assist these larger customers, and when there is interest, perform on site evaluations or audits to identify cost effective opportunities for energy efficiency. These audits provide some of the only direct customer interaction for SCE as representatives assess existing lighting, HVAC systems, and other electricity consuming appliances depending on the business. With the targets for energy efficiency increasing, improvements in the audit process or scope may provide a method to achieve additional electricity savings. For SCE and their efficiency seeking customers, additional opportunities may exist to save money and resources. To assess the potential opportunities, we partnered with three of SCE's hotel customers to perform a combined energy, water, and natural gas audit in order to measure the total resource use from specific technologies within the commercial sector.

Approach

Targeting the Commercial, Industrial and Institutional Sector

Given that the majority of urban energy and water use in Southern California comes from the residential sector, it has been the focus of both energy and water conservation efforts. However due to the high energy intensity of commercial and industrial water use, the CII sector alone accounts for over 50 percent of total end user water-related electricity and natural gas use – exceeding the residential sector (Klein, 2005). Paired with the fact that the CII sector has the second highest potential for urban water conservation in Southern California (Table 2); it's evident that water conservation in the CII segment can potentially rival the large opportunities to reduce in the residential sector in terms of combined resource savings and benefits.

Table 2 California urban water use and estimated conservation potential

California Urban Water Use By Sector	Water Use in 2000 (AF/year)	Best Estimate of Conservation (AF/year)	Potential to Reduce Use (%)	Minimum Cost Effective Conservation (AF/year)
Residential Indoor	2,300,000	893,000	39	893,000
Residential Outdoor	983,000 - 1,900,000	360,000 - 580,000	25 - 40	470,000
Commercial/Institutional	1,850,000	714,000	39	658,000
Industrial	665,000	260,000	39	

Source: (P.H. Gleick et al., 2003)

Selecting Hotels

In deciding which area within the CII sector to analyze, we relied heavily upon the recently completed WEEP Report (Bureau of Reclamation, 2009). In 2007, the BOR partnered with the CEC and Metropolitan Water District of Southern California (MWD) in order to examine opportunities to integrate water and energy efficiency programs. Their report focused on CII customers, who across energy utility, water district, wastewater sanitation districts, and other state and local agencies, represented some of the largest energy, water, and natural gas users.

In order to determine which CII customer classes were the largest combined resource users and therefore had the highest potential for savings; the BOR collected data for Southern California from the CEC (electricity, natural gas), the West and Central Basin Municipal Water Districts (water), sanitation districts of Los Angeles County (wastewater), and the City of San Diego (water, wastewater). Using this averaged data the WEEP report then ranked total electricity, natural gas, water, and wastewater use for all the CII customer classes (Bureau of Reclamation, 2009).

Based on the North American Industry Classification System (NAICS), the BOR identified 15 key CII customer classes to target for future water and energy programs, which included Casinos, Restaurants, Hospitals, and Laundry Services. Of these segments, Accommodations particularly is relevant due to its multiple energy and water needs (Table 3); which include resource intensive end uses such as laundry services, restaurants, and landscaping. The Accommodations sector also stands out due to its economic importance to California as a whole, and especially to Southern California – where energy intensity of water is the highest in the state.

Table 3 CII Accommodation sector resource use and CII ranking

	NAICS Code and Description: 721 Accommodation	
Utility	**Percentage of Southern California total utility volume used by Accommodation Sector**	**Accommodation Sector CII Rank**
Electricity	2.5%	8th
Natural Gas	5.4%	4th
Water	5.0%	5th
Wastewater	4.4%	5th

Source: (Bureau of Reclamation, 2009)

We selected three hotels in Southern California interested in analyzing their water and energy use. Two local hotels were chosen, one in Goleta and one in Santa Barbara, and another in Moreno Valley (Riverside County). The local hotels provide an interesting contrast since the Goleta facility is less than three years old while the Santa Barbara hotel was built in the 1980s. The Moreno Valley hotel was chosen specifically due to the high embedded energy in the water that serves the area, which is primarily imported from Northern California and the Colorado River.

Significance of Tourism in Southern California

Approximately 351 million domestic and international visitors traveled to and through California in 2008 ("California Tourism Highlights - California Tourism Industry Website," n.d.). Over the course of the year, the international visitors alone increase California's population by over 33 percent ("California Statistics & Trends - California Tourism Industry Website," n.d.)[1]. These numbers represent a serious economic influx to the state: in 2008 direct travel spending was \$97.6 billion – providing 924,000 jobs and \$4.4 billion in local and state tax revenue (Dean Runyan Associates, 2009).

The pillar of California's tourism economy is the Accommodations industry: visitors spent \$16.2 billion on lodging alone in 2008, which supported 533,000 jobs in the accommodations and food service sector (Dean Runyan Associates, 2009). Between 2001 and 2007, accommodations and food services was the 4th fastest growing industry in California, with a growth rate of 14.6 percent (California Economic Development Partnership, 2009).

Central and Southern California economies particularly rely upon accommodations – in fact 71 percent of California's entire lodging inventory is located in these high tourism regions (California Tourism Industry, 2009). In Santa Barbara County, the location of two of our case study hotels, the accommodations and food service industry was the seventh fastest growing industry in the county – growing 6.8 percent between 2001 and 2007 (California Economic Development Partnership, 2009). Visitors spent a total of \$343 million on accommodations alone in 2007, which employed 10,300 people (Dean Runyan Associates, 2009). Riverside County, the location of our third case study hotel, didn't experience the same growth but employed four times as many people in the Accommodations sector; and earned over \$1 billion in 2007 (Dean Runyan Associates, 2009). However due to the economic recession, California hotel revenue in 2009 is predicted to experience its largest decline in annual revenue since 1932 (PKF Consulting,

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[1] **Assuming a 36.7 million CA population, and 13.4 million international visitors in 2008.** Source: The California Tourism Industry, http://tourism.visitcalifornia.com/Industry/Research/CaliforniaStatisticsTrends/.

2009). Strategic investment in decreasing operating costs such as utility bills can be an important way to offset that decline.

Prior Research

As mentioned previously, more research on residential water end use and behavior is available than studies in the CII sector. Notably, the 1984 HUD and Mayer et al 1999 studies were some of the first to accurately assess water conservation potential by closely measuring water end use and have yielded valuable information on actual water use behavior. Unfortunately such a thorough water use assessment doesn't yet exist for the hotel sector. Most previous studies attempting to characterize commercial and specifically accommodation utility savings opportunities have either relied upon generalized regional data and assumptions concerning water use or specifically characterized water use either in terms of percentage of total by end use or summarize water use in terms of gallons per day per guest/room (Bureau of Reclamation, 2009; P.H. Gleick et al., 2003). See Appendix E for an overview of previous water use characterization studies.

Previous commercial and hotel studies, while useful, avoid specific measurement and complete characterization of water end use and instead report water use per room or guest instead of actual end use. Since it is unknown through what end use the water is coming from (i.e. showers, pools, laundries), determining the actual calculation of resource savings potential is not possible. The few studies which have employed data loggers and flow trace analysis (see (Mayer & DeOreo, 1999) for a comprehensive study on residential water end use; and several hotels in the (Redlin, DeRoos, Administration, & Foundation, 1990) study and (Greater Vancouver Regional District, 1998) study provide sub-metered water data) have more accurately characterized water use and savings potential. However, these studies have ignored direct energy savings opportunities as well as multiple benefits of saving both upstream and downstream embedded energy in their savings calculations. Our project's goal is to accurately determine specific water and energy savings potential at three case study hotels. As mentioned, a precise analysis of savings potential is dependent upon accurate characterization of water and energy end use.

Not only is the hotel sector financially important to California as a whole, but as mentioned previously it has been identified as having a large combined resource savings potential. Estimates from the BOR show that efficiency in various end uses in the Accommodation sector can yield large percentages of water, electricity, and natural gas savings – see Table 4 (Bureau of Reclamation, 2009). However these figures are generalized based on averaged data from different energy, water, natural gas, and wastewater agency service areas. Because of this, the predicted utility savings in the table below are based on hotel end use assumptions and may or may not be representative of actual Accommodations sector savings potential. For this reason, our project selected three case study hotels in order to identify resource savings from specific end uses.

Table 4 Potential savings by end use in the accommodations sector[2]

Water and Energy Savings Potential for Accommodation Sector			
End Use	Water	Electricity	Natural Gas
Swimming Pools	30%	50% to 70%	50% to 70%
Laundry*	10%-90%	45% to 80%	45% to 90%
Plumbing Fixtures*	20%-50%	10% to 25%	10% to 25%
Lighting	-	30%	-
Cooling	20%-30%	20%-30%	-
Landscape	20%-50%	-	-
Food Service	10% to 30%	10% to 30%	10% to 30%

Source: (Bureau of Reclamation, 2009)

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[2] **The reported energy savings for the starred end uses will either come from electricity OR natural gas depending on the machine or heater energy source.**

Water and energy are intrinsically linked, yet the resources are managed and planned separately. This lack of coordinated management causes many opportunities for combined energy and water savings to be overlooked. California leaders are beginning to see the need for integrated management; especially as population projections predict significant growth in California and subsequent increased water and energy demand. Energy utilities like SCE will have to expand the current infrastructure to meet the potential growth in demand. Climate change projections could potentially further stress the water supply in California, making it extremely difficult to meet the water needs of growing populations. Research quantifying the benefits of combined energy and water conservation needs to continue as California designs conservation programs and policies that focus on combined energy and water efficiency (California Energy Commission, 2005).

This project aims to demonstrate that combined energy and water saving strategies provide simultaneous benefits to businesses, utilities, and the environment. There are difficulties which state agencies, utilities, and businesses experience while working toward efficient resource management. The difficulties can range from administrative, financial, legal, and technical for both businesses and the utilities (Bureau of Reclamation, 2009). The WEEP report lays out a framework for assessing combined water and energy conservation opportunities in the CII sector (Bureau of Reclamation, 2009). We chose one of the commercial classes highlighted in the WEEP report, hotels, to focus on for our case studies. We found three different hotel case studies: two in Santa Barbara County, and one in Riverside County. The hotel sector is one of the largest and fastest growing industries in the state. Our group chose to focus on hotels not only because of the large opportunity for energy and water conservation, but also because the variety of end uses at hotels can also be applied to many other commercial sectors. Each case study has regional differences in water supply, energy demand, and the intensity of embedded energy in water.

Part II: Integrated Energy and Water Audit Case Studies

Methods: Auditing Justification and Procedure

SCE Electricity Audits – Method and Interpretation

The following analysis is based on SCE audit guidance documents, communication with SCE staff, and observations of actual SCE audits. The SCE audit method for hotels is focused on lighting and HVAC efficiency measures. First, the auditing professional notes the exterior lights, size of building, and age of building. Once inside the hotel the lighting is inspected in all common areas and then in a sample of guestrooms. The auditor does not inspect each guestroom, but the data gathered in a sample of guestrooms is extrapolated over the total number of guestrooms. Each different area of the hotel is labeled as a specific use area: lobby, conference room, hallway, kitchen, or guestroom. For exterior and interior lighting the auditor notes the lamp type, ballast type, number of lamps, and type of control (manual switch or automatic sensor) for all the use areas. The data for the lighting used in each use area of the hotel is entered into a software system that computes retrofit results.

HVAC inspection begins at the exterior of the building as the auditor notes any air conditioning units that may be visible. The most common air conditioning units used in guestrooms are individual Package Terminal Air Conditioning (PTAC) units, which often have part of the unit installed on the exterior of the guestroom. During the interior inspection, the auditor confirms the type of air conditioner used in the sample of guestrooms. If the air conditioner is a PTAC unit the type of thermostat, control set points, and nameplate are noted. If the guestroom uses a water chiller unit the auditor asks the facility manager about usage trends and control settings. The same procedure is followed for the inspection of large common areas like the lobby or dining room. If the common areas are water chilled the auditor finds the number of units, size of chiller, nameplate of the model, and control set points. As with lighting, the data is entered into SCE's auditing software to generate retrofit savings results.

Overview of Synergy Methods

To analyze the estimated annual water, natural gas and electricity consumed by each end use category at the hotels, we used the information collected from audits, hotel staff, and a thorough literature review. After obtaining specific resource use numbers, we calculated the embedded energy used in delivering and treating the water consumed by the hotel. By doing so, we can suggest the areas where there may be benefits for SCE and other utilities to encourage efficiency for their hotel customers. Furthermore, we analyzed SCE's energy mix to estimate the GHG reductions by kWh saved through water conservation and, more broadly, end use efficiency potential at our case study hotels.

Our group designed an integrated energy and water audit protocol, the *Synergy Audit*, to supplement SCE's traditional energy audit by quantifying the energy related to all water consuming end uses. We performed these procedures alongside the SCE team, members of the local water districts, and hotel staff members at each of the three hotel locations. A week before administering the integrated audits on site, the hotel manager was asked to fill out a *Pre-Audit Questionnaire*. The questionnaire requested that the manager provide facility specific information such as, establishment and renovation dates, number and type of rooms, occupancy rate data, and access to the electricity and water bills over the past three years. The information not only made the auditing team better acquainted with the hotel, but also provided important data used in calculating the typical yearly energy and water uses.

Each Synergy team member became specialized in one or more of the six hotel water end-use categories: Laundry, Domestic Fixtures, Landscaping, HVAC, Pools and Spas, and Food Service. On average, each audit lasted 3-5 hours, and while each member was responsible for their designated categories, everyone was involved in the entire process. Table 5 shows the resources needed for the various energy and water end-uses. The entire *Synergy Audit Guidance Document* and *Pre-Audit Questionnaire* can be viewed at the end of the report in Appendix A.

Table 5 The technologies that the Synergy studied and the resources used by each

Type of Resource Used by Each Targeted End Use			
Fixture	**Water**	**Gas**	**Electricity**
Ice Machines	X	-	X
Dish Washers	X	X	X
Pools	X	X	X
Washing Machines	X	X	X
Faucets	X	X	-
Shower Heads	X	X	-
Landscaping	X	-	-
Toilets	X	-	-

Food Service

Food services are known to represent a substantial portion of the energy and water demand across commercial buildings. In fact, food services consume approximately 2.5 times more energy per square foot than other commercial buildings. While full service restaurants comprise the major share of foodservices in the commercial sector, lodging constitutes a non-trivial share of the market. In the year 2000, 4.5% of all commercial foodservice sales in the United States were attributed to lodging services (Consortium for Energy Efficiency, 2005b).

While it is common for many large, resort style businesses in the accommodations sector to offer extensive food and dining services, the three hotels examined for this project did not offer a full service kitchen. The Goleta hotel has a partial service kitchen equipped with an oven, sink, dish washer, microwave, and ice machine. The Santa Barbara hotel provides only a coffee bar to their guests. The hotel in Moreno Valley has a relic kitchen that is currently used only for heating continental style breakfasts and dish washing. Many of Moreno Valley’s kitchen appliances are no longer hooked up or in operational capacity.

Previous studies have identified priority retrofit targets and management practices for reducing either energy or water consumption in commercial food service establishments and served as important references for this project (San Francisco Department of Public Health, 2009); (Efficiency Partnership, 2006); (Karas et al., 2005); (North Carolina Division of Pollution Prevention and Environmental Assistance, 2009). For our hotel audits, eight appliance targets and behavioral aspects were considered when auditing a full service kitchen:

1. Pre-rinse spray valves;
2. Steamers;
3. Water heaters;
4. Ice machines;
5. Dish washers;
6. Hot water system insulation;
7. Automatic flue dampers above burners;
8. Recirculation pumps on the hot water system

To corroborate the scope of our inspection, prior research by the Consortium for Energy Efficiency (2005), summarized in Table 8, revealed the following water and electricity savings potential when upgrading outdated conventional appliances:

Table 6 Potential water and electricity savings for selected food service fixtures

Appliance	**Water Saving Potential**	**Electricity Saving Potential**
Pre-rinse spray valves	30%-60%	N/A
Steamers	90%	30%-50%
Ice Machines	20%-40%	15%-50%
Dish Washers	30%-50%	30%-50%

Source: (Consortium for Energy Efficiency, 2005b)

The analysis for food services was both qualitative and quantitative. Qualitative aspects focused on management practices and did not attempt to capture numerical savings to water, natural gas, or electricity. For instance, maintaining sound installation on the hot water piping and tank system prevents energy loss that takes place through heat transfer. Similarly, deactivating the recirculation pumps on the hot water system at night or during non-business hours can save electricity or natural gas costs. Additionally, keeping the dish washers in the automatic conveyor mode recommended by the manufacturer optimizes resource use for each wash cycle.

Qualitative analyses also focused on pre-rinse spray valves. The main objective was to ascertain whether hotel kitchen services were employing the use of water efficient sprayers. Yet, the only pre-rinse spray valve encountered during our inspection was at the Moreno Valley hotel. Flow rate calculation revealed the spray valve to operate at 1.6 gpm, which is within the bounds of conventional high efficiency sprayers (North Carolina Division of Pollution Prevention and Environmental Assistance, 2009).

Quantitative analyses were designed such that numerical approximations of water, electricity, and natural gas use could be assigned to each relevant food service end use. Specifically, quantitative analyses were conducted on food service ice machines and dish washers.

Calculations for ice machines first require manufacturer information on the gallons of water used per 100 pounds of ice production, electricity used per 100 pounds of ice generation, and ice harvest rate in 100's of pounds per day. From there, assumptions on average use and operational capacity were made to approximate monthly or annual resource use. Our analysis assumed ice machines operated at 75% of capacity annually on average (Pacific Gas and Electric Company, 2006). Annual ice machine water consumption (in gallons) was computed using:

Annual ice machine water consumption (gallons) =
$0.75 \times Harvest\_rate \times (gallons/100lbs) \times days \times units$,

where *harvest rate* is the daily maximum production of ice in 100s of pounds, *days* is the number of days used per year, and *units* is the number of units of the chosen model at the facility. Annual ice machine electricity consumption was found by multiplying the manufacturer provided kWh specification by the harvest rate and summing over 365 days of use:

Annual ice machine electricity consumption (kWh) = $0.75 \times Harvest\_rate \times (kWh/100lbs) \times days$
.

Water, electricity, and natural gas use were determined for dishwashers in a method very similar to the one used for ice machines,

Annual dishwasher water consumption (gallons) =
$(gallons/rack/unit) \times (cycles/day) \times racks \times (use/week) \times 52$,

where *racks* represent the number of racks in the washer and *use/week* is the number of uses per week averaged over the year, and *gallons/rack/unit* is provided by the manufacturer. Annual dishwasher electricity consumption was found by multiplying the kilowatt (kW) rating of the machine by the estimated number of operating hours per year:

Annual dishwasher electricity consumption (kWh) =
$idle \times (wash\_time/60) \times racks \times (days\_used/year)$,

where *idle* represents the electricity consumption (kWh) when the machine doors are closed and *wash_time* represents the minutes required to wash one rack. The *idle* function was provided by the manufacturer for the machines studies in our analysis. Annual dishwasher natural gas consumption was computed using the following function:

Annual dishwasher natural gas consumption (therms) =
$therms \times (gallons\_hot\_water/use) \times racks \times (use/week) \times 52$,

where *therms* is the natural gas required to heat one gallon of water to washing temperature (*W*) from 55 degrees Fahrenheit,

$$\frac{[8.34Btu \times (W^{0}F - 55^{0}F)]}{100{,}000Btu/therm}.$$

Pools and Spas

Since pools and spas require water, natural gas, and electricity they are among the most resource-intensive end uses at hotels. In order to determine the usage at our case study hotels, we recorded the pool and spa heater, circulation pump, and light specifications. These measurements, combined with operational data provided by hotel staff (see Appendix A for pool and spa auditing forms) provided the information necessary to calculate the pool and spa resource use described below.

Monthly pool and spa water use (gallons) due to evaporative loss was calculated using the following equation:

$$Pool\_Evaporative\_Water\_Loss = Pool\_Surface\_Area \times Evaporation\_Rate$$

where the local evaporation rate was assumed to be equal to the measured evapotranspiration rate based on local temperature (California Department of Water Resources, 2009). In addition to water replacement due to evaporation, hotels also periodically drain and refill their spas anywhere from several times a month to once every two months.

The following equation calculates the daily electricity use of pool and spa pumps (kWh):

$$Pump\_horsepower \times 0.746 kW / horsepower \times daily\_run\_time = kWh\_electricity$$

The pool pump run time varies by hotel and depends upon how long the pool pump timer is programmed for. Spas also use electricity to run their jet pumps, which can be calculating using the same equation as above by estimating the time that the jets are operated.

The electricity used by pool and spa lights is a simple function of the light wattage multiplied by the run time of the lights:

$$Light\_wattage \times daily\_run\_time / 1000 = kWh\_electricity$$

Finding the natural gas used to heat pools and spas requires calculating the complex relationship between the initial pool temperature, the desired temperature increase, combustion rate of the heater, heat loss from evaporation, the ambient temperature of the air, wind speed, and the pool's volume.

Our analysis does this by first calculating the natural gas needed to heat up the pool or spa to its programmed temperature when turned on in the morning, and then finding the natural gas equivalent to the heat lost from the water surface. These two equations are listed below:

$$water\_volume \times (final\_temp - initial\_temp) \times 8.34 = BTUs\_Energy$$

$$surface\_area \times (final\_temp - initial\_temp) \times operating\_time \times loss\_factor = BTUs\_Energy$$

See Appendix C for a detailed explanation of the pool and spa calculations.

Heating, Air Conditioning, and Ventilation (HVAC)

The DOE estimates that HVAC systems in U.S. households account for 31% of total electricity use. Hotels employ similar patterns of HVAC electricity usage and some HVAC processes require large amounts of water as well. Specifically, water is needed for large air conditioning systems that utilize cooling towers and for hot water heaters. To identify the opportunities for water conservation in cooling towers and hot water heaters we first found how each technology operated and identified the processes where it would be visible to us if water resources were being wasted. We did not directly observe the use of cooling towers in our hotel audits, but cooling towers are such intense water users it is important to discuss a method for assessing cooling tower water use.

Cooling Towers

Most air conditioning in hotels doesn’t involve a cooling tower, as each individual room has a separate air conditioning system. Small air conditioning systems use ambient air, electricity, and chemical refrigerants, but do not use water. Cooling towers are needed when large common areas like the lobby, meeting rooms, or eating areas use central air conditioning. There are two main types of cooling towers: direct (open circuit) or indirect (closed circuit). Open circuit cooling towers allow the water being cooled to have contact with surrounding air. Indirect cooling towers completely contain the cooling water in tubes and do not allow access to outside air (Betterbricks, 2005). Both types of cooling towers operate on the same principle: warm air is blown over a stream of water to force some of the water to evaporate. The evaporation process cools the stream of water that is in the unit, and the cooled water is stored and piped to air handlers throughout the building. The constant cycle of evaporations requires the cooling tower unit to continually make up the water lost to evaporation (Cooling Technology Institute, 2009).

In open circuit systems, it is important to reuse as much water as possible, but the mineral build up in recycled water can cause scale build up and limit the effectiveness of reusing water. Also, impurities in left in the water can lead to the growth of harmful pathogens. Therefore, the remaining water must be completely flushed out of the system at regular intervals, a process called “blowdown”. We identified that it is at the blowdown point in the cooling process that water could be conserved, especially if the cooling tower is not running efficiently. Visible leaks, blowdown blockage, automatic blowdown function set too frequently, and lack of insulation on the pipes are all signs that a cooling tower is wasting water (Iklim Ltd Sti, 2006).

Hot Water Heaters

Hotels need the ability to heat significant amounts of water to meet the demand of their guests. An efficient water heater uses less electricity or natural gas, and saves the hotel money on their electricity or natural gas bill. During our hotel audits we noted the model, type, and capacity of the water heater. There are several indicators that show if a hot water heater is running less efficient than possible: lack of insulations on inlet and outlet pipes, a maximum temperature set higher than needed, and absence of heat trap valves on the inlet and outlet pipes (United States Department of Energy, 2005). Complete insulation of the pipes running out of the water heater increases efficiency, since less heat is allowed to escape from the pipes as water is pumped throughout the hotel. Insulation jackets around the tank and insulation foam under the tank also increase efficiency. Heat trap valves control or prevent conductive heat loss at the point where the inlet and outlet valves connect to the hot water tank. We also noted or asked the hotel manager the year of installation for the hot water heater, since hot water heaters older than ten years operate at 50% efficiency (Clean Air Trust, 2008).

Data Analysis

During our hotel audits we found that the three hotels we assessed do not use cooling towers as part of their air conditioning system. The Moreno Valley hotel uses split system air conditioning where each room is cooled individually. The Santa Barbara hotel and the Goleta hotel use individual units for their guest rooms and common areas. Although we did not directly observe the use of cooling towers in our hotel audits it is still important to show how water savings would be calculated. Cooling towers are intense energy and water users and are common in large hotels. The USEIA reported that HVAC and hot water heating accounts for 26% of the electricity consumed in hotels (United States Energy Information Administration, 2008). The water needed for cooling alone uses about 26% of the total water consumed in hotels (SWFWMD, 1997).

Indirect and direct cooling towers use the same amount of water. It is the humidity, wet-bulb temperature, water temperatures coming in and out of the tower, and amount of water lost to drift that determine how often a cooling tower must have blow down and make-up water. The calculations for determining cooling tower water use are both qualitative and quantitative. For the qualitative analysis the cooling towers should be visually inspected at each hotel. Then, the cooling towers should be inspected for leaks and visual signs of mineral buildup. If there were no obvious leaks or mineral buildup it should be assumed that the cooling tower was running efficiently. A complete cooling tower audit should include questions to the operating manager at the hotel about typical use patterns of the cooling tower.

For the quantitative analysis the auditing team should determine the actual water use in each cooling tower by calculating the amount of water the cooling tower requires for make-up.
A simple equation for determining make-up is (Iklim Ltd Sti, 2006):

$$Make\_Up(gpm) = Evaporation\ (gpm) + Blowdown\ (gpm) + Uncontrolled\ losses,\ drift\ (gpm)$$

A more detailed expansion of the above calculation should account for variable operating conditions: tower water flow, hot water temperature, cold water temperature, wet bulb temperature, and drift rate (SPX Cooling Technologies, 2009). Output for water use includes: evaporation, drift, blow down, and total water use. The auditing team should then compare the calculated water use with the stated cooling tower use patterns from the hotel manager to create monthly averages and yearly use averages.

Laundry

Hotel on-premise laundry facilities use a considerable amount of electricity, water and natural gas, with water and wastewater accounting for half of the total operating costs (Alliance for Water Efficiency, 2010). Industrial washing and on-premise laundries in California use nearly 30,000 AF of water each year (Cohen, Ortez, & Pinkstaff, 2009). Almost all hotels do all laundry on premise and the potential for water conservation exists in most facilities (Alliance for Water Efficiency, 2010). During the auditing procedure, it is important to gather information pertaining to the sheets and towel re-use policies, frequency, timing, and settings of washes and the clothes washer model(s). Changes to any of these aspects of hotel laundries can save significant resources, but there is a balance between saving resources and still maintaining quality cleaning of sheets and towels necessary for the hotel business. Because commercial clothes washers can be extremely expensive to replace, it is important to consider behavioral modifications or less costly technical adjustments prior to large capital investments in more efficient technology.

Energy and water use per load can also vary with the cycle settings, such as temperature and speed, but it is typical for those settings to be managed and maintained by contractual service providers rather than the hotel themselves. The hotel policy on washing sheets and towels has been proven to substantially impact the loads per day so it is essential to note the current policy in order to make behavioral suggestions to the hotel. For instance, many hotels put linen reuse place cards in each room to explain the value of linen reuse, and how to signal the housekeeping staff to change the sheets and towels. For each of our case study hotels, they change the linens on every third day of a guest's stay unless requested to do otherwise by the guest. Furthermore, there is value in noting whether or not the staff weighs each load before it is washed to ensure each machine is run at maximum capacity. The latest commercial washing machine models tend to be the most efficient, and while it is not expected that the hotel make frequent expensive upgrades, it is important for the managers to be aware of the savings potential of replacing or retrofitting older equipment.

To assess the water and energy conservation potential of the on-premise laundry, it is imperative to *determine the cycle frequency* of each machine and apply that to the *energy and water use specifications* of that model. Ideally, one would put a meter on the washing machine to measure actual energy and water use. Our case-study hotels did not keep a log of the washing machine cycles, but they provided us with an estimate of the minimum and maximum cycles per day on each machine.

It is assumed that the occupancy of the hotel has a positive linear relationship with the frequency the washing machines operate throughout the day. At our case study hotels, occupancy rates were presented as the average percentage of rooms sold by month, over at least the past two years. Using the monthly data we were given, we averaged the percentages for each month to estimate the monthly occupancy over a typical year. For simplicity, it was assumed that each day of the month had the same average monthly occupancy rate. To estimate the cycle frequency for each washing machine at the hotels, we created a linear relationship between the minimum and maximum loads per day and the minimum and maximum monthly occupancy rate by applying it to the slope-intercept equation for a line. For each machine at the hotels, we assumed a linear relationship between the cycles per day and the occupancy. Once we determined the cycles per day, we extrapolated that frequency out for the entire month, and aggregated all of the monthly cycles to estimate the cycles per year.

$$cycles/day = percent\_occupancy \times factor + offset$$

The manufacturer specifications of each model reported the average electricity, natural gas, and hot and cold water used per cycle. To determine the monthly and annual resource consumption by each on-premise laundry, we applied our resource consumption estimates to the daily, monthly and annual cycle frequency. Appendix D provides a detailed description of the specific data analysis calculations, resource consumption results and retrofit recommendations for laundry.

Domestic Fixtures

Characterizing the energy and water use from "domestic fixtures" – which includes faucets, toilets, and showers – is difficult as it involves highly variable human behavior patterns in addition to fixture specifications.

Our analysis relied upon fixture measurements taken at our three hotel case studies, including toilet gallons per flush (gpf), showerhead gallons per minute (gpm), and faucet gpm. These specifications were compiled with occupancy information and assumptions concerning usage of the fixtures to calculate guest and employee water usage per fixture type. The fixture water use assumptions were taken from water use studies (discussed in Appendix E), while facility manager observations helped us calculate water use in common areas such as lobby and pool bathrooms.

The following equations model shower, faucet, and toilet water use attributed to hotel guests:

$$Hotel\_Monthly\_Occupancy \times 1.8 \times 3 \times measured\_toilet\_flow = Guest\_Toilet\_Water\_Use$$

$$Hotel\_Monthly\_Occupancy \times 1.8 \times 0.75 \times 8.2\,\min utes \times measured\_showerhead\_flow$$
$$= Monthly\_Guest\_shower\_water\_use$$

$$Hotel\_Monthly\_Occupancy \times 1.8 \times 3 \times 0.11\_\min utes \times measured\_faucet\_flow = Guest\_faucet\_use$$

Note that our analysis assumes 1.8 guests per occupied room during the off season, and 2.5 guests per room in the peak tourist season. See Table 7 below for the assumptions used in these calculations.

To calculate employee water usage, our analysis relies upon previous studies that have characterized employee restroom frequency along with measured specifications of the employee toilets and sinks:

$$\#\_Employees \times 2.6 \times days\_per\_month \times measured\_employee\_toilet\_flow$$
$$= Employee\_Toilet\_Water\_Use$$

$$\#\_Employees \times 2.6 \times 0.11\min utes \times days\_per\_month \times measured\_employee\_faucet\_flow$$
$$= Employee\_Faucet\_Water\_Use$$

Other fixtures not captured through guest and employee analyses included disparate sources such as lobby bathrooms, employee break room faucets, kitchen food preparation areas, pool area bathrooms, and gym bathrooms and showers. Due to highly variable use of these facilities, our analysis relied upon estimates of use from interviews with hotel managers – those most aware of facility use. The equations below outline our calculations of common area urinal, toilet, and faucet use:

$$Manager\_estimation\_use\_per\_day \times 0.25 \times days\_per\_month \times measured\_urinal\_flow$$
$$= Common\_Area\_Urinal\_Water\_Use$$

$$Manager\_estimation\_use\_per\_day \times days\_per\_month \times measured\_toilet\_flow$$
$$= Common\_Area\_Toilet\_Water\_Use$$

$$Manager\_estimation\_use\_per\_day \times 0.11\_\min utes \times days\_per\_month \times measured\_faucet\_flow$$
$$= Common\_Area\_Faucet\_Water\_Use$$

Note that in general these sources were the smallest contributors to the hotel's overall fixture water use.

Table 7 Assumptions for domestic fixture use, based on various studies

Fixture User	Toilet flushes per capita per day:	Urinal use per capita per day:	Shower per capita per day:	Shower duration (min):	Faucet minutes per day:
Guests	3	N/A	0.75	8.2	0.33
Employees	2.6	N/A	N/A	N/A	0.29
Visitors	Estimated through Facility Manager Interviews			8.2	0.11

Once we had calculated fixture water use by area and frequency, we calculated the natural gas use for heating that water (for showers and faucets) using the following equation:

$$Fixture\_water\_use \times 0.73 \times 539.5 = BTUs\_Fixture\_Natural\_Gas\_Use$$

Where seventy three percent of the water used in the sinks and showers at the hotel was assumed to be hot, and therefore require natural gas for heating. All the assumptions used in our fixture calculations are reported above, and a full explanation of these assumptions and sources can be found in Appendix E.

Landscaping

Landscapes at hotels often convey an image of beauty and place. Well maintained plantings help represent the hotel and allow it to fit into its surroundings. While many hotel guests will not notice the landscape, others may truly enjoy their surroundings because of the design and plants within the landscaping. By pursuing landscape water savings without losing track of these goals, the hotel can maintain its desired image and also be more efficient. Saving water in the landscape provides the hotel with the single largest opportunity to reduce water waste. Although not associated with significant direct or downstream energy costs, energy embedded upstream in the water cycle can be significant for water imported long distances, resulting in indirect electricity and GHG savings. In addition, where water districts have moved to a tiered rate structure, strategies that realize large water savings can have an even larger marginal decrease in cost by getting water use into a lower tier, reducing the unit price.

Two main goals were part of the landscape evaluation; identifying the water needs of the existing landscape, and estimating the water delivered by the irrigation system. Assessing the outdoor landscape water use at our case study hotels required an extensive examination of the plant species present, environmental conditions of the landscape, and the irrigation systems. By understanding the watering needs of the plants, the conditions that affect evaporation and water loss, and the irrigation patterns such as frequency, duration, and method, we can identify specific practices that are inefficient and wasteful water use.

Determining Water Needs of Plants

To evaluate the water needs of the landscaping, we documented the plant species present within each zone in order to calculate each species' water requirements, and the maximum water needs of each zone. Information regarding the plant density within each zone, and the microclimate conditions were also recorded in order to better understand parameters that affect evapotranspiration within each zone.

Measuring Water Applied by Irrigation

Working with staff at our case study hotels, we manually turned on all functioning irrigation zones to document the condition of the irrigation system. When available, maps of the irrigation zones were obtained for reference and hand drawn when not available. Necessary repairs to the irrigation system were noted such as problems like pooling, overspray, lack of mulch, and broken or poorly adjusted sprinklers, otherwise known as spray heads (Figure 12). Pooling results from water being applied at a rate higher than the infiltration capacity of the soil, and often leads to running off the soil. Overspray occurs when spray heads are broken or poorly adjusted, applying water to a non-irrigated surface. Irrigation zones were also assessed to determine if more efficient methods such as drip irrigation could be installed to retrofit the existing systems. Photos of zones were taken to further document plant types and note particular irrigation problems.

Figure 12 Examples of runoff from pooling and lack of mulch (left) and broken spray heads (right)

Settings for the irrigation controller were also examined to record watering day(s), start time(s), irrigation duration, and settings for the water budget feature. The water budget setting provides a watering index to allow all irrigation zones to be controlled with a single adjustment based on the current weather and precipitation (Santa Barbara County Water Agency, 2009a). This value is a percentage of evapotranspiration (ET) and is often found on water district websites to help customers reduce overwatering. Given the complexity of irrigation systems and the multitude of zones within some landscapes, the water budget feature simplifies the adjustment process and reduces the probability of adjustment errors. Additionally, the water budget feature can generate substantial water savings. During our site visit we asked the hotel landscaping manager’s several questions. Specifically, we obtained information about how often the controller is adjusted for weather and seasonal variations, and about corporate landscaping policy requirements.

Total landscape area of each zone was also measured. For the Goleta and Santa Barbara Hotels, this was done using a rolling tape measure while satellite images accessed from Google Earth ® and photos from the site visit were used to develop estimates of landscape area for the Moreno Valley Hotel.

To estimate plant water needs in a diverse landscape, we followed the Landscape Coefficient method outlined in the Water Use Classification of Landscape Systems (WUCOLS) (University of California Cooperative Extension and California Department of Water Resources, 2000). References to specific calculations for determining water needs of plants were derived from the above WUCOLS methods. The WUCOLS landscape coefficient method uses of a series of simple calculations based on specific information collected in the field to estimate ET and irrigation efficiency so that the appropriate amount of water can be applied. To accomplish this, we developed an Excel spreadsheet for each hotel to incorporate the biological, physical, and environmental parameters necessary to calculate the landscape coefficient estimate of water use.

The landscape coefficient method is designed to maintain plant health and appearance, reduce water waste, and minimize money spent on the increasing cost of water (University of California Cooperative Extension and California Department of Water Resources, 2000).

Using the data collected on site and the locally available evapotranspiration data available from the California Irrigation Management Information System (CIMIS) (Department of Water Resources, 2009), we were able to calculate monthly and annual plant water needs for each hotel. To calculate the amount of water applied through the irrigation system, we recorded the operating schedule and measured flow volume of the irrigation system. Based on methods from WUCOLS (University of California Cooperative Extension and California Department of Water Resources, 2000) and data provided by staff, we calculated a range of values for water applied monthly and annually and compared this, where available, to landscape water billed. Lastly, electricity use by the irrigation system was determined based on operating time and power consumption of the irrigation controller and valves. The WUCOLS equations and a detailed description of the methods to calculate plant water needs, estimates of irrigation water applied, and electricity use of irrigation systems are included in Appendix F.

Methods for Calculating Natural Gas, Electricity, Water and Retrofit Costs

Resource costs incurred directly by the hotel were modeled for all resources relevant to the end use of interest (i.e. water, natural gas, electricity). All resource costs were time discounted using a 3.2% discount rate (United States Department of Energy, 2009f). Utility rates for natural gas, water, and electricity were assumed to remain constant over the lifetime of the end use of interest. Efficient retrofit upgrades were compared to the existing fixtures currently in place over the relevant life expectancies. Rebates, if available, were subtracted from the initial cost of a retrofit in year one. Present values were calculated using:

$$PV = \left\{ \frac{-pmt \times (1 + rate \times type) \times \left[\left(\frac{(1+rate)^{n-1}}{rate} \right) - fv \right]}{(1+rate)^{n}} \right\},$$

where *PV* is the present value, *pmt* is the payment amount, *rate* is the discount rate, *n* is the number of payment periods, *type* is defined as 1 if the payment is made at the beginning or 0 if payment is made at the end of a period, and *fv* is the future value. Future values were chosen to be zero and it was assumed that payments were made at the end of a period.

Payback period was found using,

$$\text{Payback period} = \frac{Purchase + installation}{Savings / year},$$

where *savings/year* is the monetary savings from reduced water, electricity, and natural gas consumption and *purchase + installation* is the initial purchase and installation cost of the retrofit.

The hotel in Santa Barbara faces sewer rates that are determined according to consumption. Therefore, sewer charges per thousand gallons were added to the water utility charges per thousand gallons for the Santa Barbara hotel. On the other hand, sewer charges for the Moreno Valley hotel and Goleta hotel are determined according to days per billing period and number of guest rooms within the hotel, respectively. Therefore, sewer charges were not considered in our cost calculations for the Moreno Valley and Goleta hotels. Both hotels in Moreno Valley and Goleta have separate accounts to manage indoor water use versus outdoor water use.
Refer to Appendix H for detailed information on utility rates.

Estimating the Embedded Energy in the Water Cycle

Calculating the embedded energy in the water production cycle required data gathering and multiple requests for public information. First, the water districts and wastewater treatment plants that serve the cities in which our case studies are located were identified. Second, the water supply and water production amounts of AF per year were gathered. Third, each water district's water production cycle was examined and the components that require energy were identified. Lastly, public requests for information were made to each water district and to each wastewater treatment plant. We requested all of the electricity bills for the water district's water production system and for the wastewater treatment plant.

Our case study hotels are located in Goleta, Santa Barbara, and Moreno Valley. Each city is provided water by a different water district: Goleta Water District, The City of Santa Barbara, Public Works, and Eastern Municipal Water District (EMWD) (Figure 2). All three water districts use a distinctive water production system to meet their community's water demands. Wastewater treatment occurs at Corona del Mar Treatment Plant, El Estero Treatment Plant, and the Moreno Valley Reclamation Facility for Goleta, Santa Barbara, and Moreno Valley, respectively. According to the California Water Code section 10620, each urban municipal water utility is required to prepare an Urban Water Management Plan every five years (Eastern Municipal Water District, 2005). The most current Urban Water Management Plans were submitted to the California Department of Water Resources in 2005, and cover the water supply and water production amounts for the 2004 water year. The 2004 water supply and water production numbers were used for our embedded energy analysis, unless the district provided more recent numbers that coincided with the requested electricity information.

The components of the water production cycle that require energy input are: transport, ground water pumping, treatment, distribution, and wastewater treatment. In Southern California, about 70% of the energy involved in water production is imported water, 15% is wastewater treatment, 9% is local distribution, and 6% is ground water (Wilkinson, 2000). Figure 13 shows energy required at various steps of the water production cycle for Southern California (Garrison et al., 2009). Wilkinson outlined the embedded energy required for the SWP and the CRA, and this analysis assumes that the numbers reported are accurate.

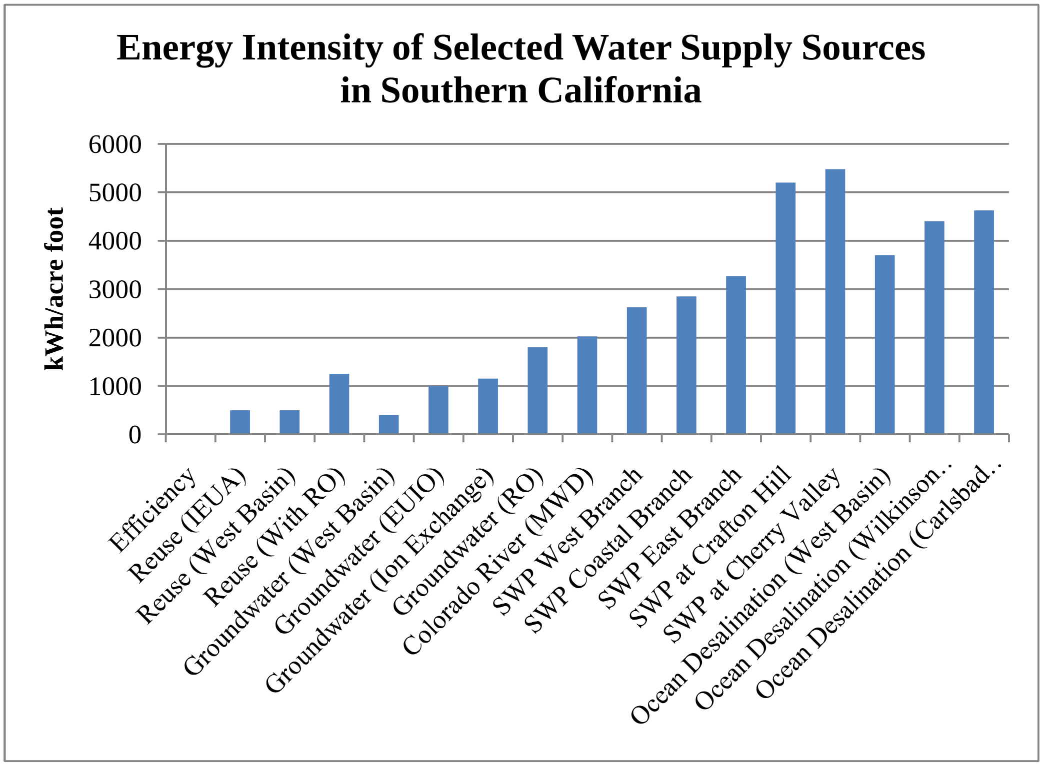


Figure 13 Energy intensity of selected water supply sources in southern California
Source: (Garrison et al., 2009)

We used Wilkinson's SWP energy embedded numbers for Goleta, Santa Barbara, and Moreno Valley, while the CRA numbers were only used for EMWD embedded energy calculations. Surface water for Goleta and Santa Barbara comes from Lake Cachuma; Santa Barbara also obtains surface water from Gibraltar Reservoir, Devil's Canyon Creek, and seepage into Mission Tunnel (City of Santa Barbara Public Works Department (b), 2005)(Goleta Water District, 2005). These sources require little pumping and are delivered into the city on a gravity-fed basis; we considered them to have negligible embedded energy when they enter the Goleta or Santa Barbara water system. Tables 8 and 9 show the volume of water (AF) associated with each part of the water production system at Goleta and Santa Barbara. The total amount of waste water processed is represented as "total downstream."

Table 8 Goleta water cycle production in 2007

Goleta Water Production Summary 2007 (AF)	
Surface Transport	10,409
Imported Transport	3,007
GW Pumping	439
Recycled Water	1,012
Treatment	13,855
Distribution	14,867
Total Upstream	**14,867**
Total Downstream	**6,042**

Source: (Goleta Water District, 2005)

Table 9 Santa Barbara water cycle production in 2005 UWMP

Santa Barbara Water Production Summary 2005 (AF)	
Surface Transport	13,180
Imported Transport	890
GW Pumping	882
Treatment	12,714
Distribution	13,538
Total Upstream	**13,538**
Total Downstream	**9,857**

Source: (City of Santa Barbara Public Works Department (b), 2005)

To calculate embedded energy, we needed specific electricity information for each component of the water production cycle. The three water districts were contacted and their electricity bills were requested. The kWh consumed and the electricity cost information was obtained for the entire water production system at Goleta and Santa Barbara. Due to limitations in data gathering at EMWD, only the electricity cost information was obtained. The data we acquired most likely includes electricity used in non-water production processes, like office or administrative needs. We assumed that all of the electricity information given to us by each water district is required to produce water and is important for our analysis. The kWh hours and billing information was entered into a spreadsheet and compared to the reported AF amount for each component of the water production cycle. The total kWh was divided by the total AF distributed for that year to obtain the kWh/AF values for each district. Results are reported in kWh/AF and kWh/gallons in order to be relevant to our water use results for domestic appliances, laundry, and landscaping at each hotel. Table 10 shows the calculations involved in Goleta’s embedded energy in the water cycle.

Table 10 Calculations for Goleta Water District embedded energy 2007

Goleta Water District Embedded Energy 2007				
Water Production	AF	kWh	kWh/AF	kWh/gal
Surface Transport	10,409	-	-	-
Imported Transport	3,007	8,777,433	2,919	0.00896
GW Pumping	439	171,966	392	0.00120
Recycled Water	1,012	107,738	106	0.00033
Treatment	13,855	565,760	41	0.00013
Distribution	14,867	99,656	7	0.00002
Total Upstream	**14,867**	**9,722,552**	**654**	**0.00201**
Total Downstream	**6,042**	**3,661,040**	**606**	**0.00186**

Source: (Goleta Water District, 2005)

The water resources division of the City of Santa Barbara, Public Works, has six components of their water production process that require energy: surface transport, imported transport, groundwater pumping, potable treatment, distribution, and wastewater treatment. On a kWh/AF basis the most embedded energy intensive water production component is imported transport (Table 11).

Table 11 Santa Barbara embedded energy calculations from 2004-205 water year.

Santa Barbara Embedded Energy 2005				
Water Production	**AF**	**2005 kWh**	**kWh/AF**	**kWh/gal**
Surface Transport	13,180	-	-	-
Imported Transport	890	2,597,910	2,919	0.00896
GW Pumping	882	50,066	57	0.00017
Treatment	12,714	606,320	48	0.00015
Distribution	13,538	1,536,979	114	0.00035
Total Upstream	**13,538**	**4,791,275**	**354**	**0.00109**
Total Downstream	**9,857**	**7,397,319**	**750**	**0.00230**

Source:(City of Santa Barbara Public Works Department (b), 2005)

The total upstream embedded energy for Goleta is 654 kWh/AF and is 354 kWh/AF for Santa Barbara. Total embedded energy for Goleta is higher than Santa Barbara since Goleta Water District produces recycled water, an energy intensive process, and Santa Barbara does not. The total downstream embedded energy for Goleta is 606 kWh/AF and 750 kWh/AF for Santa Barbara. Santa Barbara has higher amounts of downstream embedded energy as Goleta recycles some water and thus reduces the amount of water that is processed as wastewater.

Moreno Valley is served by EMWD and has a different mix of water supply sources than Santa Barbara or Goleta. Table 12 shows the complete water cycle summary for EMWD during the 2004-2005 water year.

Table 12 Water produced at Moreno Valley from the 2005 UWMP.

Moreno Valley Water Production Cycle 2004 (AF)	
Summary	AF of Water
Imported Transport	81,900
Ground Water	18,000
Ground Water Desalination	3,600
Recycled	25,000
Treatment	103,500
Distribution	103,500
Total Upstream	**103,500**
Waste Water	50,630

Source: (Eastern Municipal Water District, 2005)

About 80% of EWMD's drinking water supply is imported and some groundwater is desalinated for potable uses; thus the energy embedded in water is higher than for Goleta or Santa Barbara which both rely more on surface water than imported water (Figure 14).

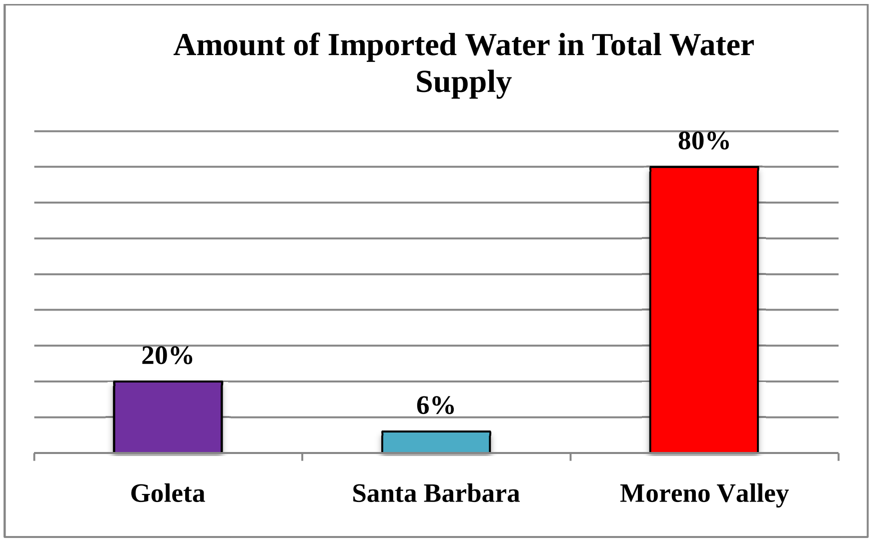


Figure 14 Amount of imported water in total water supply at Goleta, Santa Barbara, and Moreno Valley.

Imported water is purchased from MWD and processed at two different MWD treatment plants: Skinner and Mills. The imported water is either from the SWP and CRA. EMWD's Perris microfiltration plant processes untreated imported water from MWD (Table 13). EMWD's Urban Water Management Plan stated that a blend of SWP and CRA water was processed at Skinner (Eastern Municipal Water District, 2005). For our calculations, we assumed that the blend was 50% SWP and 50% CRA. The amounts of kWh/AF involved in the transportation of SWP or CRA to Municipal Water District was previously calculated by Bob Wilkinson. Those values, 3,200 kWh/AF for CRA and 2,000 kWh/AF for SWP, were multiplied by the amount of water imported from each source to find the total kWh used (Table 13). EMWD provided us with the total electricity cost of their entire water production system (not including embedded energy of transport), which was: $3,081,740. We were unable to attain the total amount of kWh consumed by EWMD in 2005. To compensate for the lack of data we used the average price per kWh that SCE charges their large business customers: 0.152 kWh (Southern California Edison, 2009b). The cost of electricity for EWMD was divided by the average price per kWh to find total kWh used for water production. The kWh used was divided by the total amount of water distributed in 2005 to find the kWh/AF for the entire water production system in 2005 (Table 15).

Table 13 Calculations for EMWD embedded energy for 2004-2005

EMWD Embedded Energy Calculations					
Imported	**Acre Feet Used**	**Imported Source**	**kWh used**	**kWh/AF**	**kWh/gal**
Skinner	18,000	1/2 CRA	28,800,000	3,200	0.00982
		1/2 SWP	18,000,000	2,000	0.00614
Mills	55,900	all SWP	178,880,000	3,200	0.00982
Perris FP	8,000	all SWP	25,600,000	3,200	0.00982
Total Imported	81,900		251,280,000	3,068	0.00942
AF Distributed	103,500		20,268,099	196	0.00060
Total Including Transport	**103,500**		**271,548,099**	**2,624**	**0.00805**
Total Downstream	**50,631**		51,489,059	1,017	0.00312

Source: (Eastern Municipal Water District, 2005)

Figure 15 summarizes the total upstream embedded energy calculated for Goleta, Santa Barbara, and Moreno Valley – amounting to 650, 350, and 2,600 kWh/AF, respectively. The highest amounts of upstream embedded energy are found at EMWD as compared to Goleta Water District and City of Santa Barbara, Public Works.

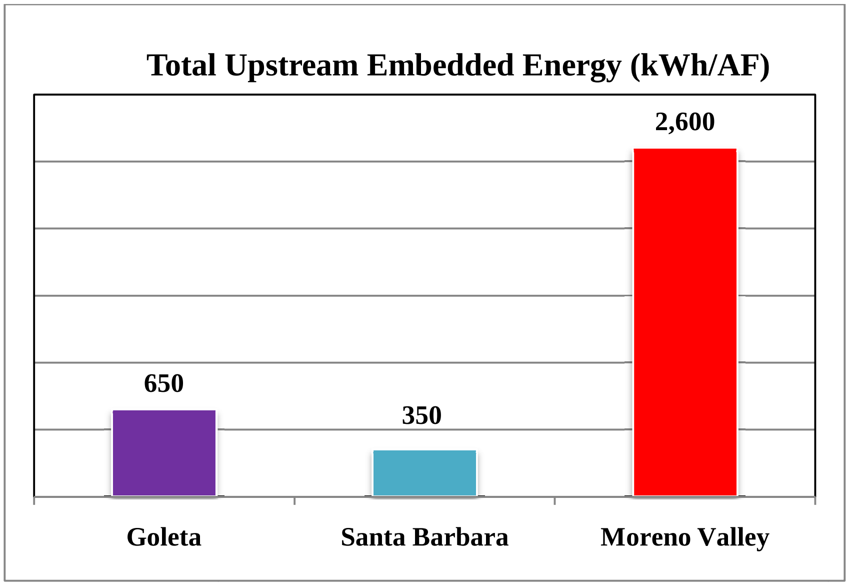


Figure 15 Total amount of embedded energy calculated for Goleta Water District, City of Santa Barbara, Public Works, and Eastern Municipal Water District.

Methods for Estimating Greenhouse Gas Emissions Reductions

Greenhouse gas emissions were estimated for natural gas and electricity consumption summed over the relevant end uses examined in our study (i.e. toilets, faucets, shower heads, ice machines, washing machines, and dishwashers). Ice machines, washing machines, and dishwashers use electricity explicitly. Faucets, showerheads, washing machines, and dishwashers all use natural gas by virtue of hot water consumption. GHG emissions in carbon dioxide equivalencies from natural gas consumption were determined using the equation:

GHG from Natural Gas =

$$0.1 mmbtu/therm \times 14.47 kgC/mmbtu \times 44 gCO_2/12 gC \times 1 metric\_ton/1000 kg$$

$$= 0.005 metric\_tons\_CO_2/therm\_natural\_gas,$$

where *mmbtu* represents one million British Thermal Units (BTU) (Intergovernmental Panel on Climate Change, 2007);(United States Environmental Protection Agency, 2008a).

GHG emissions from electricity consumption were determined from SCE's 2009 projected power mixture (Southern California Edison, 2009c) (Figure 16). Coal and natural gas constituted approximately 10% and 51% of SCE's 2009 energy mixture, respectively. Natural gas fired electricity production plants were assumed to generate 1.321 pounds of carbon dioxide equivalents per kWh. Coal fired electricity production plants were assumed to generate 2.095 pounds of carbon dioxide equivalents per kWh, based on national averages (United States Environmental Protection Agency and United States Department of Energy, 2000). GHG emissions were then reported in metric tons. Example calculations follow for natural gas and coal respectively:

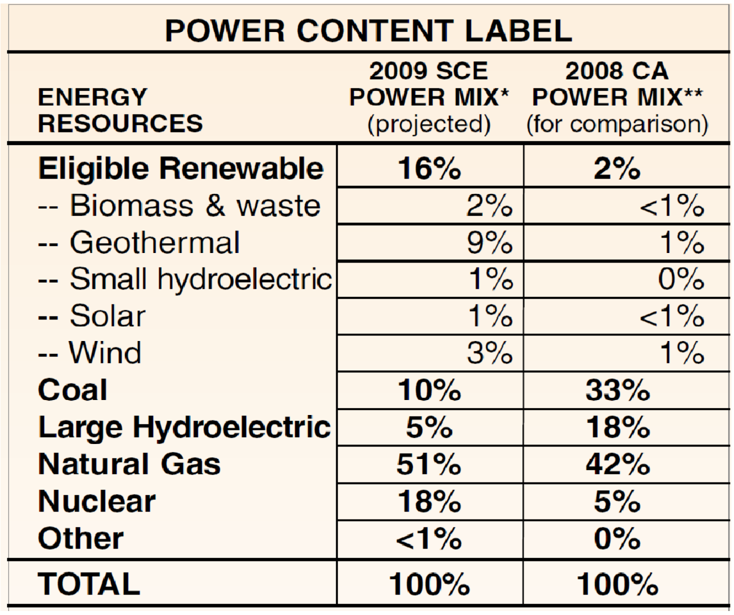
GHG from electricity produced from natural gas =

$$51\% \times E \times 1.321 poundsCO_{2e} \times \left(\frac{1 metric\_ton}{2204.6 pounds}\right)$$

GHG from electricity produced from Coal = $10\% \times E \times 2.095 poundsCO_{2e} \times \left(\frac{1 metric\_ton}{2204.6 pounds}\right)$,

where *E* represents annual electricity use in kWh.

GHG emissions from renewables and nuclear power at the point of generation were assumed to be zero. However, research has shown that GHGs are produced during the entire process chain of electricity generation (Joseph Spador, Lucille Langlois, & Bruce Hamilton, 2000). Further investigation into the emissions resulting from fuel mining, plant construction, land use change, and plant decommissioning may provide insights into the true GHG content of renewables and nuclear power generation.



POWER CONTENT LABEL

ENERGY RESOURCES	2009 SCE POWER MIX* (projected)	2008 CA POWER MIX** (for comparison)
Eligible Renewable	**16%**	**2%**
-- Biomass & waste	2%	<1%
-- Geothermal	9%	1%
-- Small hydroelectric	1%	0%
-- Solar	1%	<1%
-- Wind	3%	1%
Coal	**10%**	**33%**
Large Hydroelectric	**5%**	**18%**
Natural Gas	**51%**	**42%**
Nuclear	**18%**	**5%**
Other	**<1%**	**0%**
TOTAL	**100%**	**100%**

Figure 16 Power content of SCE's energy provision for 2008 and 2009.
Source: (Southern California Edison, 2009c)

Part II Summary

Our integrated energy and water auditing procedure, the Synergy Audit, was not designed to replace SCE's existing electricity. Rather it was designed to add value to their existing audit by quantifying the energy savings associated with water conservation at the end use. The techniques used to determine the resource consumption for each end use category can be found in Appendices A through F at the end of the report. After we found the estimated resource use at each case study hotel we also evaluated the energy embedded in water and estimations of GHG emissions. Information from each water district serving our case study hotels was used to calculate embedded energy. The energy embedded in water is the highest at Moreno Valley, followed by Goleta, and then Santa Barbara. GHG emissions were calculated based on the emissions produced from natural gas use, direct electricity use, and the energy embedded in water.

Part III: Results, Discussion and Recommendations

Results, Discussion and Recommendations

Introduction

To convey specific results from our study, we begin by discussing retrofits and savings specific for each case study hotel. We follow with general recommendations for energy and water efficiency best management practices pertaining to the hotel sector. We also discuss how these results relate to Southern California Edison through relevant policies that affect current energy and water conservation efforts, and provide our thoughts on how policies which integrate energy and water efficiency may improve statewide goals for resource conservation. We describe how integrated programs can both provide end users with better information regarding combined savings potential and demonstrate how integrated energy and water efficiency can result in a more cost effective approach to resource efficiency.

Case Study 1: Goleta Hotel

The hotel in Goleta was built in 2007 with modern and relatively efficient energy and water using appliances. Additionally, the staff already adheres to many resource conservative policies such as linens and towel reuse and adjusting the irrigation schedule for rain events. Even with efficient technologies and practices, there are still several areas where the hotel can incur even more savings from cost effective, combined water and energy conservation efforts.

Through our auditing procedure and analysis we estimated the water used for each of six end use categories: domestic fixtures, washing machines, landscaping, ice machines, dish washers, pools and spas. Water not accounted for is referred to as “other”. See Appendix G for a summary of savings calculations. For the Goleta hotel, most indoor water use (43%) is associated with toilets, shower heads, and faucets – which are collectively referred to as domestic fixtures. The next largest category represents 29% of water use (other/losses). The category other/losses is the difference between what our team estimated for total annual water use and the average amount of water billed to the hotel for a typical year[3]. The discrepancy between our estimated water use and the hotel’s average water use according to billing history may be a function of the limited scope of our audit, assumptions based on literature, variance in the hotel’s water use from year to year, or some combination thereof[4]. The remaining categories make up the remaining 28% of our total estimation of annual water consumption. Figure 17 summarizes our annual water use estimation by end use category.

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[3] **Water used for a typical year is the averaged monthly water billed to the hotel for 2008 and 2009.**

[4] **This caveat is true for all hotels in our study.**

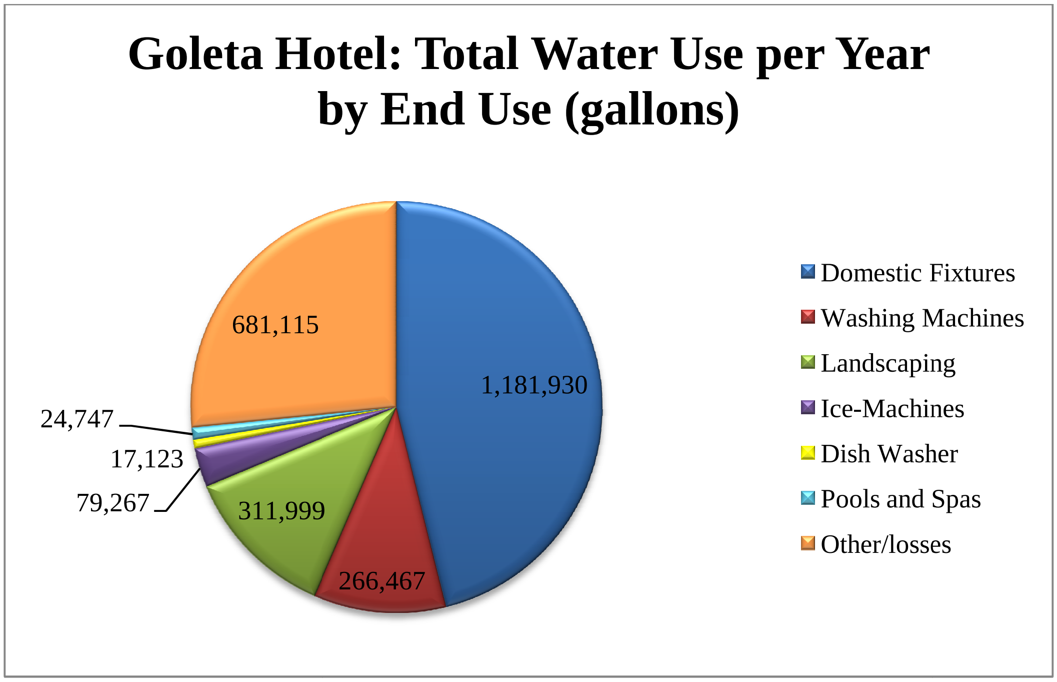

Figure 17 Total water use per year for the Goleta hotel.

Annual natural gas use was averaged over the most recent two years of billing history (2008 and 2009). Total annual natural gas consumption was estimated to be 14,617 therms. Our calculations for annual consumption overestimate natural gas use by 2,029 therms when compared to the hotel's averaged annual use. Pools are estimated to be the largest end use followed by domestic fixtures (Figure 18).

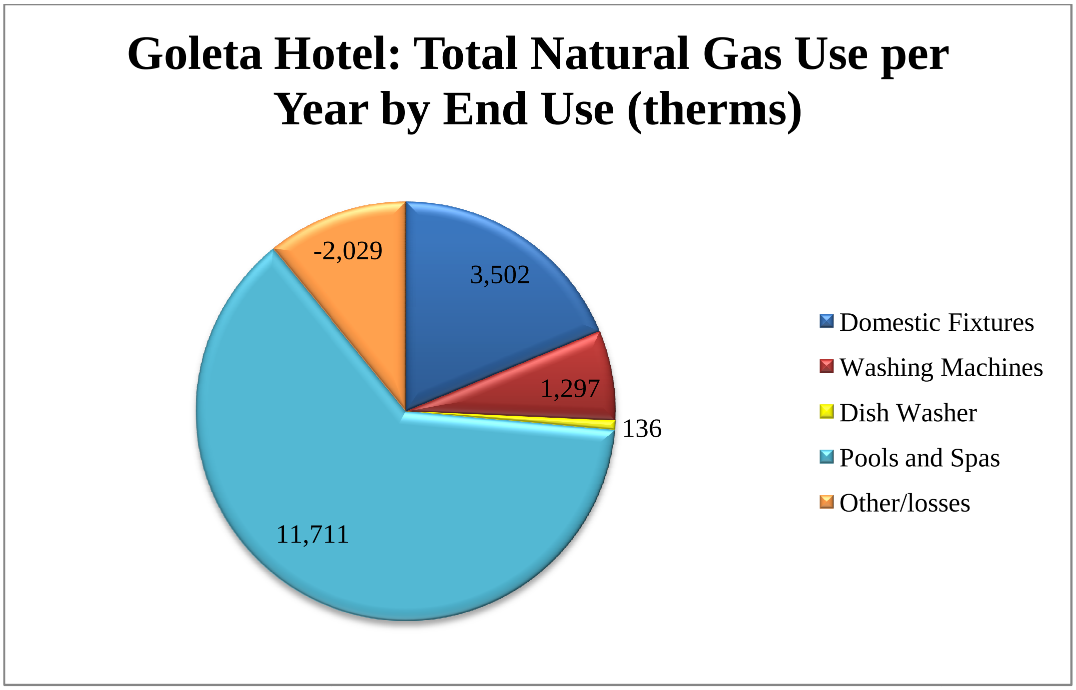

Figure 18 Total natural gas use per year for the Goleta hotel.

Annual electricity use was obtained from the most recent complete year of billing history (2008). Total electricity consumption for 2008 was approximately 550,000 kWh. Figure 19 shows our estimated amounts of electricity consumed annually according to end use. Our targeted end uses consume relatively little electricity compared to total annual consumption levels. End uses such as lighting, televisions, refrigerators, and other electronics consume substantial levels of electricity, yet were not captured by our audit design. Total electricity consumption of our six targeted end uses comprises 9% of total annual electricity use for the hotel. Ice machines are estimated to consume the most electricity of our targeted end uses (25,664 kWh). Pools and spas are estimated to be the second largest electricity consumer (18,428 kWh). Washing machines, dish washers, and landscaping are estimated to annually consume 2,408 kWh, 278 kWh, and 277 kWh respectively.

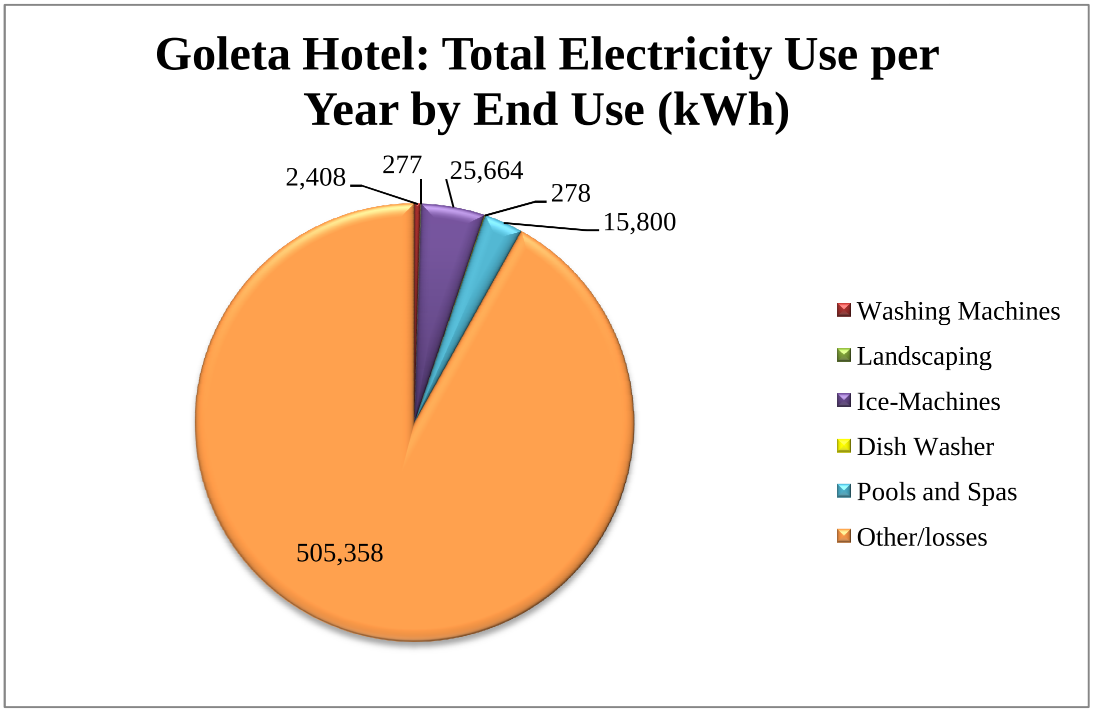

Figure 19 Total electricity use per year for the Goleta hotel.

Figure 20 below presents a summary of the relative magnitudes of direct electricity and natural gas associated with water consumed by our six identified end uses (note the log-scale in the y-axis). Natural gas used by other/losses does not appear because our calculations overestimated annual natural gas use by 6,588 therms. Consideration of the joint resource savings associated with retrofits and behavioral changes is precisely what our auditing procedure is designed to capture.

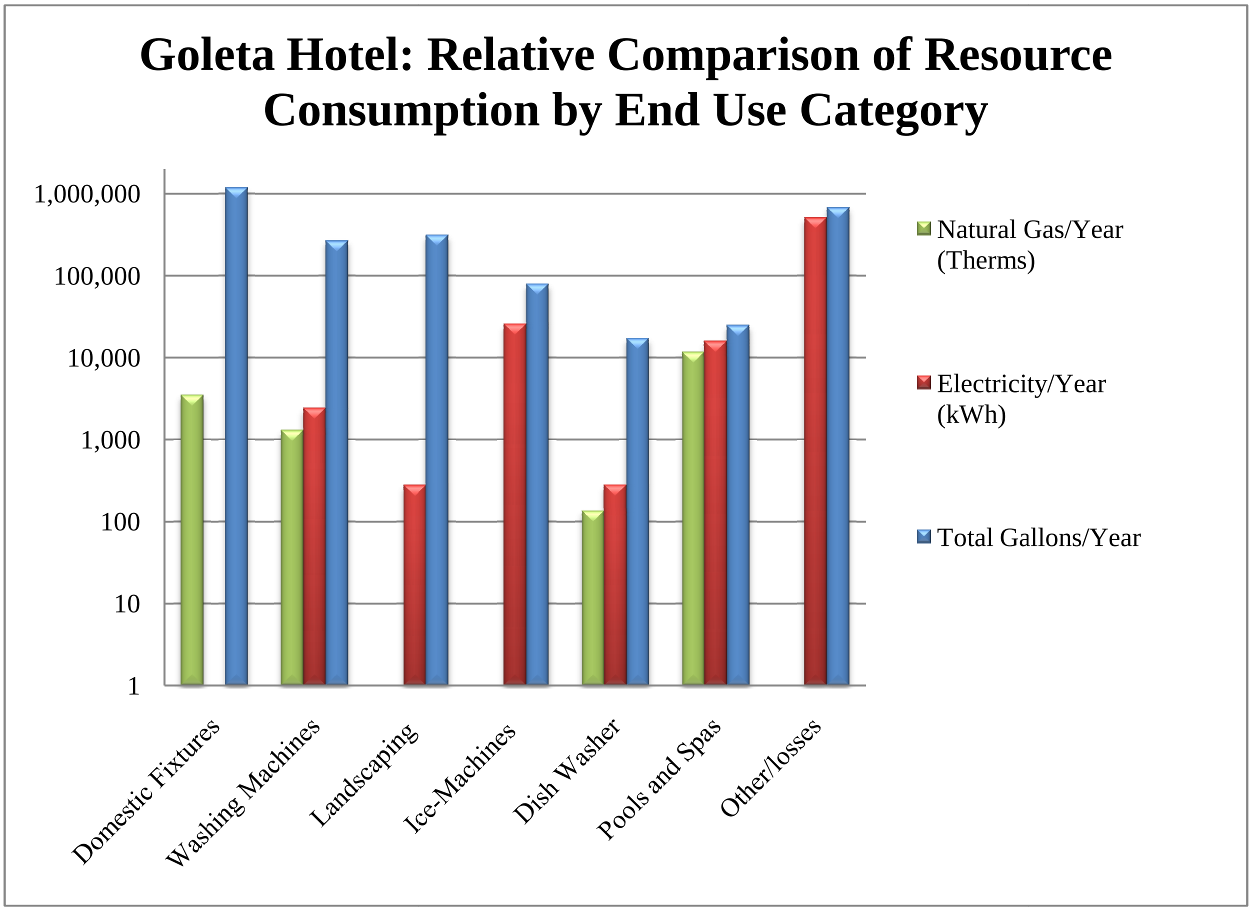

Figure 20 Relative comparison of resource consumption by targeted end use.

Goleta Retrofit Savings Analysis

Retrofit feasibility was determined by evaluating whether the upgrade would provide a payback period that was shorter than the expected lifetime of the retrofit. For the Goleta hotel, feasible retrofits consisted of showerhead, faucet, pool and spa, and irrigation upgrades. The dish washer and ice machines employed at the Goleta hotel already surpass Consortium for Energy Efficiency (CEE) Tier III efficiency standards and therefore feasible upgrades are not available at this point in time. Toilet and laundry retrofits were shown to reduce water, electricity and natural gas, but the large initial purchase costs rendered net economic losses over their respective lifetimes.

Showerhead Retrofits

The existing showerheads at the Goleta hotel were measured to have a flow of 2.0 gallons per minute. Despite the fact that they are already considered to be a “low-flow” showerhead, we modeled an upgrade to showerheads with 1.75 gallons per minute flow – yielding a water savings of about 2 gallons per shower. Even though newer showerheads exist with flow ratings as low as 0.5 and 1.0 gallons per minute, our analysis accounts for a type of showerhead that reduces flow at a level not noticeable to the hotel guest. Table 14 provides a summary of the existing cost of natural gas and water to the hotel and the estimated savings associated with our recommended retrofits. Refer to Appendix G for detailed explanation of water and natural gas resource use and savings.

Table 14 Goleta hotel showerhead retrofit measures and savings

Showerhead Retrofit Measures		
	Natural Gas	**Water**
Estimated Existing Annual End Use Consumption	*3,290 therms*	*751,195 gallons*
Estimated Existing Costs	*$2,632*	*$3,568*
Estimated Annual End Use Savings	*411 therms*	*93,889 gallons*
Estimated Annual Cost Savings	*$329*	*$446*
Estimated Total Lifetime Savings (10 yrs)	**$6,541**	
Estimated Initial Retrofit Cost	**$3,626**	
Estimated Payback Period (yrs)	**5.5**	

Faucet Retrofits

Most faucets at the Goleta hotel had an average flow of 2.2 to 2.4 gallons per minute; except for the kitchen faucets which produced water at a rate of over 6 gallons per minute. Table 17 shows the savings realized from installing a 0.5 gallons per minute aerator in bathroom sinks and a 2.5 gallons per minute aerator in the two kitchen sinks. Purchase and installation of faucet aerators are estimated to provide a return on the investment well within one year.

Table 15 Goleta hotel faucet retrofit measures and savings

Faucet Retrofit Measures		
	Natural Gas	**Water**
Estimated Existing Annual End Use Consumption	*212 therms*	*48,370 gallons*
Estimated Existing Costs	*$169*	*$230*
Estimated Annual End Use Savings	*181 therms*	*41,261 gallons*
Estimated Annual Cost Savings	*$145*	*$196*
Estimated Total Lifetime Savings (10 yrs)	**$10,431**	
Estimated Initial Retrofit Cost	**$185**	
Estimated Payback Period (yrs)	**0.2**	

Pool and Spa Retrofits

The Goleta hotel pool and spa water and natural gas use could be cut by 30 percent and 50 percent respectively, just by purchasing and using covers. The savings shown in Table 16 represent the combined natural gas savings from employing the use of a pool cover and from upgrading the current pool and spa heaters to one 16 percent more efficient. Refer to Appendix C for detailed explanation of pool water and natural gas resource use and savings.

Table 16 Goleta hotel pool and spa retrofits and measures

Pools and Spas Retrofit Measures	**Natural Gas**	**Water**	**Electricity**
Estimated Existing Annual End Use Consumption	*11,711*	*24,747 gallons*	*15,800*
Estimated Existing Costs	*$9,369*	*$118*	*$1,928*
Estimated Annual End Use Savings	*4,919*	*17,323*	*4,343*
Estimated Annual Cost Savings	*$5,434*	*$35*	*$1,398*
Estimated Total Lifetime Savings (10 yrs)		**$57,887**	
Estimated Initial Retrofit Cost		**$4,820**	
Estimated Payback Period (yrs)		**0.8**	

Landscaping Retrofits

Landscaping retrofits for the Goleta hotel include retrofitting the irrigation system with a simple and durable drip irrigation system, applying mulch to all areas with bare soil, and purchasing a rain sensor for the irrigation controller. These changes, along with careful adjustments to the irrigation controller to best match plant needs can reduce landscape water use by 22 percent. Landscape retrofits were assumed to have a ten year life expectancy. The estimated payback period is under six years (Table 17). Refer to Appendix F for a detailed explanation of retrofits and water savings calculations.

Table 17 Goleta hotel landscaping retrofits measures and savings

Landscaping Retrofit Measures	**Water**	**Electricity**
Estimated Existing Annual End Use Consumption	*311,999 gallons*	*277 kWh*
Estimated Existing Costs	*$1,482*	*$34*
Estimated Annual End Use Savings	*163,207 gallons*	*0 kWh*
Estimated Annual Cost Savings	*$775*	*$0*
Estimated Total Lifetime Savings (10 yrs)	**$6,546**	
Estimated Initial Retrofit Cost	**$3,785**	
Estimated Payback Period (yrs)	**5.8**	

Summary

Estimates reveal that the Goleta hotel can reduce annual water, natural gas, and electricity consumption by approximately 274,000 gallons, 4,800 therms, and 2,100 kWh respectively. Cost effective retrofits are projected to save the Goleta hotel over $45,000 across the lifetime of the appliances. Table 18 summarizes the estimated annual natural gas, electricity, and water costs for our six existing identified end uses. Estimated annual and lifetime cost savings from our four recommended retrofit upgrades are also presented.

Table 18 Summary of costs and savings for Goleta hotel

Goleta Hotel Summary Table	
Estimated Annual Gas, Water, Electricity Costs of Targeted End Uses	
Estimated Cost of Water	$8,937
Estimated Cost of Gas to Heat Water	$13,317
Estimated Cost of Direct Electricity for Water Using Appliances	$5,420
Estimated Annual Utility Cost for Water-Related Uses	**$27,674**
Estimated Annual Savings Associated with Retrofits:	
Estimated Annual Water Savings	$1,453
Estimated Annual Gas Savings	$5,908
Estimated Annual Electricity Savings	$1,398
Total Annual Savings Associated with Retrofits	**$8,758**
Estimated Lifetime Savings Associated with Retrofits:	
Estimated Lifetime Water Savings	$16,612
Estimated Lifetime Gas Savings	$53,088
Estimated Lifetime Electricity Savings	$11,706
Total Upfront Costs	$12,416
Total Lifetime Savings Associated with Retrofits	**$68,989**

Figures 21 and 22 summarize annual resource savings and lifetime cost savings. Refer to Appendix H for a summary of savings and payback period for our identified end uses under different water, natural gas, and electricity rate projections.

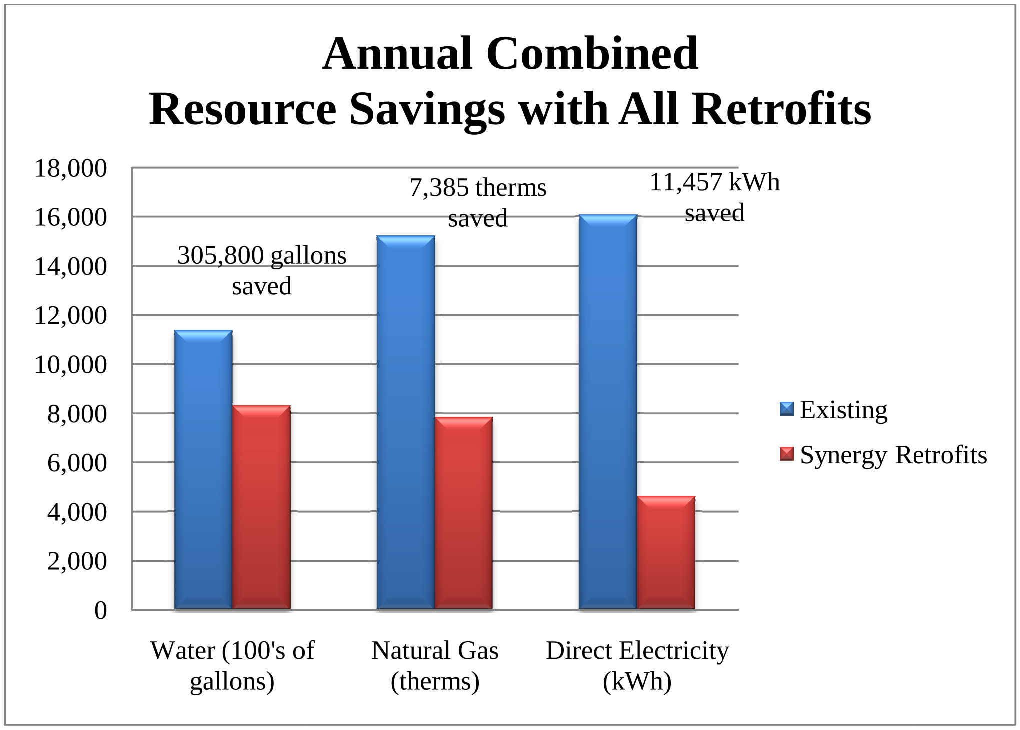

Figure 21 Annual combined resource savings for the Goleta hotel

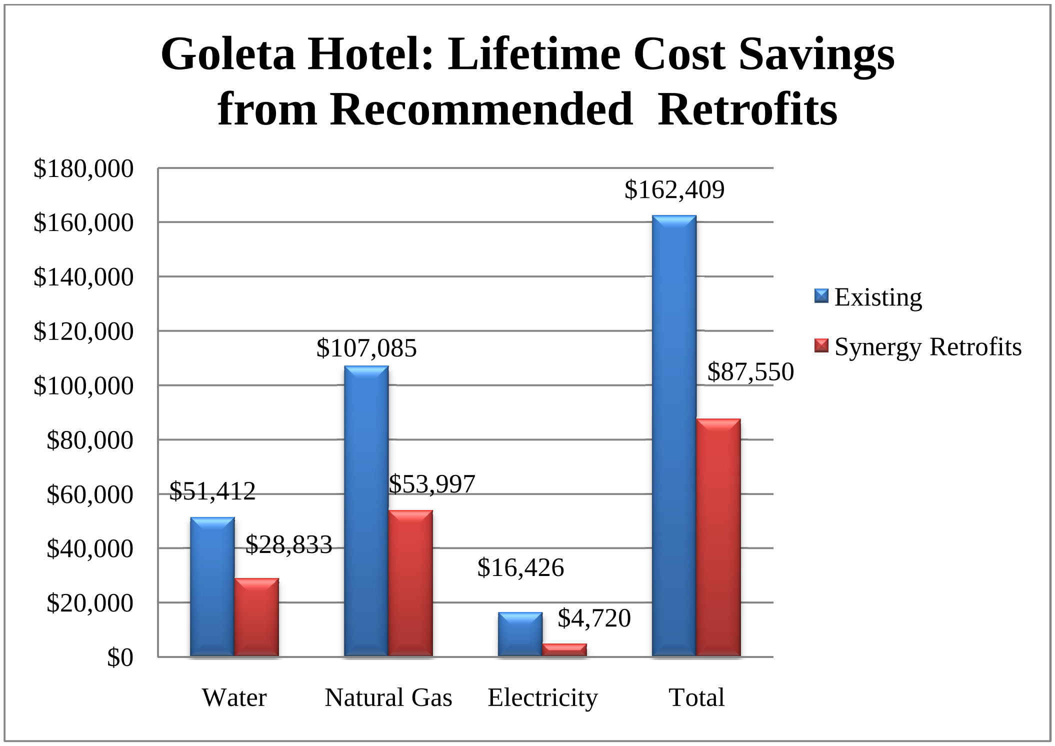

Figure 22 Lifetime cost savings from feasible retrofits for the Goleta hotel.

Case Study 2: Santa Barbara Hotel

The Santa Barbara hotel was built in 1962 and has 150 guest rooms. Offered amenities include two large swimming pools, two whirlpool spas, a fitness center, and conference room. No food services are offered through the hotel. The water using appliances are, on average, older and less efficient than those at the Goleta hotel.

Approximately 35% of water consumption at the Santa Barbara hotel is associated with domestic fixtures. Unaccounted water consumption made up 38% of estimated annual water consumption. Washing machines were estimated to account for 17% of total annual water use. Landscaping represented roughly 8% of total water use annually. The remaining categories make up the remaining 2% of our total estimate of annual water consumption. Dish washers were not examined as the hotel has none. Figure 23 summarizes our estimated annual water use for the Santa Barbara hotel.

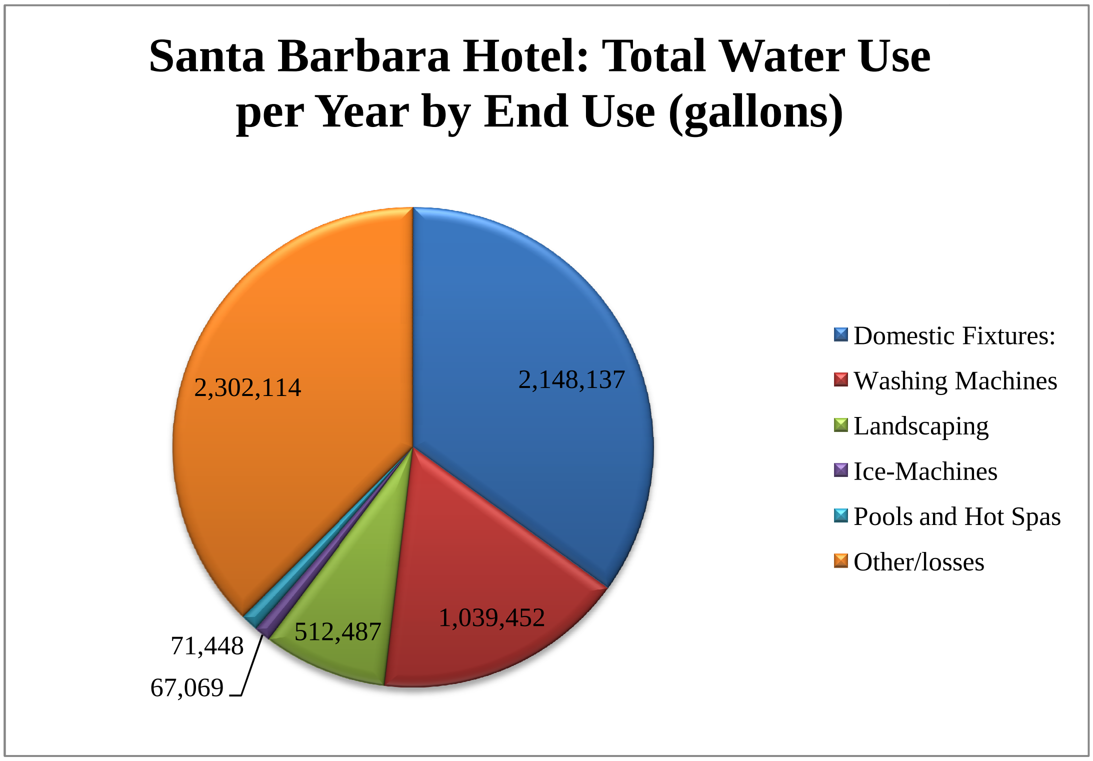

Figure 23 Total annual water use for the Santa Barbara hotel

Figure 24 shows the estimated water consumption and water-related annual natural gas, electricity, for the five identified end uses in addition to the unaccounted water use. Pools and spas were estimated to consume the most electricity of our identified end uses (20,100 kWh/year) followed by ice machines (15,600 kWh/year). While our targeted end uses only constitute 8% of the hotel's annual electricity use, the captured electricity represents potential savings that is not evaluated by SCE's current electricity auditing structure.

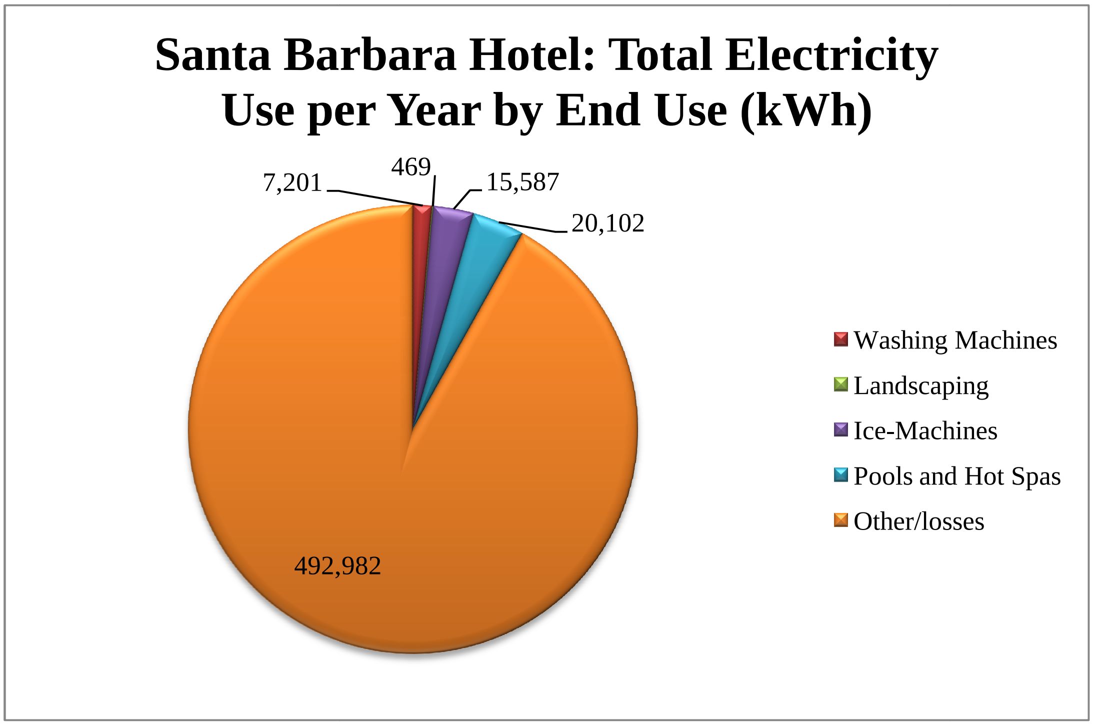

Figure 24 Total annual electricity use for the Santa Barbara hotel broken down by end use

Pools and spas were estimated to account for 31,019 therms of natural gas through heating practices, while domestic fixtures and washing machines both consume an estimated 5,000 therms annually. Our auditing procedure captured approximately 86% of estimated natural gas consumption. Figure 25 summarizes our estimated natural gas use for the Santa Barbara hotel.

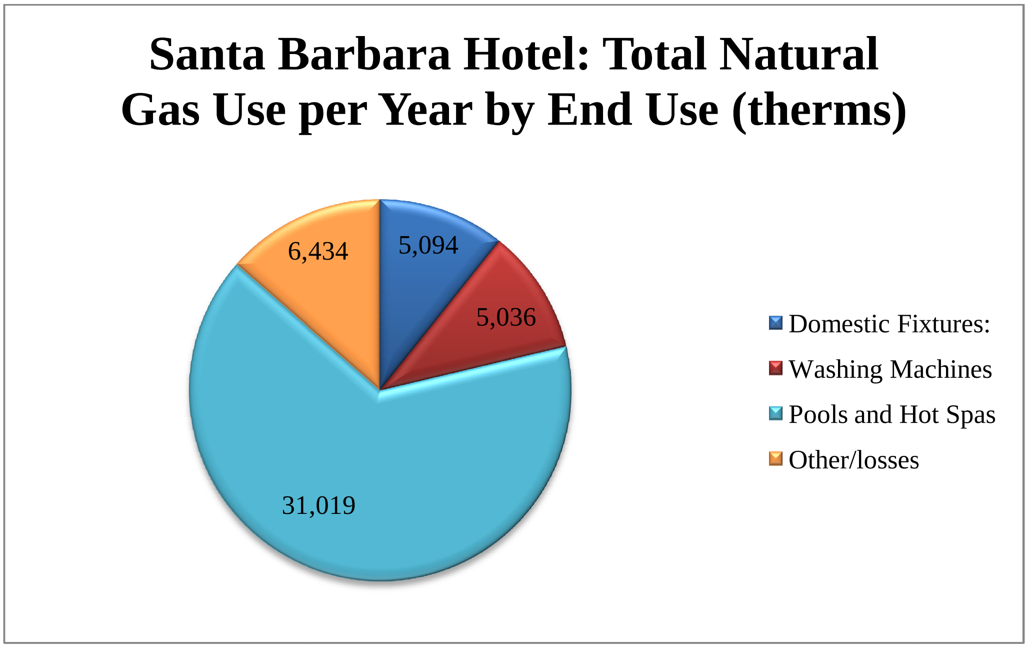

Figure 25 Total annual natural gas use for the Santa Barbara hotel broken down by end use.

Figure 26 presents a comparison of the relative magnitude of water, electricity, and natural gas consumption across our five targeted end uses. Taken as a whole, our auditing scope captured over 86% of estimated annual natural gas use, 8% of estimated annual electricity use, and 62% of estimated annual water use.

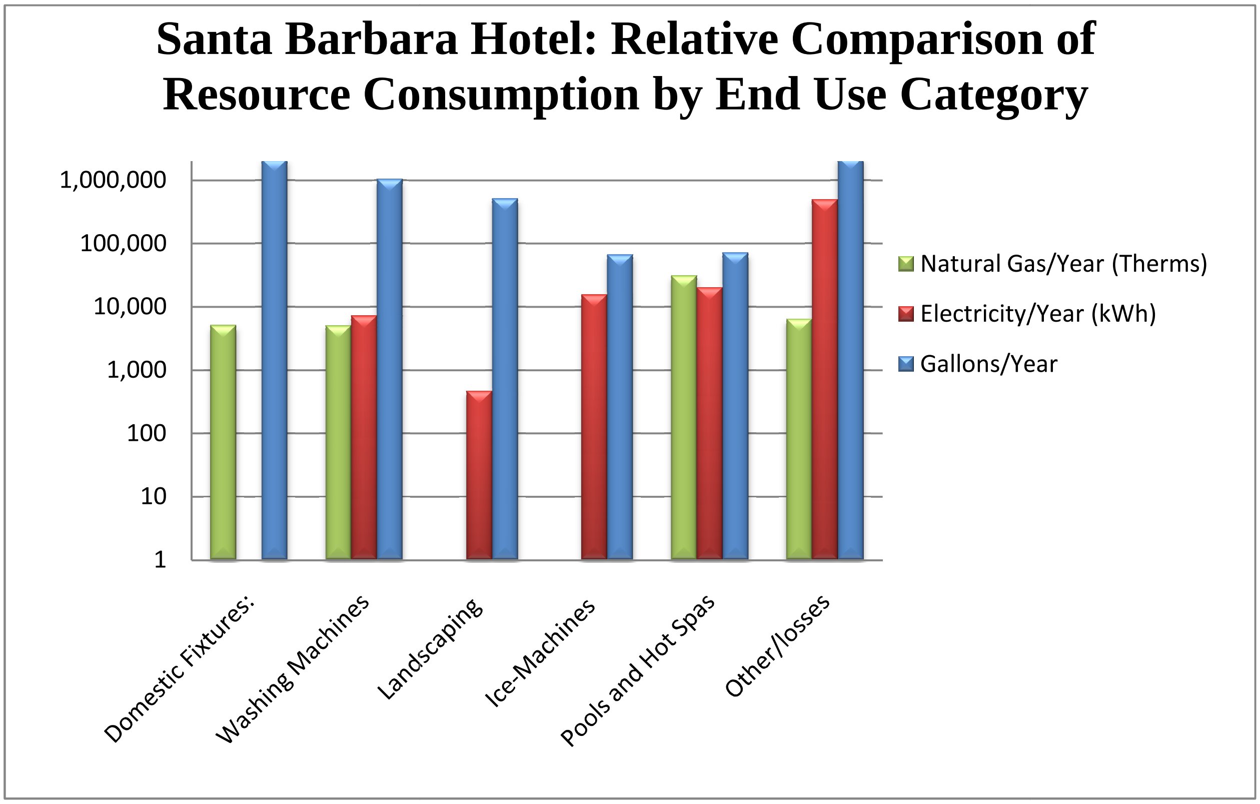

Figure 26 Resource consumption by targeted end uses at the Santa Barbara hotel

Santa Barbara Retrofit Savings Analysis

For the Santa Barbara hotel, feasible retrofits consisted of toilet upgrades, showerhead upgrades, faucet upgrades, washing machine upgrades, pool and spa upgrades, and irrigation upgrades. In fact, the Santa Barbara hotel represented the largest savings potential of our three identified case studies. While ice machines did provide resource savings, the payback period was too long to be considered a viable upgrade. Refer to Appendix H for a more detailed presentation of monetary savings.

Toilet Retrofits

Except for their lobby and pool bathrooms, all current toilets at the Santa Barbara hotel are older models which require over 3 gallons per flush. It's not surprising then, that replacing them with high-efficiency toilets that use 1.28 gallons per flush offers large water savings which are summarized in Table 19. While the payback period is rather long (11.9 years), the upgrades more then pay for themselves across the assumed lifetime (20 years).

Table 19 Santa Barbara hotel toilet retrofit measures and savings

Toilet Retrofit Measures	Water
Estimated Existing Annual End Use Consumption	*985,208 gallons*
Estimated Existing Costs	*$9,389*
Estimated Annual End Use Savings	*540,925 gallons*
Estimated Annual Cost Savings	*$5,155*
Estimated Total Lifetime Savings (20 yrs)	**$75,294**
Estimated Initial Retrofit Cost	**$44,616**
Estimated Payback Period (yrs)	**11.9**

Showerhead Retrofits

The Santa Barbara hotel guest room showerheads currently use 2 gallons per minute of water – a very efficient flow rate. However our analysis shows that even upgrading to a model using 12 percent less water saves more than enough water to pay back for itself in less than 4 years (Table 22). The recommended retrofit using 1.75 gpm is estimated to save nearly 600 therms of natural gas and 135,000 gallons of water every year.

Table 20 Santa Barbara hotel showerhead retrofit measures and savings

Showerhead Retrofit Measures	Natural Gas	Water
Estimated Existing Annual End Use Consumption	*4,718 therms*	*1,077,137 gallons*
Estimated Existing Costs	*$3,776*	*$10,265*
Estimated Annual End Use Savings	*593 therms*	*135,390 gallons*
Estimated Annual Cost Savings	*$472*	*$1,290*
Estimated Total Lifetime Savings (10 yrs)	**$14,814**	
Estimated Initial Retrofit Cost	**$5,550**	
Estimated Payback Period (yrs)	**3.7**	

Faucet Retrofits

Current flow rate at the Santa Barbara hotel faucets ranges from 2 to 3 gallons per minute. Aerators restricting water flow to 0.5 gpm were estimated to reduce natural gas consumption by nearly 300 therms and water consumption by over 66,000 gallons (Table 21). The payback period for this relatively inexpensive upgrade is less than six months.

Table 21 Faucet retrofit measures and savings

Faucet Retrofit Measures	Natural Gas	Water
Estimated Existing Annual End Use Consumption	*378 therms*	*85,792 gallons*
Estimated Existing Costs	*$398*	*$818*
Estimated Annual End Use Savings	*292 therms*	*66,701 gallons*
Estimated Annual Cost Savings	*$309*	*$636*
Estimated Total Lifetime Savings (10 yrs)	**$7,977**	
Estimated Initial Retrofit Cost	**$281**	
Estimated Payback Period (yrs)	**0.4**	

Washing Machine Retrofit

This washing machine and laundry recommendation has two components: installation of an ozone laundry system and discontinuation of triple sheeting. An ozone system can decrease the amount of hot water needed for each cycle by up to 95% because it disinfects the linens just as well or better than heating the water to 160 degrees (Articlean, 2010). These systems use the same volume of water and direct electricity as the existing system; therefore the savings are accrued from a decrease in natural gas use. Discontinuing of triple sheeting is a conservation strategy that involves no upfront costs and instant water, electricity and natural gas savings (Table 22). The savings on the utility bills can also be used to help offset the costs of upgrading to a more efficient washing machine or an ozone laundry system.

Table 22 Santa Barbara hotel savings from discontinuing triple sheeting

Annual Utility Savings from Discontinuing of Triple Sheeting

Resource	Reduction	Savings ($)	Total Annual Savings ($)
Direct Electricity	1,200 kWh	$168.00	**$2,210.23**
Gas	488 therms	$390.89	
Water	173,242 gallons	$1,651.34	

This analysis assumed that half of all washing cycles are for sheets, a third of which are the extra triple sheets. Therefore, discontinuation of triple sheeting will result in reducing all costs associated with laundry by one-sixth. These savings are also a conservative estimate because they do not include the reduced labor costs that are associated with decreased time needed to make the beds, and less time needed to wash the linens each day. Table 23 presents a summary of the existing annual resource consumption and cost as well as the estimated annual and lifetime savings associated with adjusting the triple sheets practice and installing ozone laundry systems.

Table 23 Santa Barbara hotel washing machine retrofit measures and savings

Washing Machine dual Retrofit Measures			
	Natural Gas	**Water**	**Electricity**
Estimated Existing Annual End Use Consumption	*5,036 therms*	*1,039,452 gallons*	*7,201 kWh*
Estimated Existing Costs	*$4,034*	*$9,906*	*$1,008*
Estimated Annual End Use Savings	*4,729 therms*	*173,242 gallons*	*1,200 kWh*
Estimated Annual Cost Savings	*$3,788*	*$1,651*	*$168*
Estimated Total Lifetime Savings (15 yrs)		**$66,021**	
Estimated Initial Retrofit Cost		**$16,320**	
Estimated Payback Period (yrs)		**3.7**	

Pool and Spa Retrofits

The Santa Barbara hotel has two pools and two spas, which require large amounts of electricity, natural gas, and water to maintain. The savings in Table 26 represent the reduction in utility bills the hotel could realize by using a pool cover, reducing the hours of pump operation, replacing lights with efficient LED models, and upgrading their current heaters to more efficient models.

Table 24 Pool and spas retrofit measures and savings

Pools and Spas Retrofit Measures			
	Natural Gas	**Water**	**Electricity**
Estimated Existing Annual End Use Consumption	*31,019 therms*	*46,285 gallons*	*20,102 kWh*
Estimated Existing Costs	*$24,815*	*$441*	*$2,814*
Estimated Annual End Use Savings	*18,104 therms*	*13,885 gallons*	*8,800 kWh*
Estimated Annual Cost Savings	*$14,483*	*$235*	*$1,232*
Estimated Total Lifetime Savings (10 yrs)		**$133,810**	
Estimated Initial Retrofit Cost		**$8,470**	
Estimated Payback Period (yrs)		**0.6**	

Landscaping retrofits

Landscaping retrofits for the Santa Barbara hotel include applying mulch to all areas with bare soil, converting all turf irrigation to efficient rotary nozzles, converting all non turf areas to durable drip irrigation, and installing a rain sensor. A new weather based irrigation controller should also be purchased but because the existing model was not functioning, costs for this are not included as a retrofit. These changes, along with careful adjustments to the irrigation controller to best match plant needs can reduce landscape water use by nearly 23 percent and achieve payback in just over 6 years (Table 25). Appendix F details specific retrofit recommendations and savings calculations.

Table 25 Santa Barbara hotel landscaping retrofit measures and savings

Irrigation Retrofit Measures	**Water**	**Electricity**
Estimated Existing Annual End Use Consumption	*512,487 gallons*	*469 kWh*
Estimated Existing Costs	*$4,884*	*$66*
Estimated Annual End Use Savings	*85,320 gallons*	*0 kWh*
Estimated Annual Cost Savings	*$2,167*	*$0*
Estimated Total Lifetime Savings (10 yrs)	**$9,446**	
Estimated Initial Retrofit Cost	**$5,947**	
Estimated Payback Period (yrs)	**6.3**	

Summary

Estimates reveal that the Santa Barbara hotel can reduce annual water, natural gas, and electricity consumption by approximately 850,000 gallons, 24,000 therms, and 10,000 kWh respectively. Cost-effective retrofits are projected to save the Santa Barbara hotel over $226,000 across the lifetime of the appliances. Table 28 summarizes the estimated annual natural gas, electricity, and water costs for our five existing identified end uses. Estimated annual and lifetime cost savings from recommended retrofit upgrades are also presented. Figures 27 and 28 summarize annual resource savings and lifetime cost savings.

Table 26 Summary of annual costs and annual and lifetime savings for the Santa Barbara hotel

Santa Barbara hotel Summary Table	
Estimated Annual Gas, Water, Electricity Costs of Targeted End Uses	
Estimated Cost of Water	$36,342
Estimated Cost of Gas to Heat Water	$33,023
Estimated Cost of Direct Electricity for Water Using Appliances	$6,070
Estimated Annual Utility Cost for Water-Related Uses	**$75,435**
Estimated Annual Savings Associated with Retrofits:	
Estimated Annual Water Savings	$11,134
Estimated Annual Gas Savings	$19,052
Estimated Annual Electricity Savings	$1,400
Total Annual Savings Associated with Retrofits	**$31,586**
Estimated Lifetime Savings Associated with Retrofits:	
Estimated Lifetime Water Savings	$121,485
Estimated Lifetime Gas Savings	$173,457
Estimated Lifetime Electricity Savings	$12,420
Total Upfront Costs	$81,184
Total Lifetime Savings Associated with Retrofits	**$226,179**

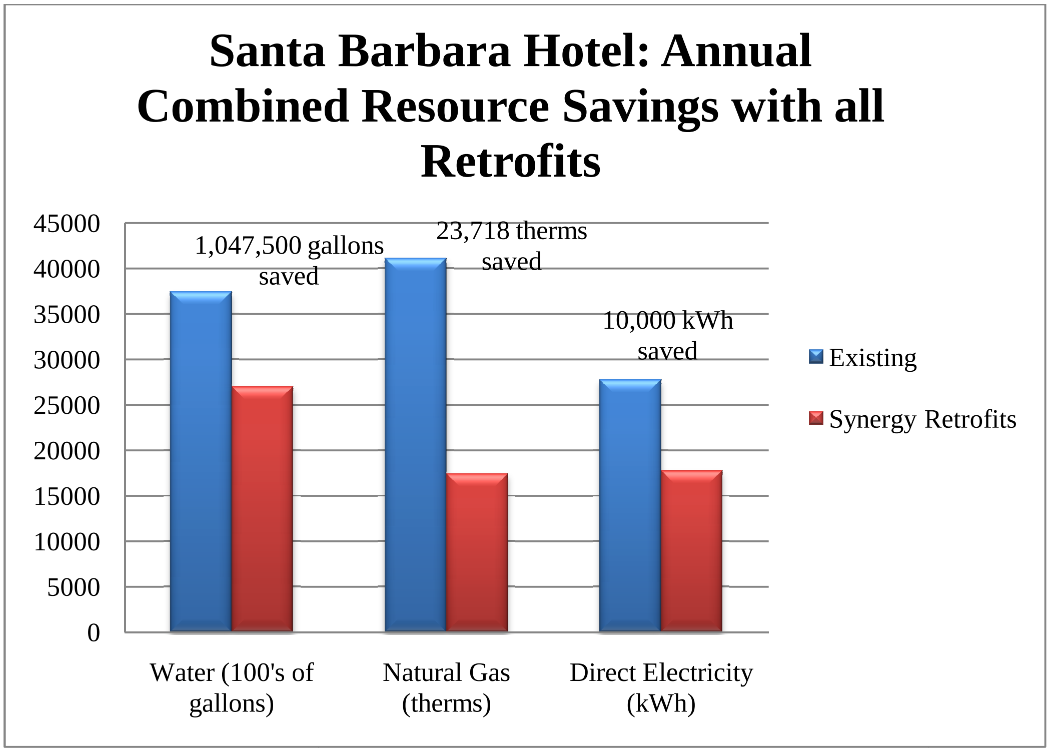

Figure 27 Combined resource savings from retrofits at the Santa Barbara hotel

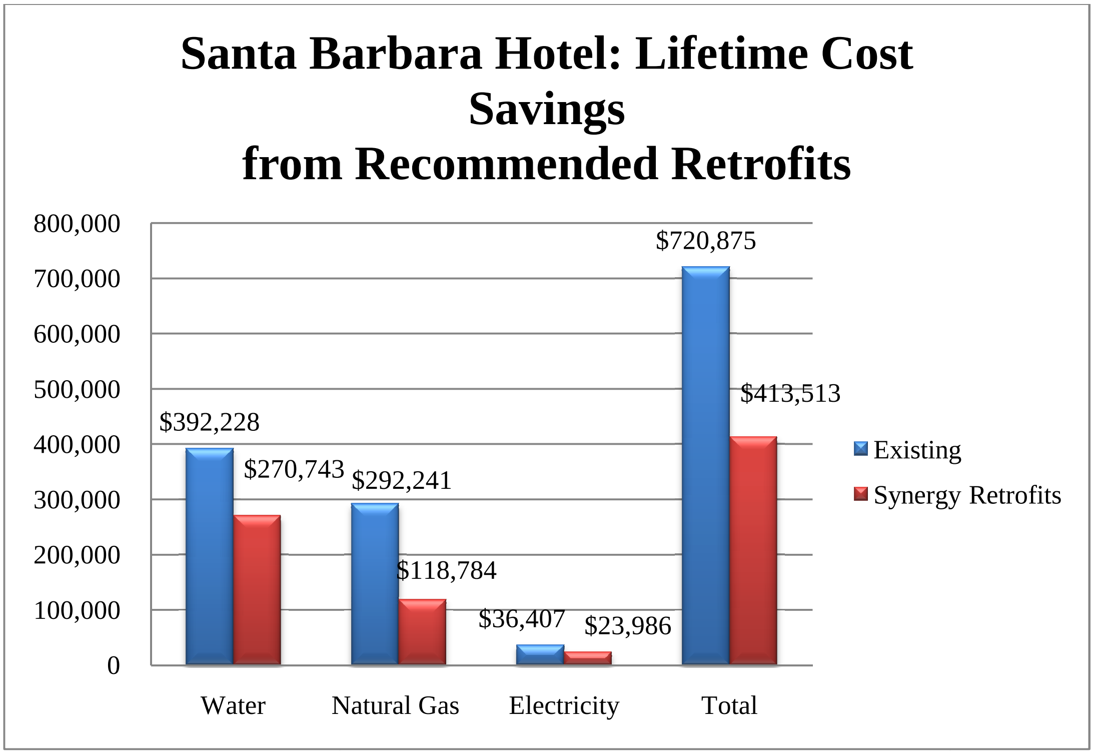

Figure 28 Lifetime cost savings from targeted retrofits and the Santa Barbara hotel

Case Study 3: Moreno Valley Hotel

The hotel in Moreno Valley contains 120 guest rooms, a pool and spa, meeting space, and a partial service dining facility. The water-using appliances resemble those of the Goleta hotel in terms of efficiency.

For the Moreno Valley hotel, 26% of water consumption is associated with domestic fixtures (Figure 29). The next largest category represents 26% of water use (*other*). Landscape irrigation was calculated to account for 20% of total annual water use. The remaining categories make up the remaining 28% of our total estimation of annual water consumption. Additionally, our analysis revealed a probable leak in the outdoor water use section which is estimated to constitute over 466,000 gallons per year (a more detailed presentation of the suspected leak is found at the end of this section) and see Appendix I for our error and confidence for our water consumption calculations.

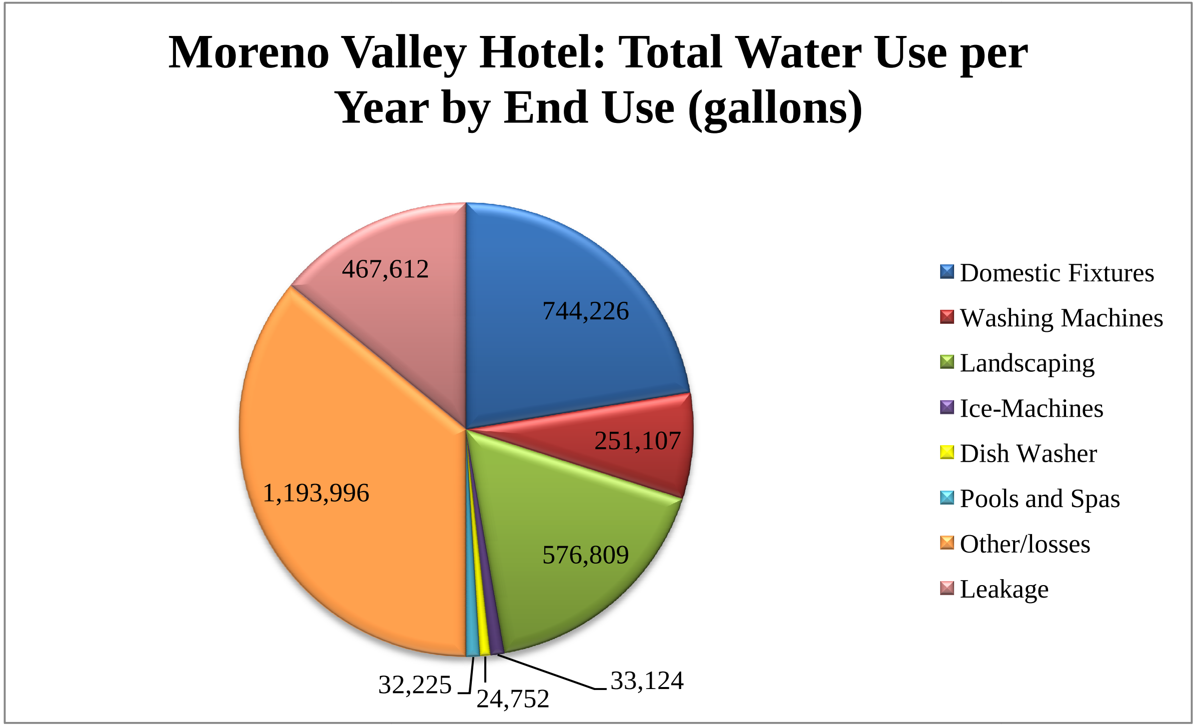

Figure 29 Total annual water use for the Moreno Valley hotel

Total electricity consumption at the Moreno Valley hotel was estimated to be 388,800 kWh based on the past two years of billing. Pools and spas were estimated to consume the most electricity of our identified end uses (23,191 kWh/year) followed by ice machines (9,516 kWh/year) (Figure 30).

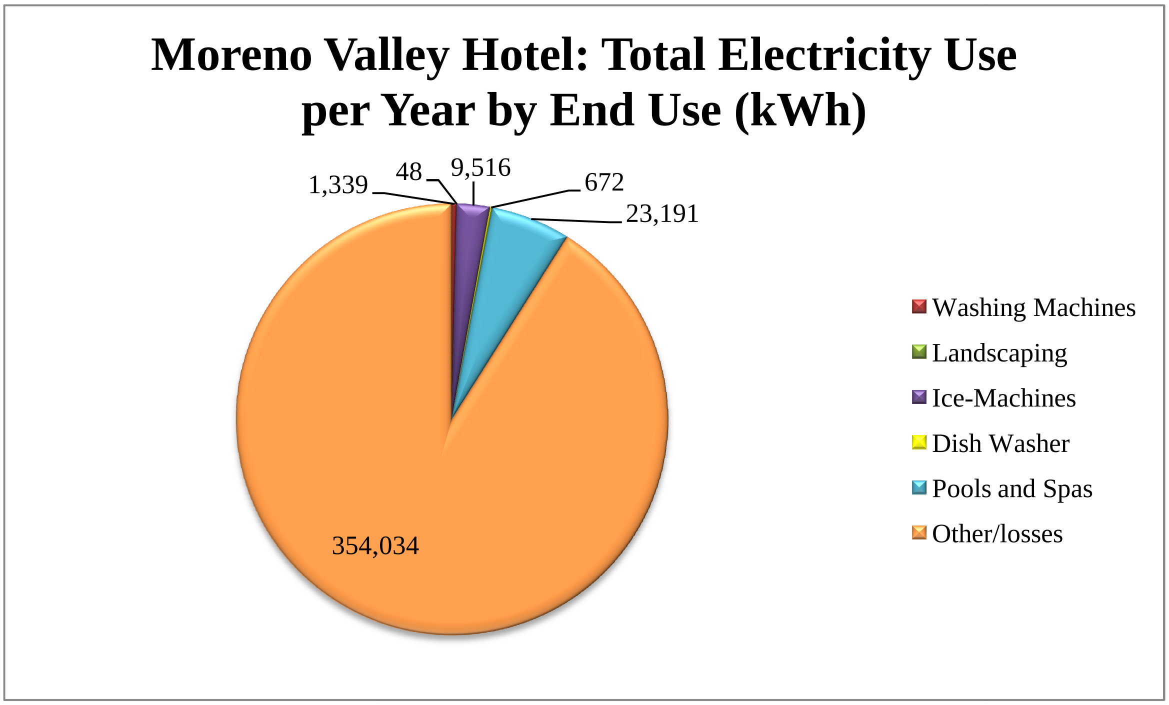

Figure 30 Total annual electricity consumption at the Moreno Valley hotel broken down by end use.

The spa was estimated to account for 3,296 therms of natural gas and domestic fixtures consume an estimated 3,260 therms annually. The pool and spa category at Moreno Valley consumes less natural gas than our other case studies because their pool is unheated. Our estimation of annual natural gas use captures 58% of the hotel's annual consumption (Figure 31). Natural gas consumption not captured by our audit was estimated to be 5,845 therms.

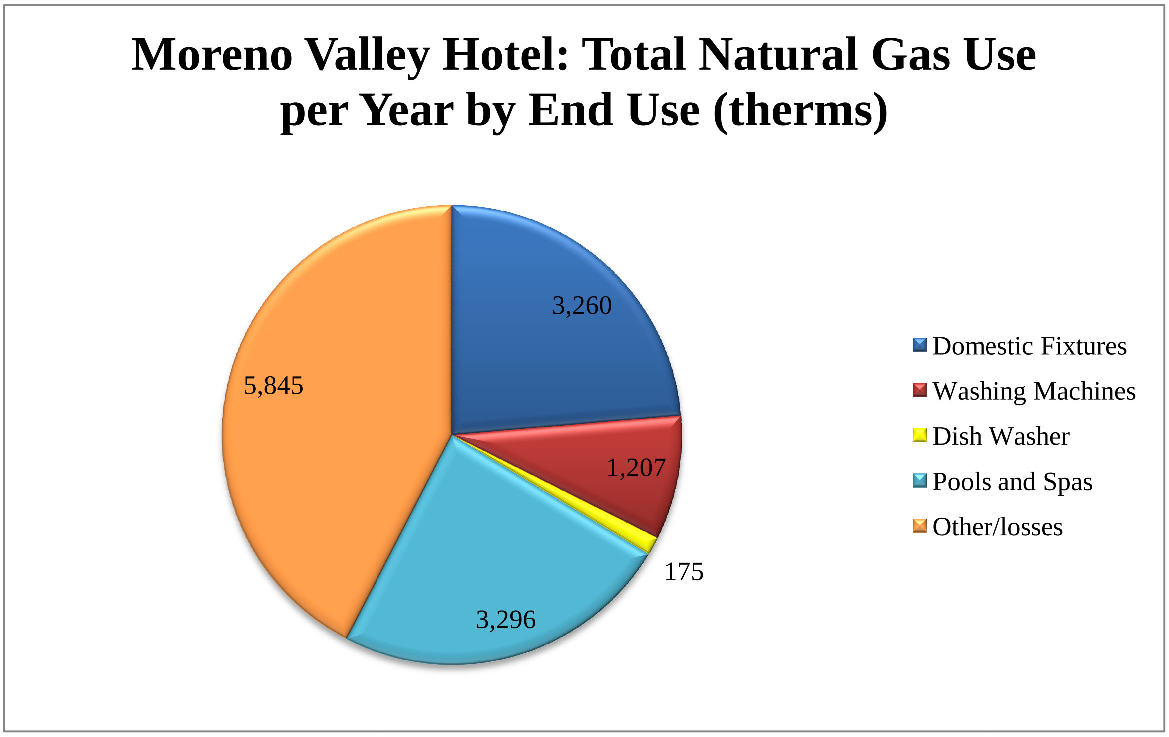

Figure 31 Total annual natural gas consumption at the Moreno Valley hotel broken down by end use.

Figure 32 summarizes the estimated annual natural gas, electricity, and water consumption for our six identified end uses; as well as the other category and leaked water use. Pools and spas were shown to account for the largest magnitude of combined resource use.

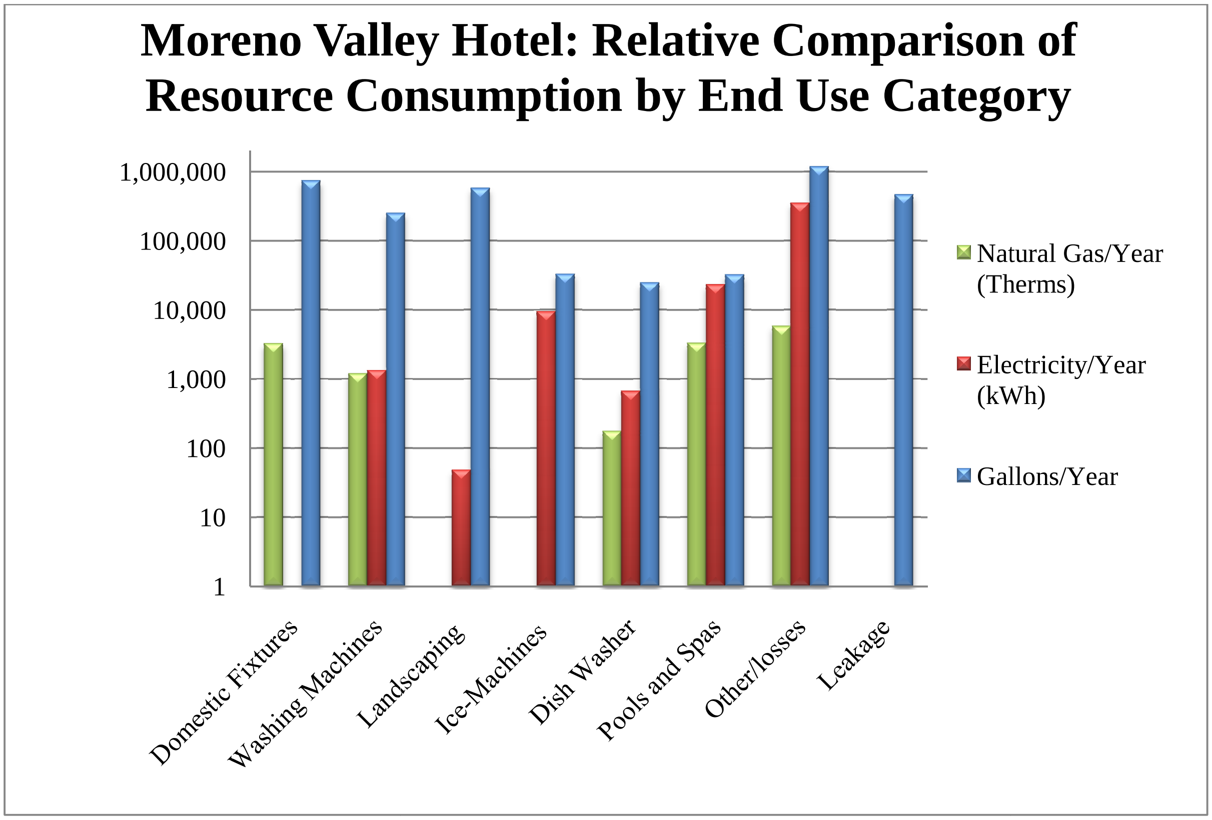

Figure 32 Resource consumption of targeted end uses at the Moreno Valley hotel

Moreno Valley Retrofit Savings Analysis

For the Moreno Valley hotel, feasible retrofits consisted of faucet, pool and spa, and irrigation upgrades. Toilet upgrades and shower upgrades were infeasible because the current appliances are already water efficient. The initial cost necessary to replace the ice machines and dish washers were too high to allow for feasible retrofits. We make further recommendations pertaining to the suspected leak later in this section. Refer to Appendix G for a more detailed presentation of retrofit feasibility.

Faucet Retrofits

The guest room faucets at the Moreno Valley hotel were very efficient, averaging about 1.7 gallons per minute. However faucets in other areas such as the pool bathroom and kitchen all consumed at least 2 gallons per minute of water. Our retrofit models the savings from installing 0.5 gpm aerators in all the Moreno Valley hotel faucets. Use of these aerator retrofits are estimated to save the Moreno Valley hotel over 100 therms of natural gas per year and 43,000 gallons per year (Table 27).

Table 27 Moreno Valley hotel faucet retrofit measures and savings

Faucet Retrofit Measures	Natural Gas	Water
Estimated Existing Annual End Use Consumption	*190 therms*	*43,351 gallons*
Estimated Existing Costs	*$194*	*$86*
Estimated Annual End Use Savings	*108 therms*	*24,744 gallons*
Estimated Annual Cost Savings	*$111*	*$49*
Estimated Total Lifetime Savings (10 yrs)	**$1,349**	
Estimated Initial Retrofit Cost	**$223**	
Estimated Payback Period (yrs)	**1.7**	

Pool and Spa Retrofits

We modeled the electricity, natural gas, and water savings possible from using a pool cover, reducing the operation hours of their current circulation pump, and purchasing a more efficient spa heater (which by itself reduces the natural gas use by 13 percent). The estimated payback period for installing pool and spa covers and replacing the spa water heater is less than one year (Table 28).

Table 28 Moreno Valley hotel pool and spa retrofit measures and savings

Pool and Spa Retrofit Measures	Natural Gas	Water	Electricity
Estimated Existing Annual End Use Consumption	*3,296 therms*	*32,225 gallons*	*23,191 kWh*
Estimated Existing Costs	*$2,512*	*$205*	*$3,224*
Estimated Annual End Use Savings	*2,292 therms*	*9,667 gallons*	*16,120 kWh*
Estimated Annual Cost Savings	*$1,747*	*$62*	*$2,241*
Estimated Total Lifetime Savings (10 yrs)		**$34,323**	
Estimated Initial Retrofit Cost		**$3,121**	
Estimated Payback Period (yrs)		**0.9**	

Landscaping retrofits

Landscaping retrofits for the Moreno Valley hotel include converting all irrigation zones to durable drip irrigation, applying mulch to all areas with bare soil, and installing a rain sensor on the existing irrigation controller, achieving a payback period of less than 2 years (Table 29). These changes, along with careful adjustments to the irrigation controller to best match plant needs, can reduce landscape water use by nearly 40 percent. In addition, we recommend assessing for underground leaks on the irrigation system to save additional water and money on the hotel's water bill. Please see Appendix F for detailed retrofit and water saving calculations.

Table 29 Moreno Valley hotel landscaping retrofit measures and savings

Landscaping Retrofit Measures	**Water**	**Electricity**
Estimated Existing Annual End Use Consumption	*576,809 gallons*	*48 kWh*
Estimated Existing Costs	*$3,674*	*$7*
Estimated Annual End Use Savings	*412,126 gallons*	*0 kWh*
Estimated Annual Cost Savings	*$2,625*	*$0*
Estimated Total Lifetime Savings (10 yrs)	**$26,274**	
Estimated Initial Retrofit Cost	**$4,484**	
Estimated Payback Period (yrs)	**1.7**	

Summary

Estimates reveal that the Moreno Valley hotel can reduced annual water, natural gas, and electricity consumption by approximately 440,000 gallons, 2,400 therms, and 16,120 kWh respectively. Cost-effective retrofits are projected to save the Moreno Valley hotel over $54,000 across the lifetime of the appliances. Figures 33 and 34 summarize annual resource savings and lifetime cost savings.

Table 30 summarizes the estimated annual natural gas, electricity, and water costs for our six existing identified end uses. Estimated annual and lifetime cost savings from recommended retrofit upgrades are also presented.

Table 30 Summary of existing annual costs and annual and lifetime savings from retrofits

Moreno Valley Summary Table	
Estimated Annual Gas, Water, Electricity Costs of Targeted End Uses	
Estimated Cost of Water	$5,965
Estimated Cost of Gas to Heat Water	$5,177
Estimated Cost of Direct Electricity for Water Using Appliances	$4,832
Estimated Annual Utility Cost for Water-Related Uses	**$15,975**
Estimated Annual Savings Associated with Retrofits:	
Estimated Annual Water Savings	$2,736
Estimated Annual Gas Savings	$1,857
Estimated Annual Electricity Savings	$2,241
Total Annual Savings Associated with Retrofits	**$6,834**
Estimated Lifetime Savings Associated with Retrofits:	
Estimated Lifetime Water Savings	$27,182
Estimated Lifetime Gas Savings	$15,682
Estimated Lifetime Electricity Savings	$19,082
Total Upfront Costs	$7,829
Total Lifetime Savings Associated with Retrofits	**$54,118**

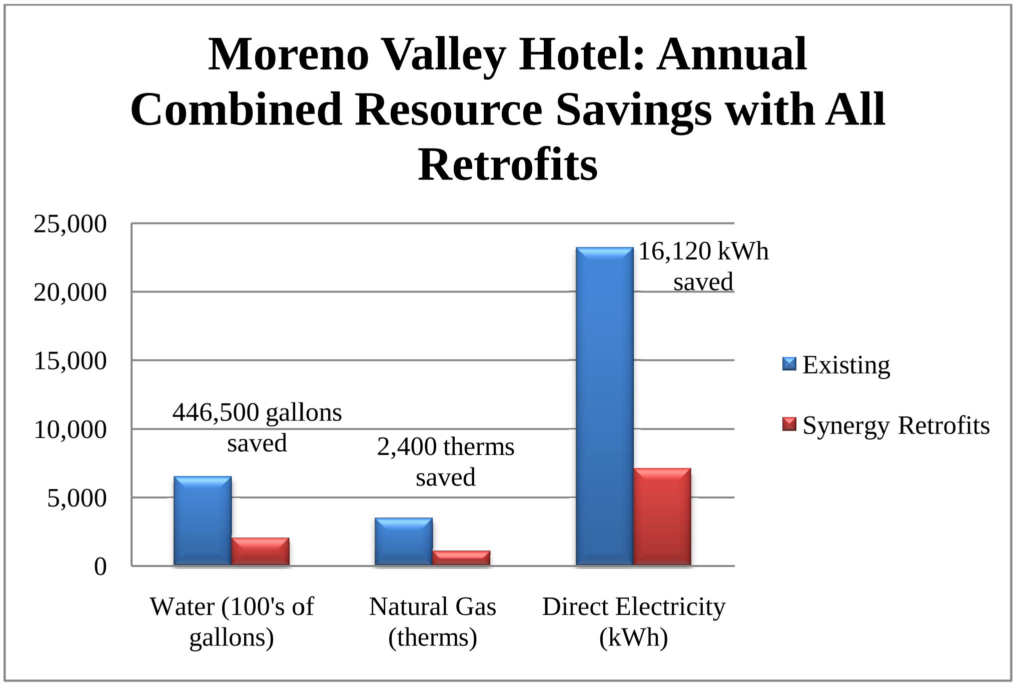

Figure 33 Annual resource savings from combined retrofits at the Moreno Valley hotel

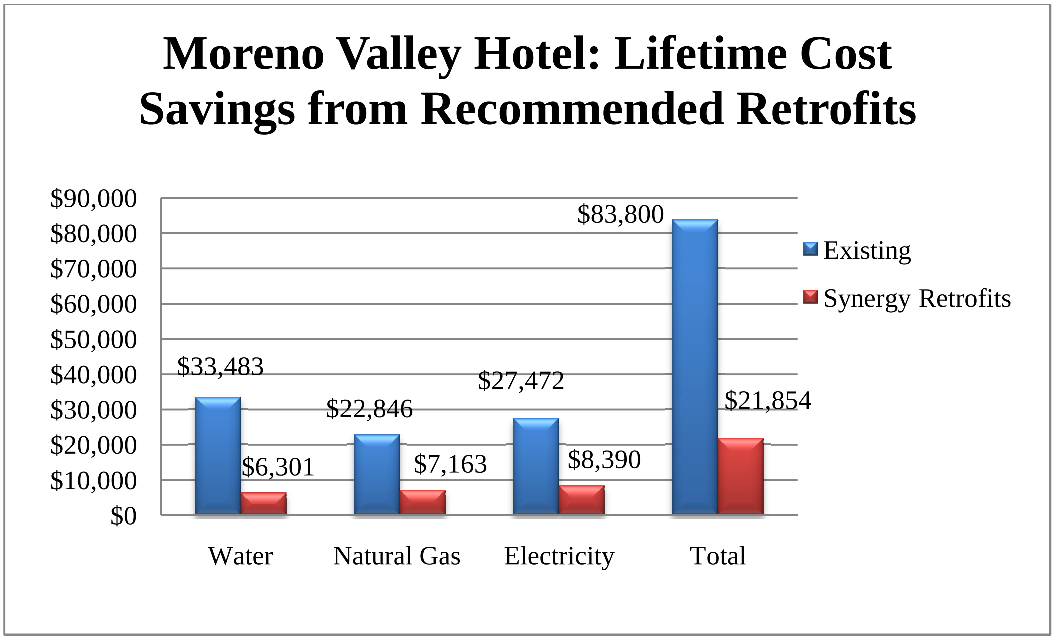

Figure 34 Lifetime cost savings from retrofits at the Moreno Valley hotel

Leak at Moreno Valley hotel

There is a large difference in the amount of water billed, the amount of water estimated to be applied by the irrigation system, and the amount of water needed by existing plants (Figure 35). The difference between the billed water use and our estimates appears to be a result of an undetected water leak. We observed the landscape water meter when the irrigation system was not turned on and the meter did not spin, suggesting that any leak on the landscape system would be beyond the irrigation control valves. This would result in a leak that only occurs while the particular station is turned on, which also may reduce the likelihood of the leak becoming large enough to notice above ground. We recommend making an appointment with a licensed leak detection company in the area and coordinate this with the hotel landscaper to ensure they can assist in evaluating all irrigation stations and plumbing. Leaks such as the one suspected here can result in large ongoing costs for a commodity never put to use. Rapid repair of leaks saves money and depending on the extent of the leak, could be the least expensive way to save water waste.

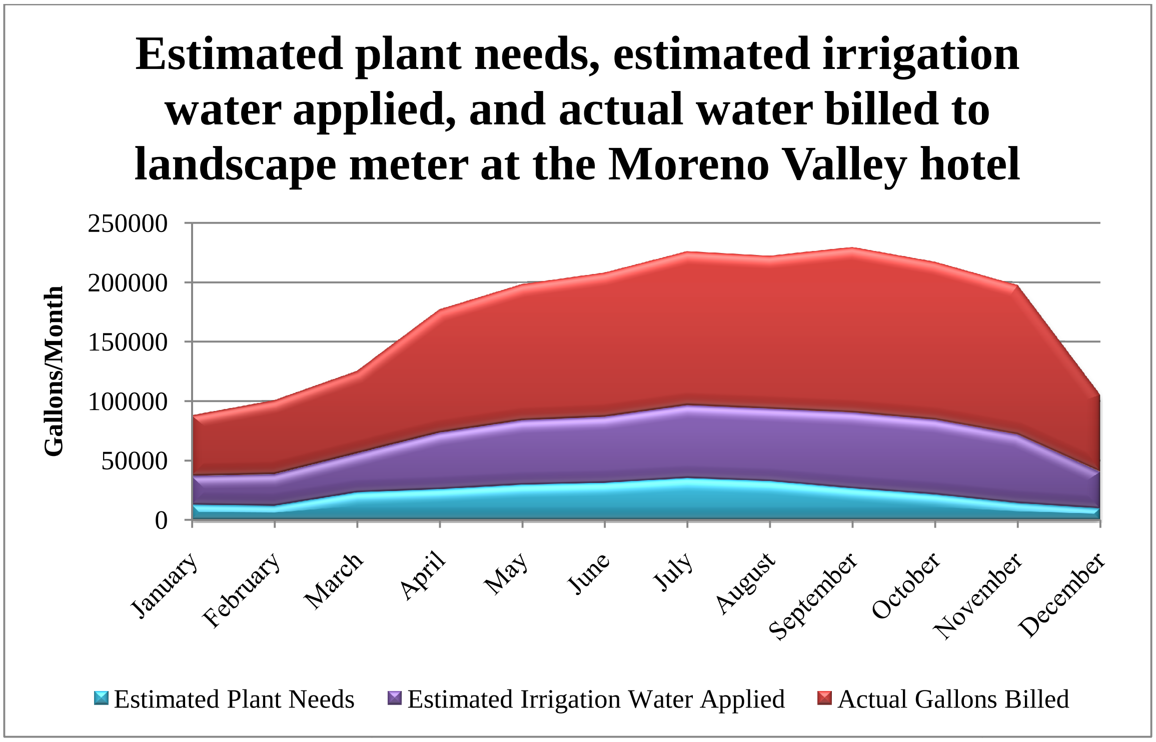

Figure 35 Estimated plant needs, estimated irrigation water applied, and actual water billed to landscape meter at the Moreno Valley hotel.

Summary

Cost-effective retrofits were identified for all three hotels in our case study. The Moreno Valley hotel exhibited the smallest lifetime cost savings at just over $54,000. The Santa Barbara hotel exhibited the largest potential for cost savings at just over $226,000. Summed over all three hotels, these recommended retrofits are estimated to save over 33,500 therms of natural gas, 37,500 kWh of electricity, and 1.75 million gallons of water annually. The estimated electricity savings just from the water-related uses identified in this report are roughly equivalent to the total annual electricity consumption for three households. Our estimated natural gas savings are equivalent to the annual consumption over 34 households (United States Environmental Protection Agency, 2010). Finally, our estimated water savings are equivalent to the volume of water used by a family of four for 12 years (United States Environmental Protection Agency, 2008b).

Hotels: Efficiency Recommendations

This section reports our general recommendations for all hotels seeking to improve resource efficiency within their facilities. These suggestions are both behavioral and technological and can be applied to other commercial businesses such as commercial laundries, restaurants, and casinos as well as our case study hotels. We then report our specific hotel case study results and recommendations separately. In the next section, we compare our *Synergy Audit* hotel retrofit suggestions with those of SCE and identify added resource and cost savings.

General Best Management Practices for Resource Efficient Hotels

Through becoming more knowledgeable about the available retrofit and behavioral options for hotels, our group assembled a list of general best management practices (BMPs) for all hotels interested in resource efficiency. From this list we were also able to generate a suite of specific retrofit and behavioral suggestions for our hotel case studies. Our team recognizes there is a significant amount of time, money and effort associated with technological upgrades. In many cases we were able to quantify the estimated resource and cost savings associated with our suggestions and only recommended those BMPs which were cost effective over the lifetime of the appliance. Overall, it is important to inform the hotels of the savings potential that exists at their facility, and that there are also many behavioral changes with no upfront costs and immediate savings as well as cost-effective technological upgrades.

Food Service

A variety of straightforward measures can increase the water and energy efficiency of food service fixtures.

Ice Machines

Shifting the ice machine production timer so that ice is produced during off-peak hours can save money on electric bills.

Dish Washer

Reduce electricity bills by turning off the internal tank heater on dish washers at night and during non-business hours. Reduce water and natural gas bills by checking that rinse pressure is in agreement with manufacturer recommendations (typically around 20 pounds per square inch or psi) and wash curtains are in good working condition. Dish washer conveyors should also be kept in the automatic mode recommended by the manufacturer (Consortium for Energy Efficiency, 2005b).

Pools and Spas

Pools and spas at hotels are among the largest energy and water uses. Employing water and energy efficiency BMPs at pools and spas can reduce water, electricity, and natural gas bills without sacrificing the recreational experience of guests.

Pool and Spa Covers

Pool covers may not sound like an impressive technological retrofit, but properly used they represent the largest potential energy and water savings at the lowest price. A pool or spa cover costing $50 to $100 can reduce water loss from evaporation by 30 to 50 percent, and reduce annual heating costs by 50 to 70 percent. Pool covers provide a triple benefit in that they also result in less chemical use as well (United States Department of Energy, 2009a).

Efficient Pool Heaters

Most current pool heaters in California are required to be at least 78 percent efficient. This means that for every 100 units of gas used by the heater, only 78 units actually are used for heating the water and the rest of the heat is lost due to inefficiency. Buying a 95 percent efficient pool or spa heater can save hundreds of dollars each year in heating costs (United States Department of Energy, 2009b).

Variable Speed Pump

According to SCE, replacing a single speed pool pump with a variable speed pump can almost halve the electricity needed for pool circulation (Southern California Edison, 2010d).

Solar Pool Heater

Once efficient heaters and pool covers are used to minimize heating energy needs, a solar pool heating array can provide a large majority of the rest of the heating energy needed. Water is pumped through tubes passing through the solar collector, which then heats the water as it is sent back to the pool. While savings depend upon the system size, sun availability at the site, and other factors; the United States Department of Energy reports that pool solar water heating systems can often pay for themselves in 1.5 to 7 years (United States Department of Energy, 2009c).

Check for Leaks

It is estimated that one in every 20 pools has a leak, and just one pinhole-sized leak can result in a pool losing over 300,000 gallons of water per year. An easy way to tell if your pool is leaking is to fill a bucket with water and place it on the pool's top step. If at the end of the day the water level in the bucket is significantly higher than in the pool, water is leaking out somewhere. Sophisticated cameras or microphones can be used to find leaks, or simply compressed air or dyes (Alliance for Water Efficiency, 2009)**.**

Wind Break

Lots of wind around your pool means more water and heat will be lost due to evaporation. Consider surrounding the pool with landscaping or a fence to decrease evaporative water loss – however ensure that the wind break is not shading the pool, since the sun helps heat it (United States Department of Energy, 2009a).

Optimal Temperature and Pump Use

The optimal pool temperature ranges from 78 degrees for competitive swimming to 82 degrees for children and seniors. For every extra degree a facility heats the pool, it is increasing energy costs 10 to 30 percent. Also, the higher the temperature the more water and heat loss due to evaporation if the pool isn't covered (Alliance for Water Efficiency, 2009). For a period of inactivity of several days, turn down or off the heater – it's a myth that it takes more energy to heat the pool or spa back up than leave it on (United States Department of Energy, 2009d).

Most pool pumps circulate much longer than necessary. The Association of Pool and Spa Professionals recommends circulating the water in the pool once per day, but many pools have their pumps set to do much more. Rather than have it run continuously, set the pump to cycle for a few times a day for short periods of time (a timer can be purchased to do this for you). Also, ensure that the intake filters aren't clogged, which requires the pump to work harder. Simply operating your pump more efficiently can reduce your electricity bill up to 60 percent (United States Department of Energy, 2009d).

Proper Filter Maintenance

Don't backwash your filter too much to clean it – the average backwash uses 250 to 1,000 gallons of water, and often still doesn't completely clean the filter. Manually cleaning the filter is more effective, and saves energy and water (Alliance for Water Efficiency, 2009).

Laundry

Linen Reuse Place cards

Many hotels already implement towel and sheet reuse programs in which they encourage their guests to sleep in the same sheets and use the same towels if the duration of their stay is less than three days. There are place cards in each hotel room and bathroom that explain the purpose of this program and describe the method by which the guest can signal the housekeeper to either wash or leave the linens. These programs can reduce the frequency of washing cycles and therefore reduce water and energy utility bills and possibly decrease labor costs for the hotel as well. In addition, this effort can enhance hotel reputation, and help reduce the environmental impact of each hotel facility this can further help guests feel good about their actions.

However, even if there are already programs and cards in place, there may be ways to increase the effectiveness of these policies and maximize the potential for savings. For instance, altruistic hotel guests would be more inclined to adhere to the policy if they believe that they are making a small sacrifice to help the environment or a charity, than if they believe that they are reusing their linens only to help the hotel reduce costs (Jingzhi Shang, Debra Z. Basil, & Walter Wymer, 2010). Many people are also driven by self-interest, and may respond more positively to this policy if they believe that the resulting monetary savings to the hotel will be reflected in lower room rates (Jingzhi Shang et al., 2010). These are relatively low cost adjustments to either new or existing practices that could result in great savings and a better reputation for the hotel.

No Triple Sheeting

For decades many hotels have considered a third sheet, which is placed in between the blanket and the bedspread, to be a luxury for the hotel guest (Kozlowski, n.d.). A triple-sheeted bed prevents the blanket from coming in contact with the guest's skin unless they purposefully separate them. However, this small luxury adds more costs to the hotels with increased labor and utility costs and yet may be relatively unnoticeable to the average guest (O'Neill & Siegelbaum & The RICE Group, 2002). In addition to the challenging and timely process of making a triple-sheeted bed, the increase in labor and utility costs associated with laundering the sheets could increase substantially (Kozlowski, n.d.). It is recommended that hotels should discontinue triple sheeting to receive instant financial gain associated with decreased washing cycle frequency at no cost to them.

Weigh Each Load before Washing

The only way to ensure that each washing machine is running at maximum capacity is to measure the dry-weight of the linens before washing. This small extra step could result in large savings if the annual cycle frequency is reduced.

Adjust Washer Settings

Water consumed during a wash cycle is primarily determined by the washer programming and not washer manufacturers (Alliance Laundry Systems, 2010). Even if there are dozens of water levels, it may be difficult to save more than 10% of water used while still maintaining a superior wash quality (Alliance Laundry Systems, 2010). For instance, many cycles do not require a pre-wash or an extra bleaching cycle, but this is often built into the cycle settings. Most industrial washer programming is set by a commissioned chemical representative rather than the hotel staff or manufacturers. Considering that most of the water used for washing is hot, the energy savings could be even greater with a reduction in water use. Therefore, a hotel interested in using the most efficient settings to suit their needs should contact their chemical manufacturer.

Ozone Washing System

Ozone is a very commonly used natural sanitizer because it is a very unstable molecule that is able to oxidize most organic compounds that it encounters. In fact, it is most widely used by the bottled water industry because of its ability to kill bacteria without affecting the taste of the water. An ozone washing system is a wall-mounted system that hooks up directly to your existing washer through a series of efficient, ozone-resistant valves. This system can decrease the amount of hot water needed for each cycle by up to 95% because it disinfects the linens just as well or better than heating the water to 160 degrees. In addition to the decrease in gas costs, many laundries have reported the cold ozone rich water can extend the life of the linens when compared to washing them in hot water filled with bleach. Depending on the frequency of washing at a particular hotel, the payback period for an investment in an ozone washing system could be very short as the savings on gas bills can be reduced dramatically (Articlean, 2010).

Machines with Higher Water-Extraction Rates

All newer models of washing machines will likely be more water and energy efficient than older ones. However, when it comes time to purchase a new washing machine, the extract G-Force is a measure for comparing the washers' quality by its ability to remove moisture from the linen. A higher G-Force will result in a larger reduction in drying time. For instance, a G-Force of 98 can typically leave 93% moisture retention, while a G-Force of 345 will only leave 65% (Unimac, 2010). It is difficult to quantify the exact savings since residual moisture depends on the linen type, and dryer efficiency. However, it is important to consider because of the substantial amount of gas and time consumed during each drying cycle.

Domestic Fixtures

At our case study hotels, domestic fixture water use accounted for the largest water demand as compared to any other end-use category, including landscaping. Being that the majority of this water is used in faucets and showers, this signifies the high volume of water requires large amounts of natural gas energy to heat. This also means a lot of opportunities exist to reduce the combined energy and water fixture use at hotels, and significantly decrease their operating costs and environmental impact.

Check for leaks

Have the maintenance staff check for leaking fixtures. Some studies attribute between 6 and 12 percent of a facilities' water use to "leakage/other". Place dye tablets or food coloring in the toilet tank, and then inspect the bowl to check for toilet leaks which would increase the water requirements. Check guest rooms visually for dripping faucets and showerheads, and fix or replace as needed.

Low-flow showerheads

About 7 percent of total bathroom water use in the CII sector is from showers – and this number is greatly higher in hotels. Installing a showerhead that uses less water can save several gallons per shower, and thousands of gallons annually without compromising flow. All while costing as little as $5 to $12 when purchased in bulk. And the majority of the water reduced with a low-flow showerhead is hot – which reduces natural gas as well. For this reason, investing in low-flow showerheads usually pays for itself within 2 years (Cohen et al., 2009).

High-efficiency or Dual Flush Toilets

Generally in hotels, toilets account for 72 percent of total restroom consumption. Currently all new toilets must use 1.6 gallons per flush, and California legislation passed in 2008 will reduce that to 1.3 gallons per flush by 2014. Installing a high-efficiency (1.28 gallons per flush) or a dual flush (0.8 and 1.6 gallons per flush depending on use) can drastically reduce a hotel water bill – as much as 15,000 to 20,000 gallons per toilet (Cohen et al., 2009). Installation in high traffic areas, such as lobby or pool bathrooms, not only save more water but also give hotels a modern and efficient look.

Faucet Aerators

Since faucet aerators reduce flow, and can be purchased and installed easily, facilities often make up the cost with lower utility bills within months. Like showerheads, efficient faucets provide the dual benefit of also reducing the natural gas needed for hot tap water. Gaia Napa Valley Hotel and Spa installed high efficiency toilets, showerheads, and faucet aerators along with other best management practices mentioned in this report and realized a 45 percent reduction in total water usage and a 25 percent reduction in energy. These cost savings allow the hotel to make up the retrofit costs in 5 years (Cohen et al., 2009).

Cooling Towers

There are several relatively simple measures that can improve the efficiency of a cooling tower:

Insulation

Insulate all heating and cooling lines/vessels to minimize heat gains or losses. Keeping the water in the exposed lines insulated creates less extreme temperatures for the cooling tower to overcome.

Building Heat Load Minimization

Measures like roof reflectance, efficient interior lighting, and optimal thermostat setting for the temperature of air conditioned spaces can minimize air conditioning loads for the cooling tower.

Select high-efficiency units when replacing HVAC equipment
Reduce energy bills by selecting higher-efficiency air conditioning units. The upfront cost of the high-efficiency unit may be greater than an average unit, but typical payback periods for high-efficiency cooling towers range from two to five years (Alliance to Save Energy, 2009).

Hot Water Heaters

Two measures and practices that save significant energy and water are:

Reduce the temperature to 120 degrees Fahrenheit
Most manufactures set the water temperature at 140°F, while users only require hot water up to 120 to avoid scalding. Each 10 degree reduction in water temperature saves about 3% to 5% in energy cost. Lowering the temperature also reduces mineral buildup and corrosion (United States Department of Energy, 2009e).

Insulate the hot water tank
Insulating the hot water tank is estimated to reduce standby heat losses by 25%-45%. The reduction in standby losses results in 4% to 9% water heating costs savings. The installation of a hot water heater tank jacket is usually performed by a heating expert, but the payback period is less than 1 year (United States Department of Energy, 2009e).

Landscaping

Every landscape is different, making standardized recommendations difficult. There are however, generally accepted BMPs to consider for maintaining plant health and appearance and preventing the waste of water and money. BMPs for landscaping are both technological and behavioral but are best practiced together to ensure that savings potential of technology-based retrofits are realized. Before any technical solutions can be presented, strategies addressing the design, operation, and maintenance of landscapes should be discussed.

Hydrozones
Efficient irrigation of each zone is calculated based on the watering needs of the thirstiest plant. The concept of grouping plants of similar watering needs within an individual irrigation zone is called a hydrozone. The inclusion of low water use and high water use plants together results in overwatering some plants within the zone and can lead to significant water waste and disease problems for plants receiving too much water (University of California Cooperative Extension and California Department of Water Resources, 2000). While the hydrozone concept is most important during the design phase of a landscape, high water use plants can be removed from an irrigation zone to allow for a reduction in watering needs of the zone.

Convince the landscaper to conserve water
Landscapers do not pay the water bill and so are not as concerned as the building owner or manager with minimizing water costs. Landscapers typically over-water to ensure plants grow rapidly and stay green, keeping the owners and managers happy. However, an overwatered landscape wastes water and requires more work with additional trimming and growth control. By having owners and managers request landscapers reduce water use, they will convey cost concerns to the people in control of the ability to generate the savings. Trainings such as the Green Gardener Program® in Santa Barbara can educate staff and landscape contractors about

the importance of conserving water, reducing pesticides, and many other sustainable practices (County of Santa Barbara, 2010).

Turf removal

While replacing cool season turf with drought tolerant plants can generate some of the highest potential water savings, this can be labor intensive and includes costs for removal, transport, and disposal. Consider removing some turf zones where activities and recreation do not occur and retain ones that do. A site walk-through with a landscape professional to discuss opportunities for minimizing impacts and maximize water savings will help identify the best plan for addressing turf removal.

Non-irrigated areas

Permeable hardscapes, paths, and rock gardens often are the center of attention in landscapes. These areas draw people closer into the design, adding function and beauty into the landscape, while reducing the irrigated area. For large planted areas, or where removal of turf or high water use plants is planned consider incorporating walking paths, patios, or other permeable areas to reduce water use. This is best performed in combination with installing drip irrigation as meanders can be introduced both into the layout of the drip line and any paths without the worry of sprinkler overspray and waste. For hotel courtyards, this may be a welcome getaway.

Weather-based (ET) controllers

Evapotranspiration-based or ET controllers are designed to reduce water used in irrigation by applying the proper amount of water only when needed. ET controllers do this by adjusting watering times based on recent and predicted weather patterns based on locally available weather stations (EPA Water Sense, 2009). Traditional controllers must be adjusted manually to account for changes to seasonal water needs of plants but these regular adjustments are often overlooked, resulting in over watering relative to plants' actual needs. The result can be significant over-application of water during the majority of the year with reports of saving up to 50% of water use in certain applications (EPA Water Sense, 2009). As with nearly all technology, even ET controllers must be set correctly and adjusted to account for plant stress, runoff, etc. if water savings are to occur. While ET controllers have been shown to save water for those who over-irrigate, they also have been found to increase water use for customers who typically under-irrigate (Mayer, 2009). Lastly, rain sensors are an accessory that can be connected to most standard controllers and automatically shutoff watering cycles when measurable rain occurs.

Watering Schedules

The frequency of watering varies by age and plant species. When first establishing plants, watering may be frequent. However, for adult plants and turf grass, everyday watering encourages shallow roots which reduces drought tolerance, impedes efficient nutrient uptake, and increases evaporation from the soil (Bilderblack & Powell, 1996). By following locally appropriate watering schedules developed by water districts (Metropolitan Water District of Southern California, 2010); (Santa Barbara County Water Agency, 2010a), efficient watering schedules are easy to follow. An additional tool offered by some water districts is the weekly value for local plant water needs, using the water budget feature of controllers. First set the irrigation controller based on the plant water needs during summer, and then set your water budget feature on your controller to 100 percent. Based on a given week's water budget posted online, a simple adjustment to match the water budget percentage will reset all irrigation zones based on that percentage (Figure 36).

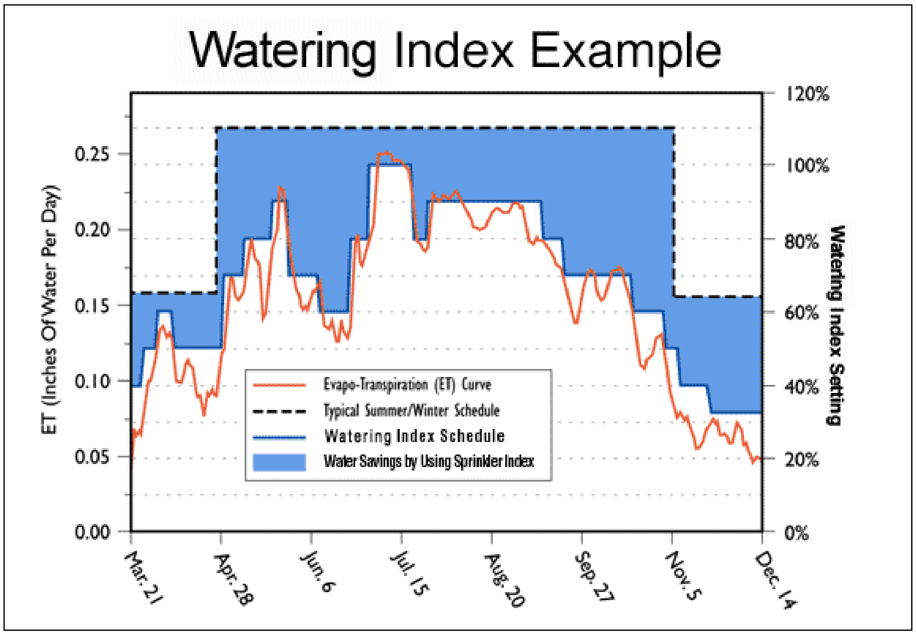

Figure 36 Typical ET curve, summer/winter watering schedule, and watering schedule based on an ET based irrigation controller
Source: (Santa Barbara County Water Agency, 2009a)

Delivering Water
The efficiency of getting water through complex irrigation systems to plants roots varies considerably. There are many methods to water plants but advances in irrigation design deliver water more efficiently by applying it slower. Traditional spray heads have high flow, or precipitation rate, of 1-2 inches of water per hour, which is often higher than the infiltration rate of the soil. This can result in pooling on the surface, higher evaporative losses, and runoff, especially on slopes greater than 10 percent (Bilderblack & Powell, 1996). Consider the following designs over standard spray heads or other sprinklers.

Rotating nozzles
As a modern retrofit for traditional spray heads, rotating nozzle spray heads produce multiple streams of water which rotate through the arc of the irrigated zone and have a much lower precipitation rate than traditional spray head nozzles (Hunter Industries Inc., 2007). The slower and more uniform application of water more closely matches precipitation rate with water infiltration rates into soil, reducing pooling and runoff. The streams of water also produce less misting than spray heads, resulting in less loss to wind and evaporation. These differences have been shown to save 20% or more water when used to replace traditional spray heads (Santa Barbara County Water Agency, 2009b) (Solutions for Green, 2006). These nozzles must be paired with a pressure regulating head to ensure consistent flow patterns and distances. For areas where turf will be retained, rotating irrigation nozzles are the best solution.

Drip irrigation

Drip systems are a significant advancement in irrigation technology. While not new, their use continues to spread as water becomes scarcer and waste is no longer acceptable. A well-designed drip system works by delivering water slowly and directly to the soil and the roots below, rather than spraying water everywhere. A hotel drip system should be durable by design; avoiding fragile parts and taking advantage of sufficient mulch cover to cushion the drip line and reduce the likelihood of being stepped on and broken.

Mulch

Serving many purposes in the landscape; mulch provides weed control, reduces evaporation from soil, increases soil organics as it breaks down, buffers soil temperature, and adds a distinctive look to the landscape (Connellan, 2009) (Santa Barbara County Water Agency, 2010b). Un-mulched landscapes have higher rates of evaporative water loss and can require an additional 10 to 20% water applied to maintain plant health (University of California Cooperative Extension and California Department of Water Resources, 2000). While time-consuming to apply and lasting only a few years, mulch is usually readily available from local sources for a nominal delivery charge (Santa Barbara County Public Works Department, 2007).

Maintenance

Regardless of the irrigation system installed, regular attention is important to maintain the function of the irrigation system and the desired look of the plantings. Regular but simple adjustments to the irrigation controller’s water budget feature is important to account for changing weather and is essential to actually saving water. Spray heads should be checked monthly for leaks and poor spray patterns, drip systems must be checked for broken emitters, while both need regular cleaning of filters to prevent clogging and poor performance. With drip systems, special care must be taken by landscape staff when digging to avoid cutting the drip line.

Southern California Edison: Resource Savings Potential of Increasing Energy and Water Efficiency Efforts

General Overview

Results presented at the beginning of this section are from various retrofit scenarios relevant to each hotel, which focus on resource cost savings and suggested BMPs. The retrofit results that presented here are relevant to SCE and focus on direct electricity savings, cost savings, price of retrofit, and payback in years. We modeled the retrofit results after the format that SCE use to report their findings to each case study hotel. Following SCE's method of reporting results allowed us to give context to the savings we found by comparing results and aggregated some of our findings with those of SCE. In order to compare the results we found annual use, annual cost, retrofit price, annual savings, and payback period for each end use technology that we audited. Each retrofit that we recommend is viable over the lifetime of the technology.

It is important to emphasize that we did not design a new electricity audit for SCE as we assumed the audits they perform reach the potential for electricity savings. Our combined energy and water audits were performed to quantify the water-related total resource savings and see if value could be added to the savings SCE finds with their existing audit. Therefore, the results that we reported to SCE include all potential resource savings, not just direct electricity. Our retrofits include water, natural gas, direct electricity, embedded electricity, and greenhouse gas savings. When reporting the retrofit results to SCE we first emphasize the direct electricity savings that we found. Those results are directly relevant to SCE and show additional electricity savings opportunities that could be incorporated into their electricity audits. Next, we report all of the resource savings that we found in our retrofits to display the resource savings that are not being captured. Finally, the added value that a Synergy audit gives to the existing SCE electricity audit is illustrated and discussed.

Interpreting the SCE Electricity Audit Results

The major recommendations that SCE made to the case study hotels are focused on light bulbs retrofits and best management practices for HVAC systems. Each hotel was given an "Energy Conservation Report" that highlighted potential lighting and HVAC energy savings. The energy audit results include quantitative and qualitative analysis. At each hotel the amount and type of lighting was noted by the SCE energy auditing professional and proposed replacements were suggested. The existing energy cost, energy cost savings, price, rebate, and payback period were reported to the hotel manager (Table 31). The Moreno Valley hotel was reported to have seven different groups of fixtures that could be retrofitted, for a total cost of $7,917.72 and a payback period of 1.04 years (Delgado, 2009a). The Santa Barbara hotel had four different fixture group types that could be retrofitted for a total cost of $373.18 and a payback period of 0.26 years (Delgado, 2009b). The Moreno Valley and Santa Barbara hotels would largely benefit from installing energy efficient light bulbs. The energy audit results for the Goleta hotel are qualitative and do not include any retrofit calculations due to the efficiency of existing appliances.

Table 31 Sample of SCE results from the energy audit at the Moreno Valley hotel

Lighting Retrofit Measures Fixture Group Type: HANG Quantity: 15 Exsisiting:1 Lamp incandescent fixtures using 45 watts each Proposed: Retrofit to 1 lamp compact flu fixtures using 19 watts each	
Existing Energy Cost	$1,160
Energy Cost Savings	$670
Price	$190
Rebate	$53
Payback (years)	0.20

Source: (Delgado, 2009a)

The HVAC energy efficiency savings are more difficult to interpret given that the method of analysis used by the SCE energy auditor was unclear. Results were reported to the hotels about the type of HVAC units, operational hours, and recommended improvements. The quantitative HVAC results were given for programmable thermostat improvements and new HVAC unit improvements, solely based on interviews with the hotel managers (Table 32). In terms of initial cost, annual savings, and payback period it is worthwhile for the Moreno Valley hotel and Santa Barbara hotel to install a programmable thermostat, but not a new HVAC unit unless it is necessary. The HVAC results reported to the Goleta hotel were qualitative.

Table 32 The SCE energy audit results for HVAC systems at the Moreno Valley Hotel.

Programmable Thermostat Improvement		**New HVAC Unit Improvement**	
Annual kW Savings	0	Annual kW Savings	18.609
Annual kWh Savings	5,014	Annual kWh Savings	25,291
Annual Savings	$802.24	Annual Savings	$4,046.56
Estimated Initial Cost	$125.00	Estimated Initial Cost	$60,000.00
Estimated Rebate	$54.00	Estimated Rebate	$0.00
Estimated Payback (years)	0.15	Estimated Payback (yrs.)	15

Source: (Delgado, 2009a)

After the quantitative results each report includes several qualitative recommendations to improve lighting and HVAC efficiency. The lighting suggestions include installation of occupancy sensors and information about various rebates that SCE offers for replacing light bulbs. SCE also recommends installing occupancy sensors at vending machines and includes information about an available rebate. The HVAC general recommendations include: clean HVAC condenser coils, regularly replace filters on HVAC units, and replace individual PTAC units with high efficiency units. Finally, each report includes general information about the energy efficiency programs that SCE offers, such as the Business Incentives & Services Program, Saving by Design, and the Summer Discount Program.

Direct Electricity Results

SCE presented retrofit results to the Santa Barbara hotel and to the Moreno Valley hotel. The results reported to the Goleta hotel were qualitative do not provide an opportunity for retrofit savings comparisons. Figure 37 shows the direct electricity savings results that we calculated for our retrofits scenarios at the Santa Barbara hotel. The retrofits that provided direct electricity savings to the hotel were for reducing pool pump use and minimizing washing load by not triple-sheeting. The average payback period for the retrofits that SCE suggested is 10.5 years and the average Synergy payback period for the direct electricity saving retrofits is 2.2 years. The dollar savings from the Synergy retrofits are $1,400 while the cost is $24,000. The retrofit results from our audit add about 30% direct electricity savings to the kWh that SCE found and contain a shorter payback period than the SCE analysis.

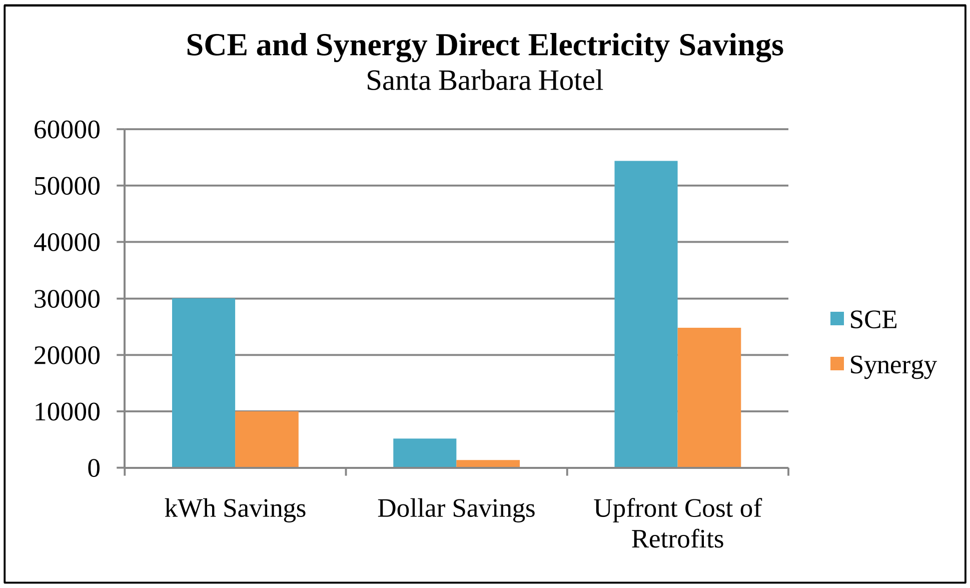

Figure 37 SCE and Synergy direct electricity savings results from retrofits at the Santa Barbara hotel.

The retrofit scenario that was economically viable and saved direct electricity at the Moreno Valley hotel was a pool retrofit. Figure 38 shows that savings from reducing the pool pumping time and replacing pool and spa lights with LEDs; and the direct electricity savings suggested by SCE for the Moreno Valley hotel. The recommended Synergy retrofit cost $3,120 and saved $ 2,240 annually. The pool retrofit adds 20% kWh savings, a small amount of electricity cost savings, and offers a payback period of 0.91 years. The payback period from the SCE recommended retrofits is 4.47 years.

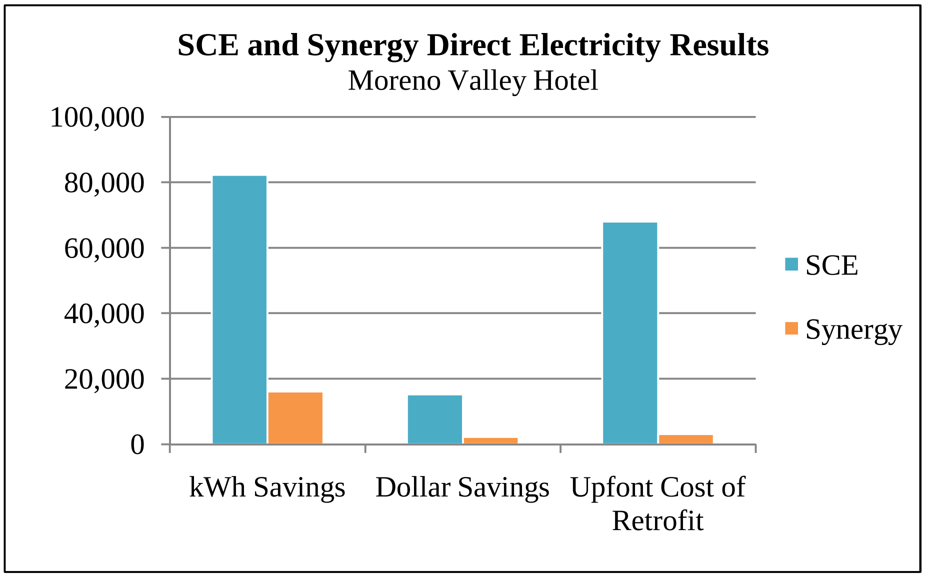

Figure 38 SCE and Synergy direct electricity results from retrofits at the Moreno Valley hotel

The retrofits scenarios for ice machines at the Santa Barbara hotel and the Moreno Valley hotel each showed about 1,000 kWh savings annually, but were not economically viable for the hotels to implement. Although SCE currently offers rebates for ice machine retrofits it would be beneficial for SCE to consider that a larger rebate could incentivize the hotel owners to install more efficient ice machine measures. SCE could then capture additional electricity savings from a technology that uses both water and energy.

Total Resource Retrofit Results and Recommendations

There is considerable potential for resource savings from audits that combine energy and water. The resource savings that we found from all of our retrofit scenarios for the Santa Barbara hotel are shown in Figure 39. The resource savings shown are the results from all economically

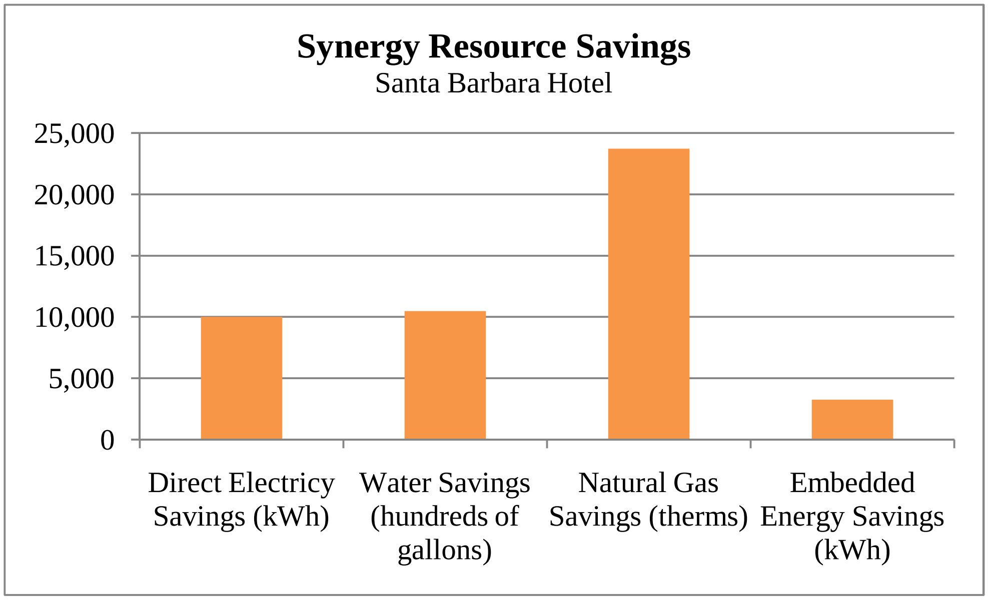

Figure 39 the total resource savings from suggested retrofits at the Santa Barbara hotel.

viable retrofits including: toilets, showerheads, faucets, washing machines, pool, and irrigation for landscaping. The most significant resource savings are for natural gas and water. Figure 40 shows the Synergy resource savings found at the Moreno Valley hotel, and further illustrates the potential for resource savings from a combined energy and water audit. The resource savings are the result of retrofits for faucets, landscaping, and a pool. Again, most of the resource savings are for natural gas and water. Embedded energy savings at the Moreno Valley hotel are over 50% higher than the embedded energy savings at the Santa Barbara hotel. Moreno Valley relies heavily on energy-intensive imported water for their water supply and each gallon of water conserved at Moreno Valley carries more embedded energy savings than at Santa Barbara or Goleta. Figure 41 shows the estimated resource savings from Synergy retrofits at the Goleta hotel.

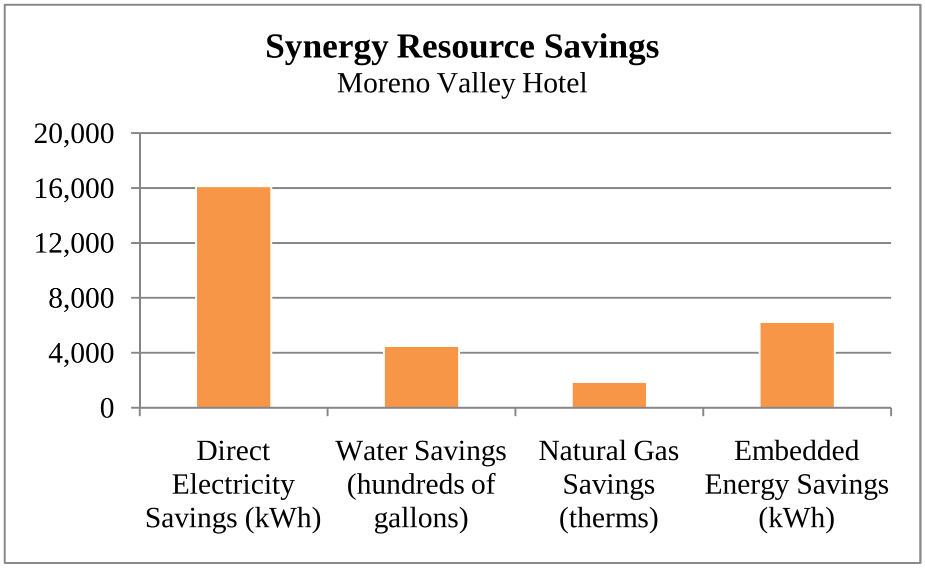

Figure 40 Total resource savings from suggested retrofits at the Moreno Valley hotel.

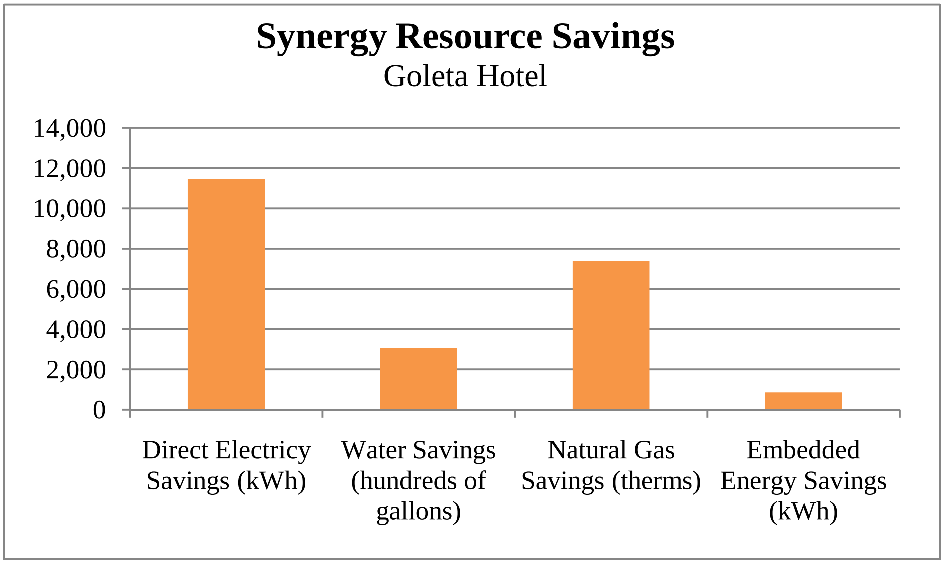

Figure 41 Estimated resource savings from Synergy retrofits at the Goleta hotel.

The retrofits recommended at the Goleta hotel include: showerheads, faucets, landscaping, and pools. The total upfront cost of all recommended retrofits is $12,400 and the total lifetime savings is $69,000. Embedded energy savings at the Goleta hotel are about 85% less than the embedded energy savings found at the Moreno Valley hotel. This is partly due to the difference in water savings found at each hotel: 446,000 gallons at the Moreno Valley hotel and 305,000 gallons at the Goleta hotel.

The total retrofit results that we found from our audit add direct electricity, natural gas, and embedded energy savings to SCE's retrofit results. Figure 42 shows the totals for direct electricity, energy savings, cost savings, and price of retrofit for SCE and all of the economically

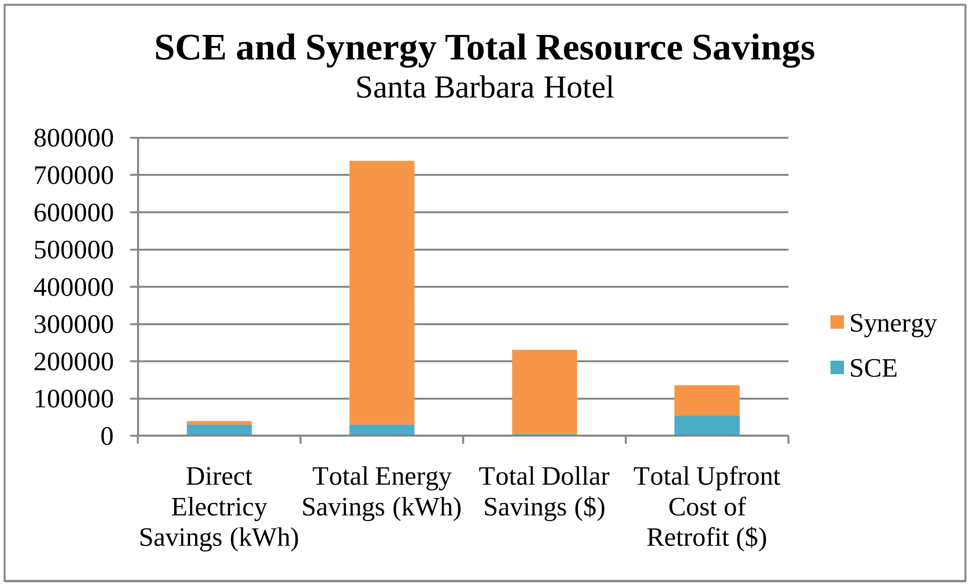

Figure 42 Synergy and SCE total energy and cost savings at the Santa Barbara Hotel

feasible retrofits we calculated at each hotel. The total energy savings bar includes direct electricity, natural gas (therms converted to kWh) and embedded energy in water. While we added only 30% to SCE's findings for direct electricity savings, the direct electricity savings that SCE currently capture is only 4% of the potential total energy savings that we calculated. SCE results for total cost savings make up 3% of the total cost savings that we found, and the retrofits that we are proposing to the Santa Barbara hotel cost only 30% more than the retrofits the SCE recommends. The total lifetime savings from the Synergy retrofit are $22,600 and the total upfront cost is $81,000.

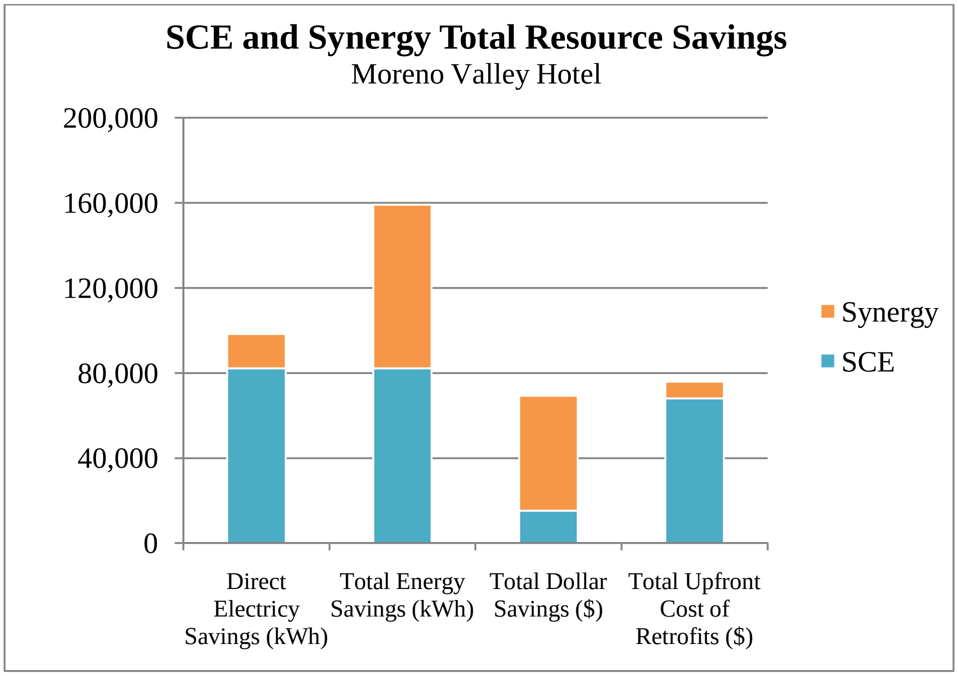

Figure 43 Synergy and SCE total energy and cost savings at the Moreno Valley Hotel

The added resource savings and cost savings results for the Moreno Valley hotel show similar results to the Santa Barbara hotel (Figure 43). The Synergy retrofits found an additional 20% direct electricity savings in comparison to the amount SCE found. The direct electricity savings from our retrofits add 93% of the total energy savings to the direct electricity savings from SCE's suggested retrofits. SCE's total cost savings are 30% of the total cost savings that Synergy found, but make up 88% of the total upfront cost for retrofits.

We also estimated GHG emissions savings from the retrofits that were suggested for each hotel (Table 33). For context, the EPA estimates that one car emits 5 metric tons of CO_2 each year (EPA, 2005). The GHG emissions savings for the Synergy retrofits at the Santa Barbara and Moreno Valley hotels is the equivalent of 32 fewer cars driving per year. The following section of this report explains the state mandates that call for electricity utilities to reduce GHG emissions. With the Synergy retrofits there could be a reduction of 160 metric tons of CO_2 equivalents each year.

Table 33 GHG emissions before and after the suggested Synergy retrofits at the Goleta, Santa Barbara, and Moreno Valley hotels

GHG Emissions from Recommended Retrofits (metric tons CO2 equivalents)			
	Goleta hotel	**Santa Barbara hotel**	**Moreno Valley hotel**
Before Retrofits	90	230	30
After Retrofits	45	100	10
GHG Emissions Savings	45	130	20

Summary

The resource savings from our combined energy and water audits are significant, especially for natural gas, water, and embedded energy. The total energy savings we calculated from the retrofits at each hotel matches or adds 70% to 80% more energy savings to the electricity savings captured by SCE's retrofits. The savings from the retrofits we recommend offer more dollar savings for the hotel and cost less than the retrofits suggested by SCE (Figures 42 and 43). Our direct electricity savings, however, only add about 3% to 20% additional energy savings that SCE could capture at each hotel. Under the current regulatory structure, the Synergy results are probably more relevant to the natural gas and water utilities than to SCE. The next section of this report explores policy changes that could allow for SCE to capture some of the resource savings opportunities that we quantified from our integrated audit. For example, policy changes that allow electricity utilities to capture GHG emission savings and savings from embedded energy in water would make our results even more relevant to SCE.

Policy Implications

Introduction

Concerted efforts by our case study hotels and other businesses to integrate energy and water conservation strategies can begin to make an impact towards lower resource use. Due to the growing effort of local, state, and federal policy makers to promote energy and water conservation, new opportunities are emerging and coordinated conservation is beginning to take shape. For many successful conservation policies, the lines between the levels of government are often blurred; many local governments have pursued efficiency and conservation programs either on their own or as a way to implement statewide policies, leveraging state and federal grants to pay for these programs. For example, the city of Santa Barbara has shown leadership toward sustainability efforts, by harnessing federal block grants for energy conservation which demonstrate progress towards meeting state goals for AB 32 and in the city general plan (Dewey, 2009). As water and energy conservation evolve, there will be important roles for all levels of government to develop effective policies that meet the specific needs of constituents.

Existing Policies

Energy and water conservation has a global reach by reducing GHG emissions but may have a greater impact locally by decreasing the need for imported energy sources. Policies at the local level, which encourage the implementation of energy and water conservation, employ local workers and can have a positive impact of job creation. As less money is spent on imported energy and water, more money can be spent on local goods and services where it will circulate throughout the community and help maintain prosperity (Allen, Hudock, & Koebel, 1985). Because of the more local nature of water resources relative to the regional and global commodities of electricity and natural gas, policies which increase water conservation have less effect on exported resource dollars but have a greater impact on local water supply security.

Local efforts to conserve water can decrease water demand and reduce the impact on limited local water supplies. With nearly all of Southern California dependant to some degree on imported water, demand reduction decreases dependency on much more expensive and energy intensive imported water supplies. As population growth is projected to increase demand, this calls for a shift toward more expensive imported water supplies, and conservation can reduce future capital investment in new water supply projects (P.H. Gleick et al., 2003) To estimate future growth and identify how water supplies will be met during normal, dry, and multiple dry years, California requires urban water districts with over 3,000 connections to submit an Urban Water Management Plans (UWMP) every five years, (California Department of Water Resources, 2010).

UWMPs can assist water districts in long term planning to prevent growth that would put water reliability in jeopardy. Since most traditional sources of water are already fully allocated in California (Burke, E. et al., 2006), alternative supplies such as reclaimed, desalted, or conservation are becoming important tools to meet future water demand. The UWMPs requires local water district’s to plan for drought which gives them the framework to understand the policies they will need to adopt to meet future needs. Local policy makers can then act to increase conservation, water recycling, and conjunctive use to better meet local needs and reduce reliance on energy intensive imported water. While some local districts have pushed conservation measures, a new law will require a minimum level of conservation from all regions of the state.

As part of California's most significant water legislation since the 1960s, SBx7 7 is one of a package of five water bills signed into law in late 2009. SBx7 7 codifies Governor Schwarzenegger's 20 x 2020 executive order, requiring California achieve a 20% reduction in per capita urban water use by 2020, with a interim goal of 10% savings by 2015 (Brandt, 2009). The state is planning a task force to develop BMPs to measure and implement water efficiency projects (Global Water Intelligence, 2009), providing guidance and flexibility for local water districts to meet the statewide target. Four options are being offered to water districts to meet the goals of the legislation, allowing for flexibility with implementation that may result in less than 20% savings. Additionally, details relating to how districts pick their base year will also affect how much conservation each district will actually have to achieve. Panel discussions at the 2010 California Water Policy Conference in Los Angeles projected that many districts will easily achieve the 20% conservation targets based on projects already performed and other mandated actions (O'Conner, Lorance, Metropulos, & Nelson, 2010); raising the question of whether this target is too conservative to truly move California towards more efficient use of water of if it would occur for many districts without additional actions. Outside of more stringent conservation targets, helping customers afford the upfront costs of investing in efficient use of water and energy may be an attractive method to encourage greater voluntary action.

Investment Barriers

Capital investment in energy and water efficiency projects is often a barrier to businesses. Projects often require significant investments up front and despite short payback periods, compete for dollars with other projects more visible to customers. While SCE's on-bill financing offers hope of alternative funding strategies for energy efficiency, water districts do not currently offer similar programs to address the initial investment in efficiency programs. Thanks to a recently passed bill in California and plans for local implementation, another solution for reducing the capital investment barrier is materializing.

The 2008 California Assembly Bill 811 authorized cities and counties to establish voluntary contractual assessment programs to reduce the upfront costs of implementing energy efficient and renewable energy projects for property owners. The California legislature declared that AB 811 has public purpose benefits, which gives local governments the authority to finance energy efficiency programs. As an example, Santa Barbara County is using its authority to create the "Elective Municipal Program to Optimize Water Efficiency, Energy Efficiency and Renewables (emPower SBC). The emPower SBC program is designed to encourage energy efficiency and thereby reduce GHG gas emissions, promote energy independence, and stimulate economic opportunities. Santa Barbara County recognizes the nexus between energy and water and includes incentives to implement water conservation measures through this program. EmPower SBC is a voluntary program that only applies to property owners that fully consent to the process. The financing will be returned to emPower SBC through semi-annual tax on the property tax bill. This program may be critical in providing customers the means to invest in energy and water efficiency outside of a traditional loan or mortgage refinancing.

Future Policies

In order to cost effectively increase water and energy efficiency, many policies could be enacted to improve how customers, utilities, and regulators address technologies and behaviors that affect consumption.

We discussed tiered and decoupled pricing in section 1, and for water utilities, neither is required. While some discretion for local conditions should remain for each water provider, tiered pricing of municipal water with a minimum percent increase for each tier should be enacted by the legislature to help meet California's conservation goals. Tiered pricing sends an economic signal to customers which offer a straightforward method to meet California's water conservation goal. While fully decoupled water rates, similar to IOUs, may not be realistic, mandatory tiered pricing can produce a strong incentive to reduce waste and encourage steps to implement energy and water efficient technologies and behaviors. While price matters, customers will also need continued assistance in knowing how to react to tiered prices in an effective way.

Policy makers should continue to appropriate money for education and demonstrations which show conservation in practice. While technology improvements will increase efficiency potential, education is essential to maximizing savings from implemented technologies, as well as by reducing wasteful behaviors. Through focused outreach to broad customer classes such as hotels, information such as BMPs specific to the customer can be provided about retrofits and how to get the most out of existing technologies. With many technologies in the commercial sector needing informed management to implement, utilities should find a balance between incentives for efficient technology and education to ensure its proper use.

Our data shows that when some conservation strategies are analyzed in an integrated way, considerable savings opportunities can be realized. However, these savings may be spread across multiple utilities, or embedded upstream or downstream of the end use, making it difficult to quantify actual savings in a rate hearing before the CPUC. Because of the challenge in verifying indirect savings, SCE has yet to count water-related electricity or other integrated water savings toward their efficiency portfolio. A regulatory approach is needed that recognizes the more diffuse savings of water and energy conservation may be cost effective and helps meet the ambitious targets for GHG and water conservation. When utilities and regulators can understand and quantify the relationship between water and energy, we may realize the value of implementing an integrated approach to conservation which best meet the goals of end users, utilities, and the planet.

Exposing Customers to Efficiency

Hotels stand as a unique opportunity for demonstration of efficient design and technologies. Customers from all walks of life can be exposed to new technologies and inform them of the value of behavioral adaptations when staying at hotels utilizing efficiency measures. When implemented and presented, these measures can help educate guests to realize alternatives exist and in fact don't change the functions or quality of their experience. Exposure to alternatives can prompt thinking about making a change (Figure 44) and hotels have an opportunity to help demonstrate this. Increasing incentives specifically for hotels to promote exposure to efficiency measures and education can provide additional indirect improvements with hands on interaction and displays. As a sector with technologies that cross the traditional residential and commercial boundaries, hotels offer the unique ability to show guests that investing in water and energy efficient technologies doesn’t change our standard of living, but can change our utility bills.

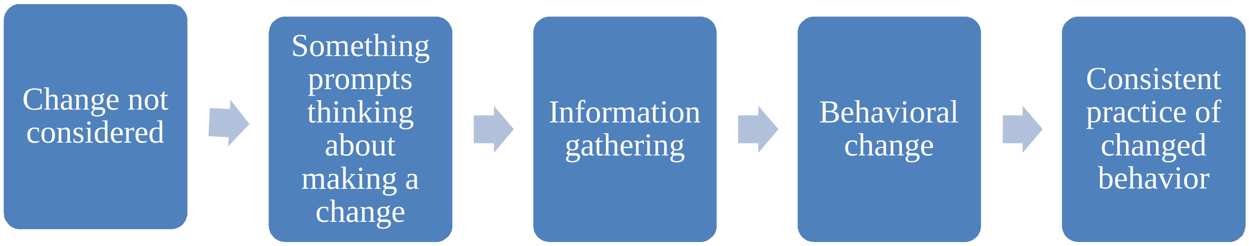

Figure 44 Sequence of contemplation leading to behavioral change

Policies that support an improved partnership model between utilities and select hotels offers the chance to create a highly visible and hands on laboratory for implementation and education. Needing regulatory approval, programs that provide increased subsidies to selected hotels to implement a suite of efficient retrofits offer obvious value to hotels in up front and monthly cost savings. In return, the hotel provides the template to demonstrate technologies as well as a venue for exposing the public to these technologies and approaches to efficiency. The ability for utilities to inform the constant stream of hotel guests of energy and water efficient technologies may be what is needed for a more widespread understanding of these technologies so technological and behavioral changes can occur. Regulatory agencies and utilities alike should forge a balanced approach between programs that reward integrated resource planning, provide incentives for efficient technology, increase rates to encourage efficiency, and educate ratepayers.

Rebates and Retrofit Scenarios

Hotels specialize in creating an environment that caters to the needs of travelers by providing customers with the essentials and amenities that make them feel at home. The often-times convoluted world of energy and water efficient retrofits are not within the hotel’s area of expertise and may fall low on their list of priorities unless particular expertise can be brought in to advise, assist, and find ways to save the hotel money. When proven technologies and behavioral changes, assistance, and calculated savings can be presented to hotels, the opportunity to reduce resource costs may outweigh the initial cost of investing in a particular suite of changes. Often times, there is a disconnect somewhere within this chain, resulting in no change to the status quo.

Rebates from utilities are carefully calculated to incentive an end user to decide to purchase a particular devise that is designed to have lower long term costs than the initial cost and conventional devise would have over its lifetime. Rebates provide savings to the consumer which lowers the cost of a particular item, help marketing efforts for new technologies, reduce market risk for manufacturers to create innovative products, and support new to the market technologies that have not yet reached the economy of scale necessary to survive (Gibbs & Townend, 2000).

Rebates can be confusing, take considerable time and effort to complete application forms, and in the case of retrofits for water and energy efficient products, may require applying for rebates through multiple utilities. To ensure rebated items produce the highest savings possible, hotel staff must be trained with new technologies to ensure proper use. By coupling rebates with sufficient education from utilities for implementation, businesses can reduce risks associated with integrating new technologies and realize the savings that are advertised.

Given scenarios where rebates for utilities are coordinated, end users may become aware of rebates they did not know existed, or realize that combined rebates allow investments to break through the return on investment barrier that often prevents implementation of new technology. Some technologies however may still incur too great an initial investment to justify, even when savings can be expected over the product lifetime. A role then exists for removing or lowering the barrier to initial investment through low interest loans or creative financing directly through the utility. An example is a pilot program that began in 2006 at SCE, which provided a zero interest on-bill financing option for a group of small commercial customers for select lighting and refrigeration retrofits (Southern California Edison, 2006).

For instance, electricity consumption by ice machines was revealed to be considerable for all three of our case studies. However, the initial capital investment that is necessary to upgrade to an energy efficient ice machine was prohibitively high to justify replacement of conventional units. In scenarios such as these where water, natural gas, or electricity savings potential are high, utilities should cooperate to offer joint rebates that may cover the difference between initial cost and lifetime savings.

Collaboration with Water and Gas Utilities

While we argue for the integration of water and energy efficient strategies, integration could take many forms. While a consolidation of utilities into one resource provider is not the likely answer, there remain many opportunities for utilities to share resources, information, and labor to improve upon the implementation of energy and water conservation. One approach might result from the CPUC requiring gas and electric utilities to work closer together to meet state energy conservation goals. Utilities and customers could benefit from coordinating rebate submissions through either agency when rebates are available from both utilities. The practical effect of this approach would be some time savings for end users and possibly for utilities as well through consolidated rebate applications and processing. While gas, electric, and private water utilities are regulated by the CPUC, public water agencies do not fall under this or other common jurisdictions, making integration of water more difficult to achieve. Barring some legislative act that brings public water agencies under a common regulatory umbrella of other energy and private water utilities such as the CPUC, hurdles will likely remain in gathering a numerous and diverse group of public water agencies to voluntarily integrate rebates and consumer education programs with energy utilities.

With CPUC direction and funding, existing programs that bring energy utility staff to end users to perform energy audits could theoretically expand to include assessment of more technologies in addition to what is currently examined. If SCE staff performs an audit at a hotel, besides looking for electricity saving opportunities, they could also perform assessments of opportunities for natural gas or water conserving measures. While utility staff would not be expected to be an expert in these other fields, auditors could follow standard methods developed by the appropriate utility to identify obvious opportunities that would be otherwise missed. This more comprehensive audit would assist the customer in identifying overlooked opportunities for savings and provide information regarding rebates through the appropriate utility. The integration of audits could allow utilities to better assist customers, recognize additional cost effective conservation, and depending on CPUC policies, be reimbursed for their shared efforts.

The connections between water and energy are not in doubt, however utility and customer views of what efficiency projects are most cost effective may be incorrect. As the energy-water connections become clearer to policy makers and regulators, and efficiency programs develop, there will be a better understanding of not just the direct savings that are possible, but how indirect water and energy savings occur. By quantifying the combination of these savings and identifying ways to assign the savings to specific utilities, the true savings of some technologies will become more apparent. Actions by the CPUC could then direct utilities to increase incentives for that show the greatest sum of savings. Achieving larger savings then benefits the utilities bottom line and society's effort to meet energy reduction and water conservation targets.

To understand these issues of combined direct energy needs for technologies and energy embedded in water, a greater amount of information sharing will need to occur to better understand these relationships. A statewide compilation of electricity and natural gas use data from water and wastewater providers relating to water sources, pumping, and treatment could begin to provide managers with the data to model these relationships and the large role energy plays within the water cycle. Models that also incorporate end user water and energy data could identify the best retrofits or regions to target for efficiency, improve program planning, and meet regulatory goals with more cost effective methods.

Relevance to the Commercial Sector

Hotels and the greater Accommodations sector are only one class within the larger commercial sector. However, their continued growth and importance to the Southern California economy and sector wide ranking as one of the highest users of electricity, natural gas, and water highlights the importance of this customer class (Bureau of Reclamation, 2009). Furthermore, hotels offer perhaps the broadest range of technologies within any one commercial class, and also overlap with technologies in the residential sector. Our narrow focus on hotels produces a wide spectrum of efficiency opportunities that can provide guidance to managers not only within the Accommodations sector, but for similar technologies within other sectors.

Because many of the technologies we address are ancillary to the function and day-to-day operation of the hotels, we hope this information can assist management in understanding the value of addressing efficiency to reduce monthly utility bills and improve the hotel bottom line. Additionally, we hope this report provides justification for utilities to seek expanded incentives and improve assistance programs within this sector so customers can realize the significant savings opportunities outlined here. Lastly, we hope our data prompts regulatory agencies to continue both research into the water energy nexus and approval of funding which increases the integration of utility programs to benefit the broader commercial sector.

Synergy Project Significance

There are an estimated 8,084 separate electricity accounts for accommodations businesses in southern California. On average, each account consumes 270 MWh of electricity every year for an estimated annual total of 2,184,600 MWh when summed over the Accommodations sector.

Total natural gas consumption for the Accommodations sector in southern California is estimated to be 69,332,300 therms. Moreover, each accommodations account is estimated to consume 3,391,430 gallons of water annually (Bureau of Reclamation, 2009).

While cost effective water, natural gas, and electricity savings were found for all three hotels in our case study, extrapolating estimated savings out to an entire business sector remains a difficult and uncertain undertaking. Estimated resource savings for our hotels were highly variable: natural gas savings ranged from 2,400 therms to 23,720 therms, electricity savings ranged from 10,000 kWh to 16,120 kWh, and water savings ranged from 305,800 gallons to 1,047,500 gallons. Furthermore, estimated electricity savings from SCE's conventional energy audit ranged from zero kWh to over 82,000 kWh.

Using the lowest resource savings we encountered as a conservative approximation for the average direct end-use savings potential for hotels, we estimate there is potential to save 19 million therms of natural gas, 2.4 billion gallons of water, and 93 million kWh of electricity across the 8,084 accommodations accounts in southern California. These savings represent a 27% decrease in natural gas consumption, 9% decrease in water consumption, and 4% decrease in electricity consumption across the entire Southern California accommodations sector (Bureau of Reclamation, 2009).

Recommendations for Further Study

Our report makes an important stride toward finding actual water and energy savings possible in our case study hotels. This data helps place macro-studies of energy and water potential savings, such as the WEEP report and the Pacific Institute Report, into context.

However there is much more that can be done in order to provide a stronger basis for coordinated utility policies that capture synergistic savings in the hotel sector. A study employing data loggers and flow trace analysis to capture exact water consumption by end use over a year at hotels would be invaluable in verifying the assumptions made in our conceptual model of hotel water use. This level of specificity, across a larger sample size of hotels, is also likely needed for CPUC in order to determine the average energy and water usage data at hotels. CPUC could then proceed to establish rebates for energy and water intensive uses at hotels such as pool pumps, pool lights, and ice machines that currently don't exist for the commercial sector.

A study with similar methodology but larger sample size would help SCE determine average water and energy uses in hotels in their service territory. Finding the market saturation of efficient appliances such as aerators, low-flow showerheads, ozone laundry treatment, and pool covers can help more rigorously analyze savings potential across the Southern California region. This data could provide a strong case for petitioning CPUC to include embedded energy into the IOUs portfolio of energy efficiency credits for greenhouse gas reductions. For water districts motivated to conserve water, this information could help determine what end uses to focus on for commercial sector rebates.

Our experience has also shown that coordinated utility management could provide beneficial opportunities for businesses, utilities and the environment. Interaction with the various water, electricity, and natural gas utilities during the course of this investigation revealed interest in the connection between energy and water, but also lack of institutional resources or capability to integrate connections into utility procedures. Utilities would also benefit from an in-depth study of current policy and legal avenues through which coordinated utility management can be pursued and the savings presented in this report achieved. Modeling policy changes and expected savings in a thorough fashion would assist IOUs then make the case to the CPUC and their shareholders how considering both energy and water can help their bottom line.

Integrated Energy and Water Conservation Strategies

The fact that we found so much combined energy and water resource savings potential in our three case study hotels shows that efficient utility management in California – the state that has put more resources into energy and water conservation than any other – still has lots of opportunity in the arena of energy and water conservation.

The good news is the fact that these opportunities are out there means there is still lots of potential for meeting our energy reduction targets for AB32 and water reduction targets for SBx7 x7. Our analysis has shown that not only is there potential, but that much of it is already reasonably cost effective for the hotels – often without rebates. For synergistic conservation strategies that offer large combined resource savings but at too high of a cost to the hotel; we have highlighted the need to develop rebate policy in order to incentivize hotels to take advantage of these energy and water reductions.

The bad news is that our case study hotels have not already implemented the energy and water reduction strategies that are already cost effective for them to do so. This indicates that many of the barriers discussed in Part 1 of this report, namely lack of awareness and capital, are preventing businesses from saving water, energy, and money through the behavioral and technological changes identified in this report. Especially the fact that synergistic reduction strategies which reduce simultaneous energy and water use – such as pool covers, efficient showerheads, and faucet aerators – have no current rebates available to our case study hotels is revealing. Utility agencies, whether they are water, electricity, or natural gas should be working together to increase awareness and incentives for these strategies; however instead it appears that the combined resource savings are being ignored through each agencies' focus on their own managed resource.

At the utility level, it is apparent energy and water are still viewed as different resources to be managed separately. It was our experience working on this study that water agencies knew their energy costs for transport and treatment of water for their operational budgets, but often did not readily know the actual amount of electricity and natural gas used in the districts' water cycle – revealing the existing institutional gap in considering embedded energy. As our analysis shows, the current commercial energy audit performed by Southern California Edison misses several large water-related electricity uses, such as commercial pool pumps and lights, as well as ice machines, which offer a large potential for electricity efficiency gains.

We hope that our analysis of combined resource savings highlights the potential that an coordinated utility management perspective can bring to California. While it is hard to predict the future of utility resource management, the one we envision would contain the regulatory environment allowing electricity utilities such as Southern California Edison to promote water conservation in order to receive credit for the energy embedded in the water – especially in areas of Southern California such as Moreno Valley where transport accounts for a disproportionately large amount of embedded energy. We also envision natural gas and water agencies collaborating together to make their customers aware of the water end uses which provide direct energy savings, and offering rebates for these uses. While “integrated utility management” is a phrase employed commonly lately at the California and federal government levels, often without official definition, these examples encapsulate what we would define coordinated utility management to be.

While a gas company offering a rebate for a pool cover or low-flow showerhead may sound odd to some readers, or an electricity company promoting drip irrigation in a place where lots of energy is used to transport water, the benefits go far beyond the combined energy and water savings. It is precisely this societal awareness of the connections between water and energy that will yield the large-scale savings necessary to achieve California’s energy and water policy goals, and mitigate the inclement effects of climate change – which represents a much higher cost to society than the capital, political, and logistical price of integrated utility management.

Appendix A: Synergy Pre-Audit Questionnaire and Guidance Documents

Synergy Project

Hotel Pre-Assessment Questionnaire

Hotel Name

Hotel Address

Synergy Project

Bren School of Environmental Science & Management, UC Santa Barbara

synergy@bren.ucsb.edu

Participants:

Name, Facililty/Property Manager, Hotel

Names, graduate student, Bren

Audit Date

This pre-audit questionnaire is a tool to obtain basic information regarding baseline water and energy use. This background information will assist the assessors in planning and conducting integrated energy and water audits and should be completed and returned prior to the site visit.

Dear [participant],

The goal of our project is to assess the potential of employing water efficiency measures in order to save both water and energy. In many areas, a high amount of energy is needed to both deliver water and treat wastewater – costs which can be avoided through quantifiable water reduction strategies.

Your participation will allow us to evaluate your facility's potential for water conservation, and the combined energy savings that could be achieved with the potential reductions. During the assessment we will gather data on water use in several key sectors:

Landscaping & pool use, guest room and hotel fixture use, restaurant use (if applicable), heating and cooling, and laundry facilities. Most of the data we will look for is type of water-using appliance, and best estimate of use.

Our team greatly appreciates your willingness to participate in our study, and at any time should you have questions please don't hesitate to contact us at synergy@bren.ucsb.edu or through one of the following phone numbers below.

Jasmine Showers

Randy Turner

Gabriel Sampson

Sarah Nichols

Isaac Pearlman

Thanks again for your participation, and we look forward to working with you directly during the assessment.

Sincerely,

Synergy Team

2. **Facility Manager Interview**

Age of building/Year of Construction: ____
Is this property owned or leased: ____

Square footage of facility: ____

Number of employees: ____

Hours of Operation: ____

Full occupancy: ____

Electricity Utility: *Southern California Edison*____________________________

Water Utility: ____

Natural Gas Utility: ____

Sewerage Utility: ____

1. Do you have water, energy, sewage, and natural gas metering data from the past five years, or permission to collect information directly from the utilities?

   ____

   ____

2. Do you have data on occupancy and other use (events, etc.) for the last two years?

   ____

   ____

3. Does the facility receive water from any other sources (e.g. surface/ground water withdrawals)?

   ____

   ____

4. In regards to your sewage and discharge data, does your facility dispose of any wastewater on site (including treating and reusing for irrigation, or disposal via septic systems), or use any pre-treatment of water before disposal to sewer?

   ____

   ____

5. Since this building was first completed have there been actual and/or planned renovations/reconstruction?

   ____

   ____

6. Does the facility use renewable energy on-site such as solar, wind power, or fuel cells?

   ____

   ____

7. Has the facility participated in any regional or local water or energy efficiency programs? If so, which ones and why.

8. Have there been any significant increases or decreases in water and/or energy use over the past two years? If yes, please explain.

9. Does this location experience any significant seasonal water and/or energy use trends? If yes, please explain.

10. Do you know of any particular areas in which water and energy use could be reduced? If yes, please explain.

Food Service: List of appliance targets

1. High pressure, low use pre-rinse spray valve [30%-60% water savings potential] (Consortium for Energy Efficiency, 2005b)
2. Ovens
    a. Range oven
    b. Deck oven
    c. Convection oven
    d. Rack oven
    e. Combination oven/steamer
    f. Cook and hold oven
    g. Conveyor oven
    h. Rotisserie
3. Steamers [90% water saving potential, 30%-50% electricity potential] (Consortium for Energy Efficiency, 2005b)
    a. Pressureless steamer
        i. Gas
        ii. Electric
        iii. Direct steam
    b. Pressure steamer
        i. Gas
        ii. Electric
        iii. Direct steam
4. Water heater at proper temperature? (120-140^{o}F)
5. Ice machine [20%-40% water saving potential, 15%-30% electricity] (Consortium for Energy Efficiency, 2005b)
    a. Flake ice
    b. Air cooled
    c. Water cooled
    d. Timer to shift ice production to nighttime off peak hours
6. Dishwashers [30%-50% water saving potential, 30%-50% electricity] (Consortium for Energy Efficiency, 2005b)
    a. Fill and dump
    b. Under the counter
    c. Turn off internal tank heater at night.
    d. Check rinse pressure (around 20psi).
    e. Maintain wash curtains.
    f. Conveyors in auto mode.
7. Insulation around hot water system?
    a. Water heater
    b. Hot water piping
8. Automatic flue damper above burners (blocks heat from escaping up flue)?
9. Recirculation pumps on hot water system? Deactivate at night

Spray valve present? ______________________________

Low water use or high water use? ______________________________

Oven type, brand, model 1: ______________________________

____

Oven type, brand, model 2: ______________________________

____

Oven type, brand, model 3: ______________________________

____

Steamer: Pressurized or Pressureless (circle one)

Gas, electric, or direct steam (circle one)

Water heater temperature? ______________________________

Ice machine type? ______________________________
Flake ice: Yes No

Air cooled or water cooled (circle one)

Dishwasher brand and model: ______________________________

____

Turn of tank heater at night: Yes No

Rinse pressure (psi)? ______________________________

Wash curtains maintained? ____________ Appearance? ______________________________

Conveyors in automatic mode? ______________________________

Automatic flue damper above burners? ______________________________

Hot water systems

Recirculation pumps on hot water system? Yes No

Deactivated at night? Yes No

Water heater insulated? Yes No

Hot water piping insulated? Yes No

Domestic Fixtures

Appliance Checklist:	Area	Rated GPM/F	Tested GPM/F	Type/Model	Total # in facility	Use per day
Toilets						
Urinals						
Faucets						
		Average:				

Other water appliances in guest rooms:	Type	Model/Series #	Total # in facility	Use per day

Notes:

Laundry Service Guidance Document

Is all laundry done on site? If not, where and how often?

Number of clothes washers in facility?

Year of Installation?

Make/Model (s)

Typical usage:

Is there a log of cycles completed by day?

Minimum cycles on slow day?

Maximum cycles on busy day?

Timing of washes?

Adjustments made:

Minimum load size?

Wash mode; Tank fill level; Speed settings; Water Temperature?

Guest Laundry:

Make/Model?

Estimated Cycles per day?

Other information:

Other Water Appliances: Model/Series, Total Units, Use per day

Steam Service:

Faucets:

Notes:

Landscape Audit Protocol- Controller

Date: ______________ Page ____ of _____

Controller Make: ______ Hotel: ______

Controller Model: ______ Notekeeper: ______

Current Time: ______ Days on (circle) M T W Th F Sa Su

Controller Time: ______ Multiple start times? ______

Controller mode when opened: ______ Controller left in same mode? ______

Set to water budget feature? ______ If water budget, what is the % setting? ______

Zone	Minutes On	Start Time(s)	Zone Description	Irrigation Type 1	Notes

Hotel: ______ Date: ______ Page ___ of ____

Notekeeper: ______ Dedicated Landscape Meter?________

Meter Make/Model_ Size?_____ Unit of Measure?

Is meter spinning on arrival?_________(if yes, leak or need to turn something off)

Irrigation Zone	Initial meter read	Second meter read	Elapsed Time (min.)	Estimated Water Use (CF/Min)	Notes
Notes:					

Pool Assessment:

Note both pool and spa (hot tub) heater efficiency, BTU/hr

What are the dimensions of your pools and hot tubs (including average depth)?

Pool:

Hot tub:

What temperature do you keep the pool? The hot tub?

Pool:

Hot tub:

What are the hours of operation of your pool and hot tub?

Pool:

Hot tub:

Are there times of the year when you leave the pool off? If yes, when and for how long?

Do you have a pool cover? If so, how often is it used?

How often is your pool emptied and refilled?

How often is your hot tub emptied and refilled?

What is the intake flow rate of your pool and spa pumps?

Pool:

Hot tub:

What is the size (horsepower) of your spa pump?

Do your pool and hot tub pumps have timers, or do they just constantly run during the pool/spa hours of operation?

Pool:

Hot tub:

How many lights are there in the pool and spa, and what is their wattage and run time?

Appendix B: Food Service

Previous studies have identified priority retrofit targets and management practices for reducing either energy or water consumption in commercial food service establishments and served as important references for this project (San Francisco Department of Public Health, 2009); (Efficiency Partnership, 2006); (Karas et al., 2005); (North Carolina Division of Pollution Prevention and Environmental Assistance, 2009). For our hotel audits, eight appliance targets and behavioral aspects should be considered when auditing a full service kitchen:

Pre-rinse spray valves;
Steamers;
Water heaters;
Ice machines;
Dish washers;
Hot water system insulation;
Automatic flue dampers above burners;
Recirculation pumps on the hot water system

To corroborate the scope of our inspection, prior research by the Consortium for Energy Efficiency (2005), summarized in Table 34, has revealed the following water and electricity savings potential when upgrading outdated conventional appliances:

Table 34 Potential water and electricity savings for selected food service fixtures

Appliance	Water Saving Potential	Electricity Saving Potential
Pre-rinse spray valves	30%-60%	N/A
Steamers	90%	30%-50%
Ice Machines	20%-40%	15%-50%
Dish Washers	30%-50%	30%-50%

Source: (Consortium for Energy Efficiency, 2005b)

Qualitative inspections should record water heater temperature, hot water system insulation and recirculation pumps, appliance maintenance, and automatic flue dampers. For fully functional kitchens, it should be determined whether the water heater is being kept at the proper temperature (commonly 120-140 degrees Fahrenheit), that hot water piping is effectively insulated, that recirculation pumps are deactivated during non-business hours, and that automatic flue dampers are in proper working condition. In addition, basic appliance characteristics are helpful in determining operating efficiency and should be taken into consideration. For instance, when inspecting dishwashers, inspectors should check whether the tank heater is turned off during non-business hours, rinse pressure settings, appearance of the wash curtains, and whether the conveyors are in manufacturer recommended settings.

Pre-rinse spray valves, steamers, ice machines, and dish washers should undergo quantitative inspection to determine water and electricity saving potential. In the case of pre-rinse spray valves, if make and model data are not apparent, then water flow should be calculated by holding a container or graduated water flow measurement bag under the spray nozzle for five seconds and measuring the quantity of water in the container. Multiplying by 20 would then provide water flow in gallons/minute. If appliance make and model data were available, then one should compute electricity and water use savings by comparing manufacturer provided data on water and electricity consumption per use to a targeted efficient upgrade[5]. Extrapolation out to annual water, natural gas, and electricity consumption between the conventional and efficient appliance would reveal any savings potential and the associated payback period from upgrades.

Data Analysis

The analysis for food services was both qualitative and quantitative. Qualitative aspects focused on management practices and did not attempt to capture numerical savings to water, natural gas, or electricity. For instance, maintaining sound installation on the hot water piping and tank system prevents energy loss that takes place through heat transfer. Similarly, deactivating the recirculation pumps on the hot water system at night or during non-business hours can save electricity or natural gas costs. Additionally, keeping the dishwashers in the automatic conveyor mode recommended by the manufacturer optimizes resource use for each wash cycle.

Qualitative analyses also focused on pre-rinse spray valves. The main objective was to ascertain whether hotel kitchen services were employing the use of water efficient sprayers. Yet, the only pre-rinse spray valve encountered during our inspection was at the Moreno Valley hotel. Flow rate calculation revealed the spray valve to operate at 1.6 gpm, which is within the bounds of conventional high efficiency sprayers (North Carolina Division of Pollution Prevention and Environmental Assistance, 2009).

Quantitative analyses were designed such that numerical approximations of water, electricity, and natural gas use could be assigned to each relevant food service end use. Specifically, quantitative analyses were conducted on food service ice machines and dish washers. Calculations for ice machines first require manufacturer information on the gallons of water used per 100 pounds of ice production, electricity used per 100 pounds of ice generation, and ice harvest rate in 100’s of pounds per day. From there, assumptions on average use and operational capacity must be made to approximate monthly or annual resource use. Our analysis assumed ice machines operated at 75% of capacity annually on average (Pacific Gas and Electric Company, 2006). Annual ice machine water consumption (in gallons) was computed using:

$$0.75 \times Harvest\_rate \times (gallons/100lbs) \times days \times units,$$

where *harvest_rate* is the daily maximum production of ice in 100s of pounds, *days* is the number of days used per year, and *units* is the number of units of the chosen model at the facility. Annual ice machine electricity consumption was found by multiplying the manufacturer provided kWh specification by the harvest rate and summing over 365 days of use:

$$0.75 \times Harvest\_rate \times (kWh/100lbs) \times days.$$

---

[5] **We differentiate between manufacturer provided data for domestic fixtures and food service appliance here. During our audit, it was possible to directly measure domestic fixture water consumption per use. For food service appliances, direct measurements were not feasible, so reliance on manufacturer data was used.**

Water, electricity, and natural gas use were determined for dishwashers in a method very similar to the one used for ice machines,

$$(gallons/rack/unit)\times(cycles/day)\times racks\times(use/week)\times 52,$$

where *racks* represent the number of racks in the washer and *use/week* is the number of uses per week averaged over the year. Annual dishwasher electricity consumption was found by multiplying the kW rating of the machine by the estimated number of operating hours per year:

$$idle\times(wash\_time/60)\times racks\times(days\_used/year),$$

where *idle* represents the electricity consumption when the machine doors are closed and *wash_time* represents the minutes required to wash one rack. The *idle* function was provided by the manufacturer for the machines studies in our analysis. Annual dishwasher natural gas consumption was computed using the following function:

$$therms\times(gallons\_hot\_water/use)\times racks\times(use/week)\times 52,$$

where *therms* is the natural gas required to heat one gallon of water to washing temperature (*W*) from 55 degrees Fahrenheit,

$$\frac{[8.34Btu\times(W^{0}F-55^{0}F)]}{100{,}000Btu/therm}.$$

Results: Goleta Hotel

Table 35 summarizes the estimated annual water and electricity consumption of the existing ice machines at the Goleta hotel. Table 36 summarizes the water, electricity, and natural gas consumption of the existing dish washer. The Goleta hotel's currently installed ice machines and dish washer already surpass efficiency standards so savings from retrofits are not available.

Table 35 Estimated annual water and electricity consumption for currently installed ice machines compared to CEE Tier III retrofit ice machines at the Goleta hotel.

Ice Machine Model	Quantity	Estimated Water Consumption/Year (gallons) * Quantity	Total Estimated Electricity Consumption/Year (kWh) * Quantity
Scotsman 1030SA-32A	1	42,311	11,498
Manitowoc SD0322A	3	36,956	14,167
Total Current Use	**4**	**79,267**	**25,664**
CEE Tier III Retrofit Use	4	87,053	25,894
Savings	**-**	**-7,785**	**-230**

Table 36 Estimated annual water, natural gas, and electricity consumption for currently installed dish washers compared to Energy Star retrofit dish washers at the Goleta hotel.

Dish Washer Model	Quantity	Estimated Water Consumption/Year (gallons)	Total Estimated Electricity Consumption/Year (kWh)	Total Estimated Gas Consumption/Year (therms)
Hobart Lxi	1	17,123	278	136
Energy Star Retrofit Use	1	37,128	273	294
Savings	**-**	**-20,005**	**5**	**-159**

Santa Barbara Hotel

Table 37 summarizes the estimated annual water and electricity consumption of the Santa Barbara hotel’s currently installed ice machines as well as estimated retrofit savings. While ice machine retrofits are estimated to save both water and electricity, the initial investment is too costly to provide a feasible payback.

Table 37 Estimated annual water and electricity consumption for currently installed ice machines compared to CEE Tier III retrofit ice machines at the Santa Barbara hotel.

Ice Machine Model	Quantity	Estimated Water Consumption/Year (gallons) * Quantity	Total Estimated Electricity Consumption/Year (kWh) * Quantity
Hoshizaki KM-630MAE	2	67,069	15,587
CEE Tier III Retrofit Use	2	53,655	14,487
Savings	**-**	**13,414**	**1,100**

Moreno Valley Hotel

Tables 38 and 39 summarize the estimated annual resource use for ice machines and dish washer at the Moreno Valley hotel, respectively. Both ice machine and dish washer retrofits were estimated to save water and energy. However, the initial costs of upgrades were prohibitively high. Refer to Appendix H for a more detailed description.

Table 38 Estimated annual water and electricity consumption for currently installed ice machines compared to CEE Tier III retrofit ice machines at the Moreno Valley hotel.

Ice Machine Model	Quantity	Estimated Water Consumption/Year (gallons) * Quantity	Total Estimated Electricity Consumption/Year (kWh) * Quantity
Manitowoc QD0322A	2	33,124	9,516
CEE Tier III Retrofit Use	2	24,090	8,569
Savings	**-**	**9,034**	**947**

Table 39 Estimated annual water, natural gas, and electricity consumption for currently installed dish washers compared to Energy Star retrofit ice machines.

Dish Washer Model	Quantity	Estimated Water Consumption/Year (gallons)	Total Estimated Electricity Consumption/Year (kWh)	Total Estimated Gas Consumption/Year (therms)
CMA B2	1	24,752	672	175
Energy Star Retrofit Use	1	13,832	365	98
Savings	**-**	**10,920**	**307**	**77**

Appendix C: Pools & Spas

Typically, the largest water use from pools and hot tubs is water loss due to evaporation, “splash out” from users, backwashing in the filter, and leaks (East Bay Municipal District, 2008). This decrease in water level is offset by periodic refilling in order to maintain topped out pools and hot tubs, and can possibly be as much as 30 to 80 inches of the pool’s surface area per year (East Bay Municipal District, 2008). Reducing this water loss offers hotels significant savings opportunities – between 33 and 50 percent in “make-up” water use according to Senevirante 2007, as cited in (Bureau of Reclamation, 2009). Controlling evaporative loss also provides the combined benefit of reducing energy use by as much as 70 percent for heating pools and hot tubs. Pool and spa circulation pumps and lights offer electricity-saving opportunities as well.

At each case study hotel, we recorded pool and spa pump and heater brands, make and model numbers, pump wattage and amperage, and heater BTU/hr rating. Interviews with hotel staff provided operational information for the pools and spas such as daily and seasonal running periods, refill rate, and physical characteristics such as pool and spa dimensions (see Appendix A for pool and spa auditing form).

Data Analysis Methods

Measuring actual water loss in order to assess actual savings at our case study hotels is difficult, since estimates of evaporative water loss rate from swimming pools vary. The Association of Pool and Spa Professionals claim that evaporative loss rate from pools can be as much as 5 to 10 inches per month during the dry California summer (East Bay Municipal District, 2008). The Marin Municipal Water District states that a 648 square foot pool will lose one inch of water per week in the summer (Marin Municipal Water District, 2010). According to the East Bay Municipal District, a long front-runner in urban water conservation, a pool can lose from 30-80 inches of water annually, or 18.7 to 50 gallons per square foot of pool surface area. According to the pool contractor responsible for refilling the pools at the Goleta case study hotel, the pool is refilled one inch per week.

In order to compare the validity of these estimates for our case study hotels, calculations of water loss from a single hypothetical pool in Santa Barbara was made using all of the above evaporative loss rates and then compared to actual measurements of evaporation in the region (See Tables 40 and 41).

Table 40: Comparison of Pool Evaporative Loss Methods

Santa Barbara Hotel	Surface Area (sq. ft)	Minimum Annual Water volume lost (gallons)	Maximum Annual Water volume lost (gallons)	Evaporative loss rate	Source
Pool	1275	36,281.4		1 inch per week at 648 sq foot pool in summer*	Marin Municipal Water District
		41,329.9		1 inch per week	Hotel Pool Contractor
		22,254.5	44,509.1	5-10 inches per month in summer*	Association of Pool and Spa Professionals
		23,842.5	63,750.0	30-80 inches annually, or 18.7 to 50 gallons per square foot of surface area per year	East Bay Municipal District

***Winter evaporative loss rate is assumed to be 1/5 the summer loss rate.**

Since evaporation varies through the year and is markedly higher in the hot, dry summer months; our analysis relies upon measured monthly evapotranspiration data from the California Department of Water Resources, which were then averaged over three years for our analysis (Table 41).

Table 41: Actual Evapotranspiration Measurements

Month	Santa Barbara/ Goleta 2007-2009 Average (inches)	UC Riverside 2007-2009 Average (inches)
Jan	2.15	2.76
Feb	2.25	2.54
Mar	3.98	4.98
Apr	4.87	5.55
May	4.88	6.36
Jun	5.25	6.71
Jul	5.69	7.57
Aug	4.44	7.00
Sep	3.82	5.71
Oct	3.92	4.59
Nov	2.44	3.04
Dec	1.83	2.07
Total	**45.50**	**58.88**

Source: (California Department of Water Resources, 2009)

Knowing the monthly evaporation average and the pool's surface area allows us to calculate the average monthly water loss from the pools and spas due to evaporation:

$$Pool\_Evaporative\_Water\_Loss = Pool\_Surface\_Area \times Evaporation\_Rate$$

This equation yields loss in square feet-inches; which subsequently can be converted into acre-feet and then gallons using the conversion 1 square foot equals $2.296*10^{-5}$ acres and 1 acre-foot equals 325,851.43 gallons. See Tables 42 and 43-44 below for hotel pool and spa square footage and monthly evaporative water loss.

Table 42: Hotel Pool and Spa Surface Areas

Hotel	Type	Surface Area (sq. ft)
Santa Barbara	West Pool	634
	East Pool	704
	West Spa	70
	East Spa	110
Moreno Valley	Spa	78.5
	Pool	799.5
Goleta	Pool	375
	Spa	30

This equation can be used to find the total annual evaporative water loss from pools and spas at each hotel over the year, as shown in below.

Table 43: Annual water loss from Santa Barbara Hotel pools and spas

	Evaporation Rate	Santa Barbara Hotel Pool and Spa Water Use (gallons)					
Month	**Santa Barbara 2007 – 2009 Average (inches)**	**West Pool Loss**	**East Pool Loss**	**West Spa Loss**	**East Spa Loss**	**Spa Refill Water**	**Total Pools & Spas Water Use**
Jan	2.15	848	942	94	147	-	2,031
Feb	2.25	887	985	98	154	540	2,664
Mar	3.98	1,572	1,747	174	273	-	3,765
Apr	4.87	1,923	2,137	212	334	540	5,146
May	4.88	1,926	2,140	213	334	-	4,614
Jun	5.25	2,073	2,303	229	360	540	5,505
Jul	5.69	2,249	2,499	248	390	-	5,386
Aug	4.44	1,753	1,948	194	304	540	4,739
Sep	3.82	1,509	1,677	167	262	-	3,615
Oct	3.92	1,548	1,720	171	269	540	4,247
Nov	2.44	963	1,070	106	167	-	2,307
Dec	1.83	721	801	80	125	540	2,267
Total	**45.50**	**17,971**	**19,968**	**1,985**	**3,120**	**3,240**	**46,285**

Table 44: Annual water loss from Goleta Hotel pool and spa

	Evaporation Rate	Goleta Hotel Pool & Spa Water Use (gallons)			
Month	**2007 - 2009 Goleta Average (inches)**	**Pool Evaporative Loss**	**Spa Evaporative Loss**	**Spa Refill Water**	**Total Pools & Spas Water Use**
Jan	2.15	502	40	1,106	1,647
Feb	2.25	525	41	1,106	1,672
Mar	3.98	930	73	1,106	2,110
Apr	4.87	1,138	90	1,106	2,334
May	4.88	1,140	90	1,106	2,336
Jun	5.25	1,227	97	1,106	2,430
Jul	5.69	1,331	105	1,106	2,542
Aug	4.44	1,038	82	1,106	2,225
Sep	3.82	893	70	1,106	2,070
Oct	3.92	916	72	1,106	2,094
Nov	2.44	570	45	1,106	1,721
Dec	1.83	427	34	1,106	1,566
Total	**45.50**	**10,636**	**839**	**13,272**	**24,747**

Table 45: Annual water loss from Moreno Valley hotel pool and spa

	Evaporation Rate	Moreno Valley hotel Pool & Spa Water Use (gallons)		
Month	**UC Riverside 2007-2009 Average (inches)**	**Pool Evaporative Loss**	**Spa Evaporative Loss**	**Total Pools & Spas Evaporative Loss**
Jan	2.76	1,377	135	1,512
Feb	2.54	1,268	124	1,392
Mar	4.98	2,482	244	2,726
Apr	5.55	2,768	272	3,039
May	6.36	3,168	311	3,479
Jun	6.71	3,343	328	3,671
Jul	7.57	3,771	370	4,141
Aug	7.00	3,489	343	3,831
Sep	5.71	2,844	279	3,123
Oct	4.59	2,286	224	2,510
Nov	3.04	1,517	149	1,666
Dec	2.07	1,032	101	1,133
Total	**58.88**	**29,344**	**2,881**	**32,225**

Note that in addition to water required to replace evaporative water loss, the Santa Barbara and Goleta hotel spas are periodically drained and refilled – once every other month for both the Santa Barbara Hotel spas, and twice a month for the Goleta Hotel spa. According the Moreno Valley Hotel facility manager, their spa is not drained and refilled.

While hot tubs will most likely have higher evaporation loss due to their warmer temperature, our calculations assume the same evaporation rate as pools. Given the small surface areas of the hot tubs, the difference is negligible in the overall pool loss analysis. It should also be noted that "splash out", or loss of water due to water spilled out of the pool during recreation, apparently hasn't been quantified or estimated in a study – most likely due to its highly variable nature and dependence on human behavior regarding pool use. However, several institutions consider the water loss due to splash out to be significant, perhaps as large as evaporation loss (East Bay Municipal District, 2008); (Alliance for Water Efficiency, 2010). In addition, backwashing the filter to clean it is a significant water use as well. Since our analysis does not factor water loss due to splash out, our calculation of water loss from pools and hot tubs is considered to be very conservative: most likely actual pool and hot tub water losses at our case study hotels will be greater than our calculated figures.

Calculating Pool and Spa Energy Use

In addition to needing water to replace that which is lost due to refilling, evaporation and splash out; the pools and hot tubs at our case study hotels also require electricity to run their circulation pumps and lights, and natural gas to heat the water.

We can use the following equation to calculate the electricity use of pool and spa pumps:

$$Pump\_horsepower \times 0.746 kW / horsepower \times run\_time = kWh\_electricity$$

The hours of operation for the pump are usually determined by a programmed timer, which pool managers set to the desired run times. Pool and spa pump run times at our case study hotels varied from 12 hours at the Goleta hotel to 16 and 17 hours at the Santa Barbara hotel and Moreno Valley hotel respectively.

Note that hot tubs sometimes have multiple pumps – one to drive the circulation, and the others to run the massaging jets. This was the case at two hotels, and we assumed their jet pump only ran on average 1 hour a day during the year.

Pool and spa lights are another source of electricity use, and are set to run on a similar timer as the pumps during the night operational hours of the pool. These hours ranged from 4 hours at the Moreno Valley and Santa Barbara hotels to 12 hours at the Goleta hotel, for 365 days during the year.

The electricity used by these lights is a simple function of the light wattage multiplied by the run time of the lights:

$$Light\_wattage \times run\_time / 1000 = kWh\_electricity$$

See Table 46 below for total annual pool and spa electricity use:

Table 46 Annual Pool & Spa Electricity Use at Santa Barbara Hotel

Santa Barbara Hotel Pool & Spa Electricity Use (kWh)					
West Pool	East Pool	West Spa	East Spa	Pools/Spas Lights	Total Pools & Spas Electricity Use (kWh)
6,535	**3,267**	**4,858**	**4,858**	**584**	**20,102**

Table 47 Annual Pool & Spa Electricity Use at Moreno Valley Hotel

Moreno Valley Pool & Spa Electricity Use (kWh)			
Pool	Spa	Pool & Spa Lights	Total Pools & Spas Electricity Use (kWh)
12,035	**9,258**	**1,898**	**23,191**

Table 48 Annual Pool & Spa Electricity Use at Goleta Hotel

Goleta Hotel Pool & Spa Electricity Use (kWh)			
Pool Pump	Spa Pumps	Pool & Spa Lights	Total Pools & Spas Electricity Use (kWh)
8,495	**5,990**	**3,942**	**18,428**

The pools and hot tubs at our case study hotels use natural gas for heating. Most pool and spa heaters are set to a desired temperature and then cycle on and off in order to maintain the programmed temperature. Finding the natural gas used to heat the pools and hot tubs requires calculating the complex interaction between the initial pool temperature, the desired temperature increase, combustion rate of the heater, heat loss from evaporation, the ambient temperature of the air, wind speed, and the pool's volume.

Our analysis took all these variables into account by calculating the natural gas needed to heat up the pool or spa to its programmed temperature when it is first turned on, as well as the natural gas required to replace the heat lost from the water surface area.

The pool and spa heating related natural gas use depends upon the initial temperature, which was assumed to be equal to the average monthly temperature of the area, the final programmed pool or spa temperature (obtained from hotel staff), the volume in gallons of the pool or spa (width, length, and depth were provided by staff or measured during our audit and then converted from cubic feet to gallons), and the energy needed to raise 1 gallon of water 1 degree Fahrenheit (or 8.34 BTUs per gallon):

$$water\_volume \times (final\_temp - initial\_temp) \times 8.34 = BTUs\_Energy$$

Calculating the natural gas needed to replace the heat loss from the pool or spa surface – or in the case of the hot summer months, the heat gain from the higher temperature ambient air transfer to the pool – is a function of the temperature difference, water surface area, hours of operation, and a “surface heat loss factor” capturing wind effect:

$$surface\_area \times (final\_temp - initial\_temp) \times operating\_time \times loss\_factor = BTUs\_Energy$$

While the surface heat loss factor multiplier varies depending upon shelter and average wind speed, our analysis assumes the low end of the loss factor range for a sheltered pool with an average wind velocity of 2-5 miles per hour (Engineering Toolbox, 2005).

These two energy values were then summed for the total heating output required for each pool and spa. However since all heaters waste a certain percentage of heat due to inefficiency (relating to their rated efficiency), this sum was multiplied by the percent inefficiency of the heater in order to calculate the total heat input needed. Table 49 and 50 below show the calculated natural gas use for heating for the Goleta hotel pool (which is heated to 80 degrees) and the annual natural gas use for our case study pools and spas:

Table 49 Monthly Pool & Spa Natural Gas Use at Goleta hotel

	Goleta Hotel Pool Natural Gas Use (79% efficient heater)							
Month	Average Ambient Temp (F)	Pool Daily Start Up Heat Load Needed (BTUs)	Monthly Pool Start Up Heat Load Needed (BTUs)	Pool Surface Heat Loss (BTU/hr)	Daily Surface Heat Loss (BTUs)	Monthly Pool Surface Heat Loss (BTUs)	Total BTU Output Needed	Total BTUs Input Including Waste Heat Loss
Jan	53	2,842,532	88,118,490	40,500	486,000	15,066,000	103,184,490	124,853,233
Feb	55	2,631,974	73,695,273	37,500	450,000	12,600,000	86,295,273	104,417,280
Mar	57	2,421,416	75,063,899	34,500	414,000	12,834,000	87,897,899	106,356,458
Apr	59	2,210,858	66,325,745	31,500	378,000	11,340,000	77,665,745	93,975,552
May	61	2,000,300	62,009,308	28,500	342,000	10,602,000	72,611,308	87,859,683
Jun	64	1,684,463	50,533,901	24,000	288,000	8,640,000	59,173,901	71,600,421
Jul	67	1,368,626	42,427,421	19,500	234,000	7,254,000	49,681,421	60,114,520
Aug	69	1,158,069	35,900,126	16,500	198,000	6,138,000	42,038,126	50,866,132
Sep	67	1,368,626	41,058,795	19,500	234,000	7,020,000	48,078,795	58,175,342
Oct	64	1,684,463	52,218,365	24,000	288,000	8,928,000	61,146,365	73,987,101
Nov	58	2,316,137	69,484,114	33,000	396,000	11,880,000	81,364,114	98,450,578
Dec	53	2,842,532	88,118,490	40,500	486,000	15,066,000	103,184,490	124,853,233

Average Temperature Source: (“National and Local Weather Forecast, Hurricane, Radar and Report,” 2010)

Table 50 Annual Pool & Spa Electricity Use at Case Study Hotels

	Type	Surface Area (sq. ft)	Temperature (Fahrenheit)	Current Annual Natural Gas Use (therms)
Santa Barbara	West Pool	634	80°F	20,430
	East Pool	704	80°F	7,750
	West Spa	70	103°F	1,104
	East Spa	110	103°F	1,735
			TOTAL:	**31,019**
Moreno Valley	Spa	78.5	104°F	3,296
	Pool	799.5	65°F	0
			TOTAL:	**3,296**
Goleta	Pool	375	80°F	10,555
	Spa	30	104°F	1,156
		TOTAL:	**11,711**	

Note that the Santa Barbara hotel east pool heating needs is significantly lower due to the fact that the staff shuts off the pool in the winter; and the Moreno Valley hotel pool is not heated at all during the year. 100,000 BTUs equals 1 therm of natural gas.

Table 51 summarizes the total water, natural gas, and electricity used by our case study pools and spas:

Table 51 Annual Pool & Spa Energy and Water Use

	Type	Surface Area (sq. ft)	Current Annual Water Use (gallons)	Current Annual Electricity Use (kWh)	Current Annual Natural Gas Use (therms)
Santa Barbara Hotel	West Pool	634	1,985	6,535	20,430
	East Pool	704	3,120	3,267	7,750
	West Spa	70	1,985	545	1,104
	East Spa	110	3,120	545	1,735
		TOTAL:	**10,211**	**19,518**	**31,019**
Moreno Valley Hotel	Spa	78.5	2,881	9,258	3,296
	Pool	799.5	29,344	12,035	0
		TOTAL:	**32,225**	**21,293**	**3,296**
Goleta Hotel	Pool	375	10,636	8,495	10,555
	Spa	30	14,111	5,990	1,156
		TOTAL:	**24,747**	**14,485**	**11,711**

Pool and Spa Energy and Water Savings

Pools and spas are significant users of water, electricity, and natural gas and therefore have a high potential for combined resource savings. However, while a wealth of information exists on how to save large amounts of energy and water in pools, the large majority of the information is targeted towards residential pool owners. While much of the information is applicable to hotels, it appears as if there is no specific rebate or information portal existing for the commercial sector to promote pool and spa energy and water savings that can drastically reduce utility bills. The only rebate found for Southern California Edison was $200 off for installation of a variable speed pump – however it is only applicable for residential customers (Southern California Edison, 2010d).

Our savings analysis focused on 6 overall individual strategies for increasing pool and spa efficiency – all of which either reduce electricity use by the pump and lights, lower natural gas use for heating, or minimize water loss.

Being that actual energy and water savings will depend upon variable factors such as climate (for solar pool heating system output), frequency of pool activity (for pool cover use); it must be emphasized that several of these predicted energy and water savings are relative estimates. Where possible, more exact savings were calculated using current pool and spa equipment specifications and use, however by nature actual savings will depend upon other factors outside of this analysis. Some calculations rely upon average savings reported in other sources. However in these instances the lowest end of the savings range is used in order to maintain conservatism in reporting total resource savings.

Reducing Pool Electricity Use

One of the easiest ways to save pool and spa energy costs is to efficiently operate the existing pumps. According to the DOE, most pool pumps operate much longer than necessary. A study of 120 pools in Florida found that pool owners could reduce their electricity costs by an average of 40 percent when they reduced the filtration time (United States Department of Energy, 2009d).

Knowing the volume of the pool, the pump’s horsepower, and the operation time we can find the turns per day using a specialized calculator. This calculator also provides the operation hours required to cycle the pool’s volume once per day – which is recommended by the Association of Pool and Spa Professionals (Pentair Water Pool and Spa, 2008). In every case the recommended run time was less than the hotel pools’ current run times, and in several cases significantly less. The new recommended run time was then used in the equation listed above to calculate pump electricity use and the electricity savings equaled the difference between the two values.

Variable speed pumps, which usually double the pump running time but cycles the pool water much more slowly (akin to a car driving slower in order to use less gasoline), can decrease the electricity cost from 30 to 50 percent (Southern California Edison, 2010d; Pentair Water Pool and Spa, 2008). In order to determine potential savings, we conservatively assumed electricity savings of 30 percent reducing in pump electricity use.

Pool and spa lights at our case study hotels ranged between 50 and 500 watts. Replacing the higher wattage lights with lower energy halogen or LED pool lights can reduce light electricity use without compromising brightness. To calculate the electricity savings from switching to LED pool lights, our analysis used the same calculation used to find current light electricity usage (see previous) with the 70 watts used by a leading pool LED model (Pentair Water Pool and Spa, 2010).

Reducing Pool Heating Energy

Purchasing a more efficient pool heater can reduce the natural gas needed to heat the pool. Pool and spa heaters have a certain efficiency ratings, and the Energy Policy and Conservation Act of 1990 requires that all new heaters have at least a 78 percent efficiency rating (United States Department of Energy, Lawrence Berkeley National Laboratory, 2009). This means that for every 100 therms put into the heater, 78 of those therms are actually used to heat the pool; while the rest are lost due to inefficiency. Heaters today exist with up to a 95 percent efficiency rating – offering significant energy savings and reduced pool and spa heating costs (United States Department of Energy, 2009b). Calculating the natural gas reduction from installation of a more efficient heater is relatively straight-forward. Knowing the current heater efficiency, we simply multiplied the current natural gas use by the efficiency gain. For example, upgrading a 79 percent efficient pool heater to a 95 percent efficient heater would result in a 16 percent savings in natural gas use.

Solar pool heating systems can provide between 700 and 1000 BTUs of energy per square foot per day; depending upon local conditions. In general, pools require an array of solar panels equivalent to their pool's surface area to cover their heating needs (United States Department of Energy, 2009c). But in the case of a hotel, it is unlikely that the facility will solely rely upon a solar heating system due to their need to provide swimming recreation at night. However a solar heating system can still provide large reductions in natural gas needed to heat pools and spas. Precisely determining the energy savings from installing a solar pool heating systems is difficult as it will vary by system, location, and operation. In order to determine heating energy savings we therefore took the average energy output advertised by the DOE, and then assumed that energy output would replace heat energy from burning natural gas to warm the pool. We assumed the hotel would purchase a solar system equal to the surface area of the pool, as recommended by experts.

Reducing Pool Water Use and Heating Energy

By far the best efficiency gain comes from using a pool and spa cover. Covers not only reduce the water loss due to evaporation, but also the heat loss from the surface of the pool. Effective use of a pool cover can reduce evaporative loss by 30 to 50 percent; and heat energy loss by 50 to 70 percent (United States Department of Energy, 2009a). Accurately calculating the savings would require knowing frequency of cover use, which would depend of course on maintenance staff protocols, occupancy, and other variables. So instead our analysis simply assumes average water and energy savings cited by the DOE: 30 percent in water and 50 percent in energy. Again, in the interest of conservatism, we used the lower estimate of savings potential when calculating both water and energy saved from use of pool covers.

Table 52 shows all possible water and energy savings across all hotels from all pool and spa retrofits (values based on annual use reported in Table 51 above). Note that some efficiency efforts preclude others – for instance it would not make sense to reduce pumping time and then install a variable speed pump. Therefore savings cannot be summed across all strategies. However, some conservation strategies complement each other: for instance use of pool cover combined with reduced pumping time; and either a more efficient heater or solar heating system could greatly reduced water evaporative loss, pump electricity use, and natural gas heating requirements. See Part 3 for the specific recommended retrofits and savings from our case study hotels reducing their pool and spa water and energy use. Also, see Appendix G for a detailed methodology of calculating the costs associated with implementing these retrofits.

Table 52 Case Study Pool & Spa Energy and Water Savings Potential

			Pool Cover		**Efficient Pump Operation (reduced time)**	**Variable Speed Pump**	**95% efficient heater**	**Solar Heater**	**LED pool & spa lights**
		Surface Area (Sq. ft)	Annual Water Savings (Gallons)	Annual Natural Gas Savings (therms)	Annual Electricity Savings (kWh)	Annual Electricity Savings (kWh)	Annual Natural Gas Savings (therms)	Annual Natural Gas Savings (therms)	Annual Electricity Savings (kWh)
Santa Barbara Hotel	West Pool	634	5,391	10,215	2,573	2,026	3,473	1,619	117
	East Pool	704	5,990	3,875	1,675	1,046	1,318	1,799	15
	West Spa	70	974	552	2,210	185	155	-	0
	East Spa	110	1,530	867	2,210	185	243	-	0
		TOTALS	**13,885**	**15,509**	**8,669**	**3,443**	**5,188**	**3,418**	**131**
Moreno Valley Hotel	Spa	78.5	864	1,648	6,317	-	363	-	336
	Pool	799.5	8,803	0	8,212	2,909	0	2,043	1,256
		TOTALS	**9,667**	**1,648**	**14,529**	**2,909**	**363**	**2,043**	**1,591**
Goleta Hotel	Pool	375	3,191	5,278	7,009	3,337	1,689	958	2,015
	Spa	30	4,233	578	4,448	-	185	-	1,007
		TOTALS	**7,424**	**5,856**	**11,457**	**3,337**	**1,874**	**958**	**3,022**

Appendix D: Laundry

Determining Cycle Frequency

It is assumed that the occupancy of the hotel has a positive linear relationship with how frequent the washing machines cycle throughout the day. The occupancy rates were presented as the average percentage of rooms sold by month, over at least the past two years. Using the monthly data we were given, we averaged the percentages for each month to estimate the monthly occupancy over a typical year (Table 53). For simplicity, it was assumed that each day of the month had the same average monthly occupancy rate.

Table 53 Average monthly occupancy rates for the Goleta, Santa Barbara, and Moreno Valley hotels

Average monthly occupancy rates as % of rooms sold			
Month	GOLETA HOTEL: 98 Rooms	SANTA BARBARA HOTEL:150 Rooms	MORENO VALLEY HOTEL: 120 Rooms
January	63.76	51.24	37.94
February	75.65	59.05	54.06
March	79.27	67.66	39.76
April	85.84	75.74	39.97
May	85.22	75.18	41.10
June	82.61	79.36	47.00
July	90.13	93.10	42.98
August	84.50	94.83	41.16
September	84.29	84.71	37.49
October	86.03	76.15	42.50
November	70.65	60.24	42.39
December	50.50	50.99	32.71

For each machine at the hotels, we used a simple slope-intercept method to estimate the linear relationship between the cycles per day and the occupancy.

$$Y = Slope * X + Y\ intercept, Where\ Y = the \frac{cycles}{day}, and\ X = the\ \%\ occupancy\ rate.$$

Table 54 below outlines the minimum and maximum cycle and occupancy rate for each hotel, and provides the function used to determine the daily, monthly, and annual cycle frequency.

Table 54 Washing machine cycle frequency for the Goleta, Santa Barbara, and Moreno Valley hotels

Cycle frequency as a function of occupancy rate							
	GOLETA HOTEL		SANTA BARBARA HOTEL			MORENO VALLEY HOTEL	
	Occupancy Rate(X)	Cycles(Y)	Occupancy Rate(X)	60lb Washer Cycles (Y)	100 lb Washer Cycles (Y)	Occupancy Rate(X)	Cycles(Y)
Minimum	0.50	6.00	0.51	10.00	5.00	0.33	6.00
Maximum	0.90	10.00	0.95	25.00	12.00	0.54	10.00
Difference	0.40	4.00	0.44	15.00	7.00	0.21	4.00
Slope	10.09		34.22		15.97	18.73	
Y-Intercept	0.90		-7.45		-3.14	-0.13	
FUNCTIONS:	Y= 10.09*X+ 0.90		(60 lb washer)Y= 34.22*X-7.45			Y= 18.73*X-0.13	
			(100 lb washer)Y= 15.97*X-3.14				

Determining the Energy and Water Use

The manufacturer operating manuals for each washing machine reported the dry-weight capacity, G-force, direct electricity and all water used during a typical cycle. For comparison’s sake, it is helpful to know the dry-weight capacity of the machines to assess the difference in the washer specifications. The G-Force of a washing machine determines how much residual moisture is left in the linens after washing, and can play a substantial role in drying time. Furthermore, a lower G-force can be an indication of an older, less expensive machine. Since there are many wash settings for each washer, it is difficult to determine the exact water and electricity used during each cycle. Therefore, a typical water and electricity requirement figure was used for the analysis. Additionally, natural gas is directly consumed by washing machines through hot water, so to estimate the gas used per month we assumed:

$$(Cycles/month)\times(gallons/cycle)\times(\%hot\_water)\times(therms),$$

where *therms* is the natural gas required to heat one gallon of water to washing temperature (*W*) from 55 degrees Fahrenheit:

$$\frac{[8.34Btu\times(W^{0}F-55^{0}F)]}{100{,}000Btu/therm}$$

Table 55 Washing machine specifications for the Goleta, Santa Barbara, and Moreno Valley hotels.

Relevant Washer Specifications: All Hotels								
Hotel	**Washer Model; Quantity**	**Capacity (lbs)**	**Max G-Force**	**Direct Electricity/Cycle (kWh)**	**Gas/ Cycle (therms)**	**Hot water/cycle (gal)**	**Cold water/cycle (gal)**	**Total water/cycle (gal)**
Goleta Hotel	Huebsch HX55PVX; 2	55	418	0.75	0.40	57	26	83
Santa Barbara Hotel	Unimac UW60PV; 2	60	300	0.74	0.43	61	29	90
Santa Barbara Hotel	Unimac UW100PV; 1	100	300	0.82	0.75	106	47	153
Moreno Valley Hotel	Unimac UW60B; 2	60	98	0.48	0.43	61	29	90

Current Estimated Water and Energy Use by Hotel Washing Machines

This analysis tailors the occupancy rate and washing cycle relationship to each respective hotel for an accurate estimate of water used during a typical year. With this monthly and yearly water usage data, it will be clear to see what percentage of total energy and water purchased is used for laundry by comparing it yearly hotel utility bills. Through those calculations one can also determine how much the laundry costs each hotel, and also the associated embedded electricity needed to pump and treat the water consumed by the on-premise laundry equipment. Additionally, financially beneficial suggestions can be made to the hotel, if equipment retrofit or behavioral change comparisons prove to save money and resources in the long run. Tables 56-58 summarize monthly cycles, electricity, natural gas, and water use for clothes washing at the three hotels.

Table 56 Summary of monthly laundry use for the Goleta hotel

Goleta Hotel	Cycles/ month	Direct Electricity/ Month (kWh)	Gas/ month (therms)	Hot water/ month (gallons)	Cold water/ month (gallons)	Total water/ month (gallons)
January	227.51	170.63	91.94	12,967.99	5,915.22	18,883.21
February	239.09	179.32	96.62	13,628.22	6,216.38	19,844.60
March	276.02	207.01	111.55	15,733.12	7,176.51	22,909.63
April	287.01	215.26	115.99	16,359.56	7,462.26	23,821.82
May	294.65	220.99	119.08	16,795.19	7,660.97	24,456.16
June	277.23	207.92	112.04	15,802.07	7,207.96	23,010.04
July	310.00	232.50	125.28	17,670.00	8,060.00	25,730.00
August	292.39	219.29	118.16	16,666.19	7,602.12	24,268.31
September	282.32	211.74	114.09	16,092.32	7,340.36	23,432.68
October	297.20	222.90	120.11	16,940.25	7,727.13	24,667.38
November	241.03	180.77	97.41	13,738.68	6,266.77	20,005.45
December	186.00	139.50	75.17	10,602.00	4,836.00	15,438.00
Annual Results	**Total Cycles**	**Total Direct Electricity**	**Total Gas**	**Total Hot Water**	**Total Cold Water**	**Total Water**
	3,210.45	**2,407.84**	**1,297.44**	**182,995.61**	**83,471.68**	**266,467.29**

Table 57 Summary of monthly laundry use for the Santa Barbara hotel.

Santa Barbara Hotel	Loads/ month (60 lb washers)	Loads/month (100 lb washer)	Direct Electricity/ month (kWh)	Gas/ month (therms)	Hot water/ month (gallons)	Cold water/ month (gallons)	Total water/ month (gallons)
January	310.00	155.00	356.50	250.56	35,340.00	16,275.00	51,615.00
February	357.17	176.01	408.63	230.59	40,444.16	18,630.27	59,074.43
March	486.77	237.49	554.95	210.52	54,867.27	25,278.52	80,145.79
April	553.98	268.53	630.14	239.59	62,256.85	28,686.29	90,943.15
May	566.47	274.69	644.44	244.99	63,671.93	29,338.12	93,010.05
June	591.15	285.87	671.86	255.67	66,362.18	30,579.15	96,941.33
July	756.65	363.44	857.94	327.24	84,679.66	39,024.25	123,703.91
August	775.00	372.00	878.54	335.18	86,707.00	39,959.00	126,666.00
September	646.07	311.50	733.52	279.42	72,429.45	33,376.61	105,806.06
October	576.80	279.51	656.03	249.46	64,812.55	29,864.03	94,676.58
November	394.83	194.25	451.46	170.76	44,675.01	20,579.76	65,254.77
December	310.00	155.00	356.50	134.07	35,340.00	16,275.00	51,615.00
Annual Results	**Total Cycles**	**Total Cycles**	**Total Direct Electricity**	**Total Gas**	**Total Hot Water**	**Total Cold Water**	**Total Water**
	6,324.89	**3,073.28**	**7,200.51**	**2,928.06**	**711,586.07**	**327,866.01**	**1,039,452.08**

Table 58 Summary of monthly laundry use for the Moreno Valley hotel.

Moreno Valley Hotel	Loads/ month	Direct Electricity/ month (kWh)	Gas/ month (therms)	Hot water/ month (gallons)	Cold water/ month (gallons)	Total water/ month (gallons)
January	216.39	103.87	93.59	13,199.81	6,275.32	19,475.12
February	280.00	134.40	121.10	17,080.00	8,120.00	25,200.00
March	226.96	108.94	98.16	13,844.51	6,581.81	20,426.32
April	220.82	105.99	95.50	13,469.90	6,403.72	19,873.62
May	234.74	112.68	101.52	14,319.17	6,807.48	21,126.65
June	260.32	124.96	112.59	15,879.81	7,549.42	23,429.22
July	245.66	117.92	106.24	14,985.13	7,124.08	22,109.20
August	235.06	112.83	101.66	14,338.66	6,816.74	21,155.39
September	206.85	99.29	89.46	12,618.03	5,998.74	18,616.77
October	242.87	116.58	105.04	14,815.10	7,043.24	21,858.34
November	234.40	112.51	101.38	14,298.34	6,797.57	21,095.91
December	186.00	89.28	80.44	11,346.00	5,394.00	16,740.00
Annual Results	**Total Cycles**	**Total Direct Electricity**	**Total Gas**	**Total Hot Water**	**Total Cold Water**	**Total Water**
	2,790.09	**1,339.23**	**1,206.68**	**170,194.44**	**80,912.11**	**251,106.55**

Resource Consumption Savings from Recommended Retrofits

For all hotel case studies we investigated installing an ozone laundry system to the existing machines. An ozone washing system is a wall-mounted system that hooks up directly to your existing washer through a series of efficient, ozone-resistant valves. This system can decrease the amount of hot water needed for each cycle by up to 95% because it disinfects the linens just as well or better than heating the water to 160 degrees. While ozone laundry systems can decrease gas used for hot water heating substantially, the total amount of water and energy used remain approximately the same. In addition to the decrease in gas costs, many laundries have reported the cold ozone rich water can extend the life of the linens when compared to washing them in hot water filled with bleach. Depending on the frequency of washing at a particular hotel, the payback period for an investment in an ozone washing system could be very short as the savings on gas bills can be reduced dramatically (Articlean, 2010). The annual hot water and gas savings for each hotel are summarized below in Table 59. Cycle frequency, direct electricity, and total water use remain constant, but the annual hot water and natural gas use decrease by 95%.

Table 59 Hot water and associated natural gas savings with installation of an ozone laundry system

Hot water and associated natural gas savings with an ozone laundry system							
	Total Cycles	Existing Annual Hot Water Use (gallons)	Annual Hot Water Use with Ozone System (gallons)	**Annual hot water saved with Ozone System (gallons)**	Existing Annual Gas Use (Therms)	Annual Gas Use with Ozone System (Therms)	**Annual Gas savings Ozone System (Therms)**
Goleta Hotel	3,210	182,996	9,150	**173,846**	1,297	65	**1,233**
Santa Barbara Hotel	6,325	711,586.07	35,579	**676,007**	2,928.06	146	**2,782**
Moreno Valley Hotel	2,790	170,194	8,510	**161,685**	1,207	60	**1,146**

Additional Savings at the Santa Barbara Hotel

The Santa Barbara hotel folds a third sheet into each bed, in between the quilt and the blanket. This analysis assumes that half of all washing cycles are for sheets, a third of which are the extra triple sheet. Discontinuing to “triple sheet” will result in reducing all costs associated with laundry by one-sixth. This is a conservation strategy that involves no upfront costs and instant savings. The savings on the utility bills can also be used to help offset the costs of upgrading to a more efficient washing machine or an ozone laundry system.

Table 60 Resource savings decrease by 1/6 through discontinuing to “triple sheet”

Resource Savings decrease by 1/6 through discontinuing to "triple sheet"						
	Total Cycles	Total Direct Electricity (kWh)	Total Gas (Therms)	Total Hot Water (gallons)	Total Cold Water (gallons)	Total Water (gallons)
Existing Use	9,398	7,201	2,928	711,586	327,866	1,039,452
Discontinuing to Triple Sheet	7,832	6,000	2,440	592,988	273,222	866,210
Resource Savings	**1,566**	**1,200**	**488**	**118,598**	**54,644**	**173,242**

The combined resource savings for the Santa Barbara hotel through installing an ozone laundry system and discontinuing to triple sheet are summarized below. From discontinuing to triple sheet, the cycle frequency is decreased by one-sixth, resulting in a one-sixth reduction in all resources. There is added savings from installing an ozone laundry system by further decreasing the hot water and associated natural gas use by 95%. Since total water use stays the same with an ozone laundry system, the total cold water used increases to offset the reduction in hot water use.

Table 61 Combine resource savings potential at the Santa Barbara hotel with recommended retrofits

Combined resource savings potential at Santa Barbara hotel from installing an ozone system and discontinuing to triple sheet						
	Total Cycles	Total Direct Electricity (kWh)	Total Gas (Therms)	Total Hot Water (gallons)	Total Cold Water (gallons)	Total Water (gallons)
Existing use	6,325	7,201	2,928	711,586	327,866	1,039,452
Use with retrofits	5,271	6,000	122	29,649	836,561	866,210
Resource savings	**1,054**	**1,200**	**2,806**	**681,937**	**(508,695)**	**173,242**

Appendix E: Domestic Fixtures

Introduction

Characterization of water use, and energy and water conservation potential in the “domestic and fixtures” category, which includes faucets, toilets, and showerheads, is by nature difficult as it involves highly variable human nature in addition to fixture specifications. A wide variety of literature has attempted to characterize human water use as it relates to fixtures. Beginning with the 1984 U.S. Urban and Housing Development Department Study, residential studies began using data loggers and flow trace analysis systems to accurately determine water use and resulting conservation potential from installed water efficient fixture retrofits such as low-flow showerheads, faucet aerators, and low-flush toilets. These studies provide invaluable data on human fixture use frequency in the residential sector; but unfortunately no such exact information exists in the much more variable Accommodations sector (see Table 62).

Table 62 Review of residential water end use studies

	Source:	**Methodology description:**	**Mean daily per capita indoor use (gallons):**	**Toilet flushes per capita per day:**	**Shower per capita per day:**	**Shower duration (min):**	**Faucet minutes per capita per day:**
Residential Studies	Mayer et al. 1999	Surveyed residential users and characterized per capita and end-use water data over 12 cities in North America. Used data logger on over 1000 homes and flow trace analysis	69.3	5.1	0.75	8.2	8.1
	1984 HUD study, Brown & Caldwell	Mailed retrofit kits for water saving fixtures and measured observed water use and savings	66.2	4.0	0.74	N/A	N/A
	East Bay MUD 1991	Recorded 2 week baseline data on water use in 33 residential homes, then measured use 1 month and 6 months after water saving fixtures were installed	40	3.2	N/A	N/A	N/A
	1993 Tampa Study	Recorded 2 week baseline data on water use in 26 residential homes, then measured use 1 month and 6 months after water saving fixtures were installed	50.7	3.8	0.7	N/A	N/A
	1995 Heatherwood Study	Used 1994 baseline data to measure water savings at 14 households from installation of high efficiency fixtures	58.8	N/A	N/A	N/A	N/A
	1995 Westminster pre-1977 housing	Measured water use at 20 homes built before 1977 (before implementation of stricter plumbing standards)	63.5	N/A	N/A	N/A	N/A
	1995 Westinster post-1977 housing	Measured water use at 20 homes built after 1977 (after implementation of stricter plumbing standards)	50.6	N/A	N/A	N/A	N/A
	1981 AWWA Handbook	Water conservation management guide estimated daily residential water use	N/A	5.0	0.9	N/A	N/A

Table 63 Review of commercial and hotel water end use studies

	Source:	Methodology description:	Toilet flushes per capita per day:	Shower per capita per day:	Shower duration (min):	Faucet use per day (min):
Commercial & Hotel Studies	MWD 2002 Hotel Audits	51% of hotel water end use is attributed to "restroom"	N/A	N/A	N/A	N/A
	Brown and Caldwell 1990	As cited in Pacific Institute "Waste Not, Want Not" report	4	N/A	16.2	N/A
	Pacific Institute	Used Brown and Caldwell 1990	4	N/A	N/A	N/A
		Based on three studies of office buildings in which the numbers varied from 2.0 to 3.45 toilet flushes per employee per day	2.60 (per employee)	N/A	N/A	N/A
		Shower use: assumed 16.20 minutes per occupied room (Brown and Caldwell 1990)	N/A	N/A	16.2	N/A
		Knights et al: 5.0-10.7 seconds after using toilet (using no soap versus soap)	N/A	N/A	N/A	0.083-0.1783
		0.11 minutes per toilet use (Pac. Institute assumption)	N/A	N/A	N/A	0.11
		The number of times that employees use urinals daily is the average of two estimates (Darell Rogers cited in Schultz Communications 1999 and Konen cited in A and N Technical Services, Inc. 1994).	1.25 (per male employee)	N/A	N/A	N/A
	Redlin, M. and DeRoos, J. (1990)	This study is based on the results of a questionnaire sent out in 1988 to 1600 hotels, with 408 valid responses. Median water use per room was reported at 144 gallons per day.	N/A	N/A	N/A	N/A
	Seattle Public Utilities	Reviewed literature and concluded most hotels use between 144 and 190 gallons per day per room	N/A	N/A	N/A	N/A
	Vancouver Regional District	Surveyed 26 self-selected Vancouver, B. C. area hotels. Medium was 73 gpd per room	N/A	N/A	N/A	N/A
	East Bay Municipal Utility District (EBMUD), 1994	Performed 500 telephone interviews, and on 657 on-site surveys, including 50 on-site surveys of Hotels/motels.	N/A	N/A	N/A	N/A
	Jane H. Ploeser et al, Journal AWWA, 1992	This article cites results of site visits to 7 hotels located in Phoenix (4), Denver (2), and Ventura, CA (1).	N/A	N/A	N/A	N/A
	La Quinta Inn chain Water Conservation Program	They use gallons per guest as a benchmark, with 125 gallons/guest for older properties (undefined) and 95 gallons/guest for newer properties.	N/A	N/A	N/A	N/A
	California Hotel & Lodging Association	218 gallons per day per occupied room	N/A	N/A	N/A	N/A

Previous attempts to characterize hotel water use by fixture rely upon questionnaires or total water usage to estimate water usage per guest or room. These approaches result in broad estimates of actual water conservation potential, due to uncertainty in actual to shower head, faucet, and toilet end use. In addition, this data most likely also includes hotel employees and visitors (e.g. those visiting hotel guests but not staying), whose water usage patterns vary from hotel guest usage. Several hotels studied in the Seattle Public Utilities report had sub-metered data providing an accurate assessment of just their landscaping or laundries water use; however none accurately assessed total water usage by end use.

Lacking the resources to employ data loggers and flow trace analysis, our approach relied upon previous studies characterizing fixture use and behavior and paired it with actual fixture water flow measurement in order to provide a detailed assessment of fixture water use at the case study hotels. Once water use at the fixture was accurately determined, we were able to calculate the embedded natural gas required for shower and faucet hot water production. Our reasoning for actually measuring water use instead of relying upon industry standards was that most actual use measurements provided by manufactures deviate from standard ratings, as explained well in the following quote from Mayer and DeOreo, two leaders in the field of water end-use behavior:

> “A toilet rated to flush at 3.5 gpf [gallons per flush] or 1.6 gpf will seldom use precisely that amount of water for a single flush, even when the toilet is new. Modifications to toilets such as new flapper valves, toilet dams, displacement devices, and float valve adjustments can also affect the flush volume (Webster, McDonnell, and Koeller 1998; Babcok 1999). Other studies have also found that each toilet is different, even if they are the same make and model (Honold and Ewald 1994; DeOreo et al. 1996c).” (Mayer & DeOreo, 1999, p. 97)

Data Collection Methods

Our analysis relied upon actual measured water use instead of factory ratings. In order to measure actual flow in hotel fixtures, flow meter bags were employed to determine faucet and shower head flow; while a T5 Flushmeter (http://www.t5flushmeter.com/company.html, 2010) measured toilet gallons per flush. The flow meter bags, made by Niagara Conservation (“http://niagaraconservation.com/,” 2009), are designed to measure 5 seconds of flow and have demarcations showing the flow rate in gallons per minute. Three measurements were taken for faucet and showerhead flow; and the average of those readings were used in our calculations. The T5 Flushmeter functions by inflating the bladder gasket to block the bowl outflow, and then uses a turbine meter to measure the water flow through the head during a flush. Due to time constraints, only one toilet flush measurement was taken; while dyes assisted the team in assessing if leakage occurred from toilet tank to bowl.

During the assessment, the fixtures of each room type (e.g. suite or standard room) were measured. At all three case study hotels, despite staff assurances, a visual inspection was made of several rooms of each type to ensure fixture models were similar. In addition to guest rooms, other common areas with fixtures (e.g. lobby bathrooms, kitchen food prep areas, pool area bathrooms, weight room showers, etc.) were measured using the same methodology. Interviews with the hotel facility managers and staff provided information regarding the frequency of usage of fixtures in these common areas which provided the basis for calculating current water and energy use.

Data Analysis Methodology

Since it would be nearly impossible to measure actual water use at each fixture over the course of a year, our analysis relies upon previous studies on fixture use to estimate actual guest water usage at our case study hotels. We then paired this data with hotel occupancy information. Our analysis used other studies to estimate hotel fixture water use by employees, and refined this estimate with interviews with facility managers estimating actual use.

The Pacific Institute's 2003 "Waste Not, Want Not" report is the only previous study that has attempted to characterize fixture use in hotels in order to estimate water conservation potential; and our analysis relies upon several of their assumptions. However the Pacific Institute, in attempting to estimate water usage across the entire hotel industry in California, by necessity did not distinguish between types of users as our report does. In order to assess water use more specifically, we included information gathered from our audits and assumptions from interviews with facility managers (see questionnaires in Appendix A) in order to analyze domestic and fixture use more rigorously at our three case study hotels.

Guest Fixture Usage

One of the first problems encountered in analyzing hotel guest water use is that hotels don't actually record how many guests are staying at the facility. Instead, our three case study hotels use occupancy percentage. Therefore, in order to determine the actual number of guests over the course of the year, calculations were made assuming a 1.8 person per occupied room rate during the off season, and 2.5 people per occupied room during the peak season. This assumption was corroborated by facility managers. Given the fact that our case study hotels are in the lower price range and appeal to primarily families and bargain travelers, and that according to our facility managers rooms are often filled with more than 3 people in the summer due to traveling sports teams and families visiting for college graduation; this assumption is most likely conservative. In the Pacific Institute report, based upon the Brown and Caldwell 1990 study, hotel guests are estimated to flush the toilet four times per day. However both studies made no effort to distinguish between guest room fixture use, and use of fixtures in other areas of the hotel by guests (e.g. pool area bathrooms, lobby sinks, etc.). Therefore, in order to avoiding double-counting fixture use, our analysis assumes that 25 percent of guest-related toilet flushes occur outside their room and is captured in our estimation of common area fixture use (see below).

Using our assumption of 3 toilet flushes per guest per day, and the hotel's actual occupancy rate, we can then calculate water use attributed to guest toilet use by multiplying the product by the toilet gallons per flush measured during our audit:

$$Hotel\_Monthly\_Occupancy \times 1.8 \times 3 \times measured\_toilet\_flow = Guest\_Toilet\_Water\_Use$$

"Waste Not, Want Not" assumes a rather high 16.2 minute per room shower use; failing to distinguish shower time between rooms with one guest and multiple guests. This analysis instead relies upon a 0.75 shower frequency and 8.2 minute shower duration per capita, which was equal to the average actual residential shower frequency and time in the Mayer et al. 1999 study that analyzed over 1000 homes in 12 different cities in North America.

Therefore, we can use our guest per occupied room assumption detailed above (note that in the above and below equations 1.8 guests per occupied room is used – during the peak season 2.5

guests per room is used as the multiplier) in order to calculate the amount of water used by guest showers:

$$Hotel\_Monthly\_Occupancy \times 1.8 \times 0.75 \times 8.2 \min utes \times measured\_showerhead\_flow$$
$$= Monthly\_Guest\_shower\_water\_use$$

Since faucet usage at home incorporates widely different activities relating to cooking and dish washing, our analysis instead relied upon the Pacific Institute assumption of 0.11 minutes (6 seconds) per toilet use, yielding 0.44 minutes of total faucet use per guest per day. Multiplying this by the faucet flow in gallons per minute via the equation below yields the water used in the guest faucets. Again, for the sake of conservatism, 25 percent of this faucet use is assumed to be captured in estimations of lobby, pool, weight room, and other common area bathrooms.

$$Hotel\_Monthly\_Occupancy \times 1.8 \times 3 \times 0.11\_\min utes \times measured\_faucet\_flow = Guest\_faucet\_use$$

Table 64 below details the guest water usage at the Goleta hotel rooms, for which we measured 1.8 gallons per flush toilets, 2 gallon per minute showerheads, and 2.4 gallon per minute faucets.

Table 64 Goleta hotel guest water usage per fixture

Goleta Hotel Total Monthly Guest Water Use (gallons)					
Month	**Occupancy %**	**Toilet**	**Showerhead**	**Faucets**	**Total**
Jan	63.76	18,828	42,886	2,761	64,475
Feb	75.65	20,177	45,959	2,959	69,095
Mar	79.27	23,406	53,315	3,433	80,154
Apr	85.84	34,068	77,599	4,997	116,664
May	85.22	34,951	79,611	5,126	119,689
Jun	82.61	32,786	74,679	4,809	112,274
Jul	90.13	36,963	84,193	5,421	126,578
Aug	84.50	34,655	78,936	5,083	118,673
Sep	84.29	33,453	76,199	4,906	114,559
Oct	86.03	25,405	57,867	3,726	86,998
Nov	70.65	20,190	45,987	2,961	69,138
Dec	50.50	14,911	33,964	2,187	51,061
Annual Total:		**751,195**	**48,370**	**1,129,358**	**1,928,923**

Employee Fixture Usage

There have been very few studies that have quantified employee bathroom use. Again, since the Pacific Institute report has been the only study to estimate commercial sector water use at this level of detail, our analysis follows their assumption of 2.6 bathroom uses per employee per day. This number in turn was taken from studies observing employee restroom use in three commercial office buildings (see Darell Rogers cited in Schultz Communications 1999 and Konen cited in A and N Technical Services, Inc. 1994). After each employee toilet use, Pacific Institute's assumption of 0.11 minutes per toilet use is employed in our analysis.

$$\#\_Employees \times 2.6 \times days\_per\_month \times measured\_employee\_toilet\_flow$$
$$= Employee\_Toilet\_Water\_Use$$

Since all case study hotels reported that the number of employees varied depending on the high tourist season in the summer and low season in winter; our analysis used the high number of employees given for the months of May through September, or 153 days, and the low number for October through April, or 212 days (high and low seasons were identified through interviews with facility managers). Since none of the 3 case study hotels had urinals in the employee rest rooms, no assumptions were needed to be made concerning employee urinal use.

$$\#\_Employees \times 2.6 \times 0.11\min utes \times days\_per\_month \times measured\_employee\_faucet\_flow$$
$$= Employee\_Faucet\_Water\_Use$$

See Table 65 below for the employee water usage per fixture at the Santa Barbara hotel, where the employee rest room contained 1.6 gallons per flush toilet and 3 gallons per minute faucet.

Table 65 Santa Barbara hotel employee water usage per fixture

Santa Barbara Hotel Monthly Employee Water Use (gallons)				
Month	**# Employees**	**Toilet**	**Faucets**	**Total**
Jan	65	8,382	1,441	9,823
Feb	65	7,571	1,301	8,873
Mar	65	8,382	1,441	9,823
Apr	65	8,112	1,394	9,506
May	77	9,930	1,707	11,637
Jun	77	9,610	1,652	11,261
Jul	77	9,930	1,707	11,637
Aug	77	9,930	1,707	11,637
Sep	77	9,610	1,652	11,261
Oct	65	8,382	1,441	9,823
Nov	65	8,112	1,394	9,506
Dec	65	8,382	1,441	9,823
Annual Total:		**106,334**	**18,276**	**124,610**

Other Fixture Usage

Other fixtures not captured through guest and employee analyses included disparate sources such as lobby bathrooms, employee break room faucets, kitchen food preparation areas, pool area bathrooms, and exercise bathrooms and showers. Due to highly variable use of these facilities, our analysis relied up estimates of use from interviews with hotel managers – those most aware of facility use.

For these areas, facility managers were given a range of use per area and instructed to give their best estimation of usage per week. Managers were asked to make an estimate for usage during both the slow season and high season in order to capture variability in fixture use during those times. In calculating actual usage, the low end of the manager’s estimate range was used for conservatism. Given that the difference between the low end and high end of their estimation amounted to less than 1 percent of the total fixture water usage at the hotel, it seems clear that the inherent error in guessing common area fixture use would not significantly affect our final results.

As mentioned previously, some common area facility use such as pool and lobby bathrooms are assumed to be from the guests themselves – thus the 25 percent reduction in guest room fixture use. Other uses are assumed to be from visitors of hotel guests, as well as from the conferences that all three of our case study hotels host occasionally. For common area bathrooms, the manager estimate of use is assumed to comprise 50 percent of men and 50 percent women. The analysis of the two bathrooms with urinals (the lobby men's bathroom at the Goleta Hotel and the pool men's bathroom at the Moreno Valley Hotel) assumes that half of the estimated use by men (or one-fourth of the total estimated use) is for the urinal – most likely a conservative assumption. See the equations below for our calculation of common area urinal, toilet, and faucet use:

$$Manager\_estimation\_use\_per\_day \times 0.25 \times days\_per\_month \times measured\_urinal\_flow$$
$$= Common\_Area\_Urinal\_Water\_Use$$

$$Manager\_estimation\_use\_per\_day \times days\_per\_month \times measured\_toilet\_flow$$
$$= Common\_Area\_Toilet\_Water\_Use$$

$$Manager\_estimation\_use\_per\_day \times 0.11\_\min utes \times days\_per\_month \times measured\_faucet\_flow$$
$$= Common\_Area\_Faucet\_Water\_Use$$

Table 66 below includes the calculation results for the men's bathroom at the Moreno Valley hotel pool, which had a 3.5 gallon per flush urinal, a 1.6 gallon per flush toilet, and a 2.2 gallon per minute faucet flow.

Table 66 Moreno Valley hotel pool men's bathroom water usage

Moreno Valley Hotel Monthly Pool Men's Bathroom Water Use (gallons)					
Month	**Use per day**	**Toilet**	**Urinal**	**Faucet**	**Total**
Jan	5	124	271	38	64,475
Feb	5	112	245	34	69,095
Mar	5	124	271	38	80,154
Apr	5	120	263	36	116,664
May	12.5	310	678	94	119,689
Jun	12.5	300	656	91	112,274
Jul	12.5	310	678	94	126,578
Aug	12.5	310	678	94	118,673
Sep	12.5	300	656	91	114,559
Oct	5	124	271	38	86,998
Nov	5	120	263	36	69,138
Dec	5	124	271	38	51,061
Annual Total:		**2,378**	**5,202**	**719**	**1,129,358**

The calculated water usage from hotel guests, employees, and at common areas was then combined into determining the total water usage at the hotel per fixture, which are reported in Part 3. See Table 9 for a summary of our fixture analysis assumptions.

Calculating Energy Embedded in Domestic & Fixtures Water Use

Once we had calculated fixture water use by area and frequency, we then calculated the natural gas use for heating that water (for showers and faucets) using the following equation:

$$Fixture\_water\_use \times 0.73 \times 539.5 = Fixture\_Natural\_Gas\_Use$$

It is assumed that 73 percent of the water used at faucets and showers is hot, and the energy to raise the temperature of the water from the starting temperature of 55 degrees Fahrenheit to 120 degrees Fahrenheit is 539.5 BTU's [6] (Nebraska Energy Office, Nebraska, 2010). Natural gas is normally billed in therms, where 1 therm is equal to 100,000 BTUs. See Section 3 for the total calculated therms used by fixtures at our case study hotels.

Calculating Combined Domestic Fixture Synergistic Energy and Water Savings

In order to determine savings potential in the domestic fixtures category, available rebates for water-efficient fixtures were researched from the hotel's local water agency. These agencies include the Goleta Water District and the City of Santa Barbara Public Works Department, both of which provide rebates for fixtures recognized by the California Urban Water Conservation Council (CUWCC). While these rebates are technically suspended for commercial businesses in the Santa Barbara and Goleta areas, our analysis assumes that the hotels will be able to take advantage of the rebate offered previously.

The Moreno Valley hotel purchases water supplied by the Eastern Municipal Water Agency, which as a member agency of MWD, offers fixture rebates through MWD's "Save a buck" water efficiency program. However, according to a program representative, there are currently no commercial fixture rebates available and no plans to offer any. See Table 67 for a partial list of fixtures for which our case study hotels could receive a rebate, as well as other potential efficient retrofits for which rebates aren't available but have high water savings potential. This includes mostly the lower-cost retrofits from the comprehensive lists available from the organizations offering rebates.

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[6] **Note that a BTU is defined as a unit of energy equal to the amount of heat required to raise one pound of water one degree Fahrenheit at 1 atmospheric pressure. Raising a gallon of water 1 degree Fahrenheit requires 8.3 BTUs and therefore raising 1 gallon 65 degrees requires 539.5 BTUs.**

Table 67 Potential fixture retrofits available to case study hotels

Moreno Valley Area Potential Retrofits

Retrofit	Manufacturer	Rated Flow	Cost	Rebate	Rebate Agency
High Efficiency Toilet	Cadet® 3 FloWise™ Round Front Toilet	1.28	$236-$331	No	MWD
Dual Flush Toilet	FloWise® Dual Flush Round Front Toilet	0.8-1.6	$329 - $371	No	MWD
High Efficiency Urinal	Allbrook FloWise 0.5 GPF - Siphon Jet	0.5	$220-$350	No	MWD
Zero-Flush urinal	Kohler Steward® S waterless urinal	0	$532	No	MWD
Waterless Urinal	Falcon Waterless Urinal F-4000	0	$244	No	MWD
Low-Flow Faucet	Reliant 3 Centerset Bathroom Faucet - 0.5 GPM	0.5	$125 - $180	No	N/A
Eco-Faucet	Toto TEL3LSC-10	0.09	$358.05	No	N/A
Aerator	Faucet aerator (order 1-5)	0.5	$2.10	No	N/A
	Faucet aerator (order 6-59)	0.5	$1.94	No	N/A
	Faucet aerator (order 60+)	0.5	$1.80	No	N/A
Aerator	Faucet aerator (order 1-5)	1.0	$1.85	No	N/A
	Faucet aerator (order 6-59)	1.0	$1.65	No	N/A
	Faucet aerator (order 60+)	1.0	$1.40	No	N/A
Low-Flow Showerhead	Bricor	1.75	$37-$45	No	N/A

Goleta & Santa Barbara Area Potential Retrofits

Retrofit	Manufacturer	Rated Flow	Cost	Rebate	Rebate Agency
High Efficiency Toilet	Cadet® 3 FloWise™ Round Front Toilet	1.28	$236-$331	$200	CUWCC
Dual Flush Toilet	FloWise® Dual Flush Round Front Toilet	0.8-1.6	$329 - $371	$200	CUWCC
High Efficiency Toilet	Evergreen Two-Piece toilet	1.2	314	$200	CUWCC
Integrated toilet/sink	Gaiam Toilet Lid Sink	1	$89	No	N/A
Water Efficient Urinal	Vitra Evergreen 5231-XXX-0198	0.25	$395	$300	CUWCC
Waterless Urinal	Falcon Waterless Urinal F-4000	0	244	$300	CUWCC
Low-Flow Faucet	Reliant 3 Centerset Bathroom Faucet - 0.5 GPM	0.5	$125 - $180	No	N/A
Eco-Faucet	Toto TEL3LSC-10	0.09	$358.05	No	N/A
Aerator	Faucet aerator (order 1-5)	0.5	$2.10	No	N/A
	Faucet aerator (order 6-59)	0.5	$1.94	No	N/A
	Faucet aerator (order 60+)	0.5	$1.80	No	N/A
Aerator	Faucet aerator (order 1-5)	1.0	$1.85	No	N/A
	Faucet aerator (order 6-59)	1.0	$1.65	No	N/A
	Faucet aerator (order 60+)	1	$1	No	N/A
Low-Flow Showerhead	Bricor	1.75	$37-$45	No	N/A

Sources: (California Urban Water Conservation Council, 2009a)**, (**Metropolitan Water District, 2010)

For our analysis of domestic fixture energy and water conservation, we chose to focus modeling the combined resource savings potential for four key retrofits: installation of a high efficiency toilets (1.28 gallon per flush), waterless urinals, faucet aerators (0.5 gallon per minute flow), and low-flow showerheads (1.75 gallon per minute flow). Note that when calculating costs of retrofits, if the manufacturer advertised a range of prices the lowest end of the range was selected since it was assumed a hotel buying enough showerheads or toilets to retrofit close to 100 rooms would receive a better deal than an entity purchasing just one fixture (see Appendix G for a detailed explanation of cost savings and payback period analysis). This analysis also relies upon industry ratings of fixture water use in order to calculate savings, even though as discussed previously often times fixtures deviate from these ratings.

Total Resource Savings Calculation Methodology

In order to calculate the savings from a fixture retrofit, our analysis assumed that the human behavior governing fixture use (i.e. the assumptions of use frequency detailed above) would be the same. Therefore, calculating savings is relatively simple: using the water use assumptions and calculation methodology described above, we can simply change the measured flow with the rated flow of the retrofit and find how much water can be saved.

For example, in the Table 66 results above for water use in December at the Moreno Valley hotel men's bathroom, we found a water usage of 124 gallons, 271 gallons, and 38 gallons from the toilet, urinal, and faucet usage respectively during the month. By changing the "measured flow" value from the calculation above to the rated flow of the water efficient retrofits we can then calculate the monthly water usage per fixture type if a high efficiency toilet, a zero flush urinal, and an aerated faucet were installed in the bathroom:

$$\begin{aligned}&Manager\_estimation\_use\_per\_day \times 0.11\_\min utes \times days\_per\_month \times retrofit\_faucet\_flow\\&= Common\_Area\_Faucet\_Water\_Use\_with\_aerator\_retrofit\end{aligned}$$

Using the equation above, we find that replacing the 2.2 gallon per minute faucet aerator with a 0.5 gallon per minute aerator results in decreasing the faucet water usage in December from 38 gallons to 9 gallons – saving 29 gallons of water.

Once direct water savings have been calculated, we then can find the associated energy savings. As mentioned above, it takes natural gas to heat the water coming out of faucets (toilets and urinals use no hot water, therefore only provide savings from water efficiency and savings in energy needed to transport the water from the source to the toilet – see Part 2 for detail on calculating the energy embedded in the treatment, transport, and wastewater treatment of water).

Since installing a 0.5 gallon per minute faucet aerator in this example saves 29 gallons of water over the course of the month, using the same calculation above for natural gas hot water use we can find how much natural gas is saved by using less water at the faucet (it's worth remembering that actual frequency of use hasn't changed).

$$Fixture\_water\_use \times 0.73 \times 539.5 = Fixture\_Natural\_Gas\_Use$$

Because we assume 73% of faucet water is hot, this means of the 29 gallons saved 21 of them would have been for hot water; and therefore reducing water flow with an aerator not only saved 29 gallons of water but also 11,421 BTUs of natural gas during the month.

For a thorough discussion of our analysis and calculations concerning energy, water, and monetary savings over the lifetime of our potential retrofits, see Appendix G.

Appendix F: Landscaping

Determining Water Needs of Plants

To estimate plant water needs in a diverse landscape, we followed the Landscape Coefficient method outlined in the WUCOLS report (University of California Cooperative Extension and California Department of Water Resources, 2000). References to specific calculations for determining water needs of plants were derived from the above WUCOLS methods. The WUCOLS landscape coefficient method uses of a series of simple calculations based on specific information collected in the field to estimate ET and irrigation efficiency so that the appropriate water can be applied. To accomplish this, we developed an Excel spreadsheet for each hotel to incorporate the biological, physical, and environmental parameters necessary to calculate the landscape coefficient estimate of water use. The landscape coefficient method is designed to maintain plant health and appearance, reduce water waste, and minimize money spent on the increasing cost of water (University of California Cooperative Extension and California Department of Water Resources, 2000).

Plant water needs have been determined based on thorough laboratory and field studies which measured plant water loss (University of California Cooperative Extension and California Department of Water Resources, 2000). Plants were identified with help from numerous individuals following which, water requirements for each species were determined using the WUCOLS plant list and other locally appropriate plant databases (Metropolitan Water District of Southern California, 2003); (Santa Barbara County Water Agency, 2010a). Values for plant water use are found using:

$$K_L = k_s * k_d * k_{mc}$$

Where k_s is the species factor and is expressed as a fraction of reference evapotranspiration (ET_o) and is presented with the other variables k_d and k_{mc} in the Landscape Coefficient in Table 68 and discussed below. Species factor ranges between 0.9 for high water use plants and <0.1 for very low water use plants.

Because all species were not present within any one plant list, data from multiple plant lists were compiled in order to determine plant water needs. We used the water needs data from the WUCOLS plant list was the main determinant in defining each plants water needs. Water use data from the Santa Barbara County Water Agency's plant list was used as a secondary list and filled the remaining gaps of the WUCOLS list. If a plant was identified as medium water use in both plant lists then the mid range value of 0.5 was chosen from the medium range of 0.4-0.6. If the plant was medium in WUCOLS but low water use in Santa Barbara's list, the lower end of the WUCOLS range 0.4 was chosen. Once the plant water requirements were identified and included within the excel spreadsheet, the highest water consuming plant within each irrigation zone was used to represent the entire zone's watering needs, k_s, in order to meet the minimum water needed by all plants within the zone.

Table 68 Landscape coefficient factors

	Species	Density	Microclimate
High	0.7-0.9	1.1-1.3	1.1-1.4
Mod./Avg.	0.4-0.6	1	1
Low	0.1-0.3	0.5-0.9	0.5-0.9
Very Low	<0.1	-	-

Source: (University of California Cooperative Extension and California Department of Water Resources, 2000)

For each zone, we recorded the environmental conditions of plant density factor (k_d) and microclimate factor (k_{mc}). Density factor can vary considerably depending on total leaf area and spacing between plantings. The larger the leaf area per square foot, the greater the evapotranspiration which results in a higher density factor k_d. Range for k_d is between 1.3 for very dense planted areas to 0.5 for sparse landscapes.

Microclimate factor accounts for the differences in evapotranspiration between sunny, hot, and/or windy locations vs. shaded, cool, and/or protected areas. Plantings near buildings, parking lots, reflective surfaces and “wind tunnels” between buildings can increase evaporation and require greater than average watering. The range for microclimate factor is as high as 1.4 for highly evaporative conditions and as low as 0.5 for plantings on the north side of buildings, courtyards, and other protected areas. Once the values for microclimate, plant density, and species water needs are known, the landscape coefficient K_L can be calculated and multiplied by the reference evaporation (ET_O) to determine landscape evapotranspiration (ET_L) using:

$$ET_L = ET_O * K_L$$

ET_O is calculated using specialized weather station available from the California Irrigation Management Information System (CIMIS) (Department of Water Resources, 2009). We downloaded monthly ET_o and precipitation values from 2007-2009 and generated an average for each calendar month (Table 69). For the Goleta and Santa Barbara Hotels, we averaged values from the CIMIS stations #94 in the Goleta Foothills and #107 in Santa Barbara while the Moreno Valley Hotel used ET_o values from station # 44 located at the University of California-Riverside campus. Values of average monthly ET_o provide the basis to calculate ET_L for all landscape zones.

Table 69 Monthly average ET values for Santa Barbara/Goleta and Moreno Valley

	CIMIS Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Santa Barbara/ Goleta Monthly Average ET (2007-2009)	94 and 107	2.15	2.25	3.98	4.87	4.88	5.25	5.69	4.44	3.82	3.92	2.44	1.83	45.50
UC Riverside Monthly ET (2007-2009)	44	2.76	2.54	4.98	5.55	6.36	6.71	7.57	7.00	5.71	4.59	3.04	2.07	58.88

To determine the total water applied to the landscape (TWA), the irrigation efficiency (IE) must be estimated. Even new and well designed irrigation systems may be only 90% efficient at getting water to the plants, while systems with improper design and maintenance may be less than 50% efficient (University of California Cooperative Extension and California Department of Water Resources, 2000). Irrigation efficiency was estimated for each zone based on irrigation type, notation of problems such as broken or leaking heads, presence/absence of mulch, and to a lesser degree, the scheduling of irrigation events. The latter matters as short duration watering everyday may encourage shallow roots prone to greater evaporation where watering too long allows water to penetrate beyond the root zone. While this process is inherently subjective, it is nonetheless a critical step. For this last step, the following equation describes the total water applied:

$$TWA = ET_L / IE$$

The final calculation of TWA within the WUCOLS framework provides a value of inches of water per month required by plants. TWA estimates the total water *needed* by plants from an irrigation system given the environmental conditions present. TWA should not be mistaken for estimates of total water actually applied by irrigation systems, which are estimated separately below. In order to compare these values with the remainder of the efficiency measures, we converted TWA from inches of water to gallons of water per zone using:

$$\frac{Gallons}{Month} = TWA * 0.62 * SquareFeet$$

We assessed these values to compare both monthly and annual water needs of landscapes at our case study hotels and is shown in Table 70.

Table 70 Monthly and annual plant water needs

Hotel	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Santa Barbara	22,825	23,870	42,318	51,764	51,852	55,804	60,536	47,192	40,635	41,663	25,926	19,405	483,789
Goleta	14,722	15,397	27,295	33,388	33,445	35,994	39,046	30,439	26,209	26,872	16,722	12,516	312,045
Moreno Valley	12,808	11,788	23,082	25,740	29,463	31,086	35,072	32,445	26,451	21,259	14,106	9,594	272,894

Calculating Water Applied by Irrigation

To understand whether sufficient water was being provided to landscapes through the irrigation system, two methods were assessed to begin this estimate. The first used measurements of water flowing through the landscape meter during the manual operation of each irrigation zone. Volume of water per unit time was recorded where available for each irrigation zone. Once each zone was turned on, we waited roughly a minute before taking the initial value to allow for air to be purged through the irrigation system, ensuring an accurate flow rate would be calculated. Once this initial reading was collected, a second reading was recorded after a given period of time to develop a calculated flow volume per unit time, which was later converted to cubic feet per minute. However, numerous zones were not activated by the controller at the Goleta and

Moreno Valley hotels, limiting the data that could be collected. Meanwhile the Santa Barbara hotel does not have a dedicated landscape meter which prevented us from accurately measuring only the water being use by each irrigation zone.

The second method used to estimate irrigation water applied was calculated using information regarding the run time of the irrigation controller and estimates of spray head flow rates. Each irrigation zone is set to run for a specific number of minutes and cycles per week, allowing us to calculate the number of minutes per month each zone is on using:

$$MinutesIrrigatedPerMonth = \frac{Minutes}{Day} * \frac{Days}{Month} * \left(\frac{\left(\frac{DaysIrrigated}{Week} \right)}{7} \right)$$

Maintenance/gardening staff at each hotel specifically told us they do not adjust the controller to water more in the summer when ET is higher, but do turn the controller off when it rains.

Ranges of estimated spray head flow or more formally, precipitation rates, for spray head type sprinklers vary and are defined by how many inches of water each would provide in an hour. Precipitation rates vary from 1-2 inches per hour (Bilderblack & Powell, 1996), 1.5-1.7 inches per hour (Carolinas Irrigation Association, 2009), to 1.8 inches per hour (California Urban Water Conservation Council, 2009b). While every hotel used spray heads as their primary irrigation source, the age and condition of these systems vary and likely do not have a common precipitation rate. Because all hotels appeared to have more than adequate pressure, we considered values toward the higher range of the industry estimates. We calculated monthly water applied for all three hotels using precipitation rates of 1.6, 1.8, and 2.0 inches per hour using:

$$MonthlyGallonsApplied = MonthlyWateringMinutes * (SprayHead\Pr ecipitationRate / 60) * 0.62 * SquareFeet$$

We selected the rate that best matched the quality of the irrigation system (Table 71). We also made sure the annual estimate was not less than estimated plant needs, and did not exceed the annual volume recorded by the landscape meter to provide lower and upper bounds to our estimates. Because all hotels plants appeared to be well watered, we assumed applied water was not less than plant water needs.

Table 71 Estimated annual water used based on three precipitation rates (Gallons/Year). Values chosen for final estimate in bold.

	Santa Barbara Hotel	**Goleta Hotel**	**Moreno Valley Hotel**
Precipitation Rate (1.6 Inches/Hour)	347,645	276,875	462,064
Precipitation Rate (1.8 Inches/Hour)	391,101	**311,484**	519,822
Precipitation Rate (2.0 Inches/Hour)	**434,557**	346,093	**576,069**
Actual Landscape Meter Bill Data	N/A	339,218	1,044,420

Estimates for volume of water applied were generated in gallons of water applied per month for each irrigation zone and summed annually for each zone and summed per month for all zones (Table 72). For the Goleta and Moreno Valley hotels, the irrigation water comes from a dedicated landscape meter, allowing us to compare the estimated monthly water applied to billed data. For both cases, the distinct seasonal increase in spring, summer, and fall and dip in winter shows that adjustments to irrigation run time to meet plants needs occurred (Figures 45 and 46). Despite maintenance staff at all three hotels informing us that they do not adjust the controller to increase watering in the summer to meet greater plant needs, we conclude this cannot be the case based on billed data and obvious variation in seasonal plant needs. Our site visits occurred in December and could not observe irrigation durations during the summer months. It is likely that landscape contractors adjust the irrigation run times without the maintenance staff's knowledge. We cannot say for certain this was the case at the Santa Barbara hotel but based on the other two hotels, we adjusted the monthly water applied values to better represent seasonal adjustments in water use.

Table 72 Monthly and annual initial estimates of irrigation water applied (Gallons/Month)

Hotel	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Santa Barbara	36,213	32,709	36,213	35,045	36,213	35,045	36,213	36,213	35,045	36,213	35,045	36,213	426,379
Goleta	26,386	23,832	26,386	25,534	26,386	25,534	26,386	26,386	25,534	26,386	25,534	26,386	310,669
Moreno Valley	48,926	44,192	48,926	47,348	48,926	47,348	48,926	48,926	47,348	48,926	47,348	48,926	576,069

We compared two different methods to model seasonality for our estimated monthly water use. The first used monthly values for ET and for the Goleta and Moreno Valley hotels, the second method used monthly landscape water bills. We normalized the monthly data for both ET and billed water use by dividing the monthly values for each by their annual average; creating a ratio we could then multiply by our initial estimates of water applied to calculate monthly irrigation volumes throughout the year using:

$$EstimatedWaterApplied(Gallons) = InitialMonthlyEstimate(Gallons) * \left(\frac{MonthlyET}{AnnualET} \right)$$

Or

$$EstimatedWaterApplied(Gallons) = InitialMonthlyEstimate(Gallons) * \left(\frac{MonthlyBilled(Gallons)}{AnnualBilled(Gallons)} \right)$$

This method does not substantially change the annual volumes of irrigated water delivered but reapportions estimates to reflect reasonable seasonal variation. Based on estimates seen in Figures 45-47, we selected the estimated water applied using the billed ratio for both Goleta and Moreno Valley hotels; and for the Santa Barbara hotel where no separate irrigation bill was available we used the estimated water applied using the ET ratio.

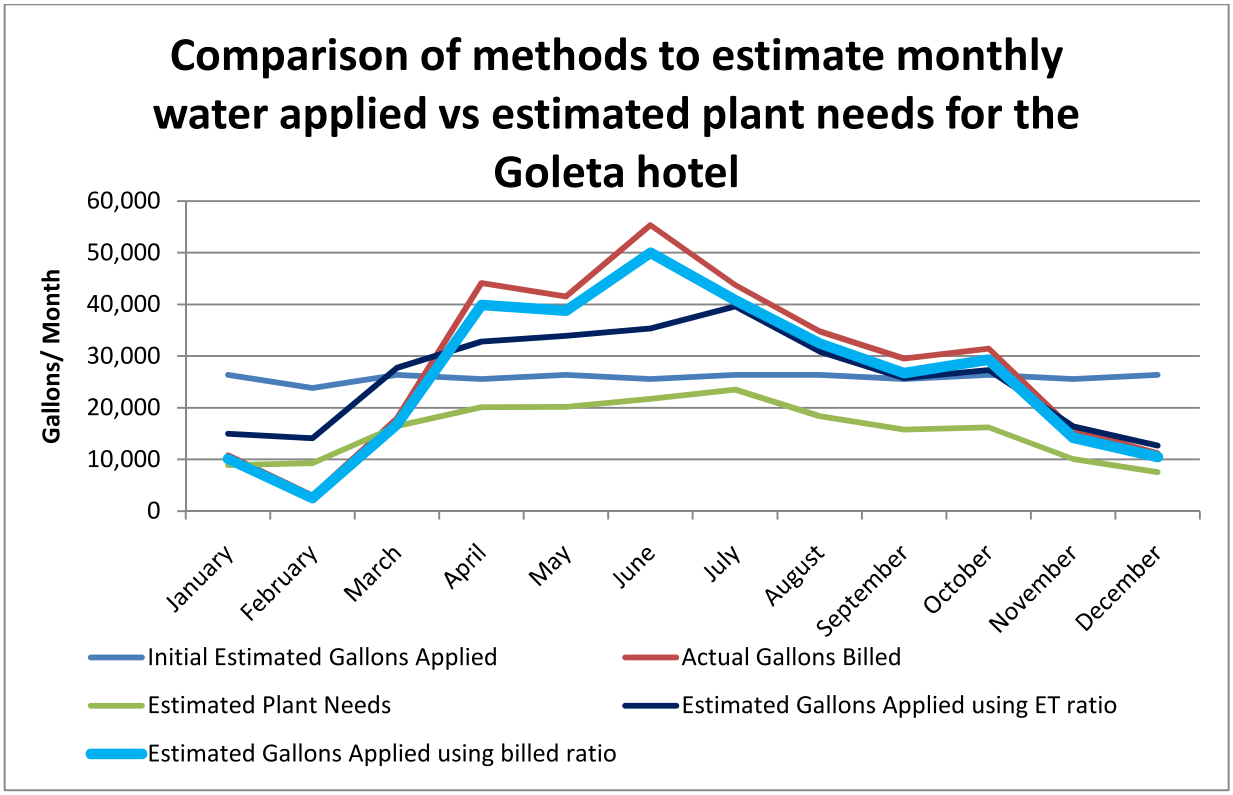

Figure 45 Comparison of methods to estimate monthly water applied vs. estimated plant needs for the Goleta hotel

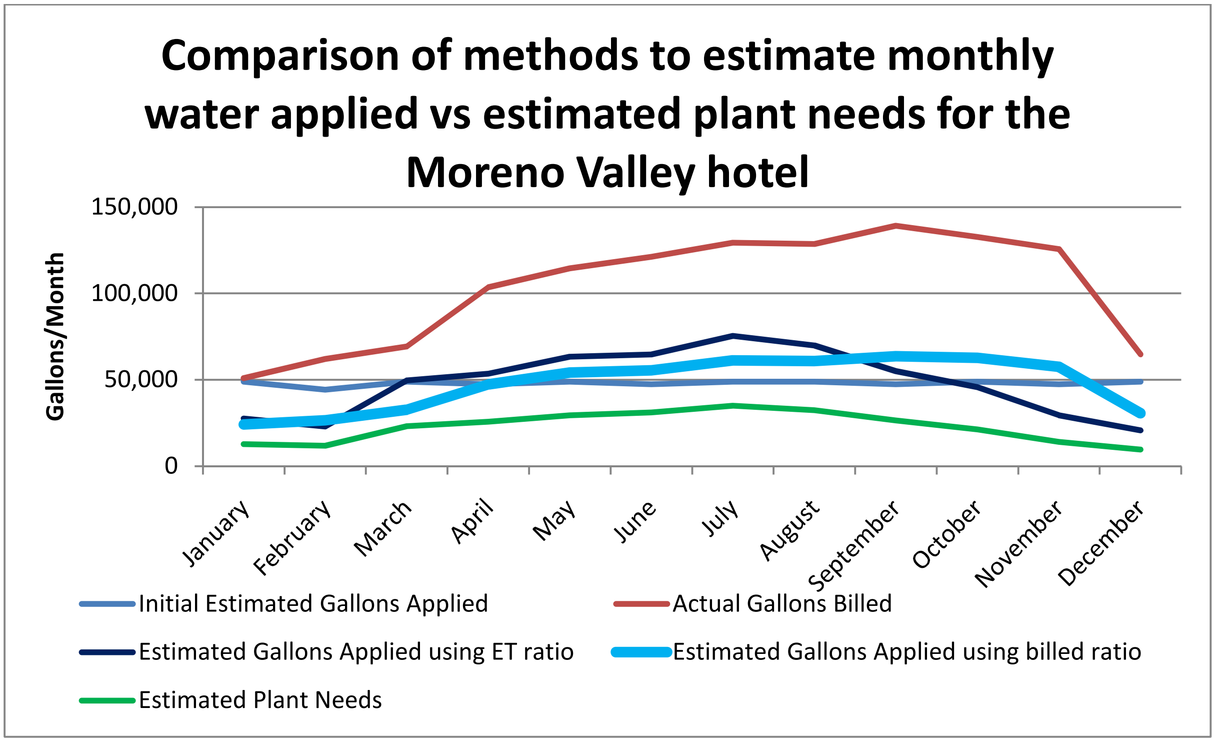

Figure 46 Comparison of methods to estimate monthly water applied vs. estimated plant needs for the Moreno Valley hotel

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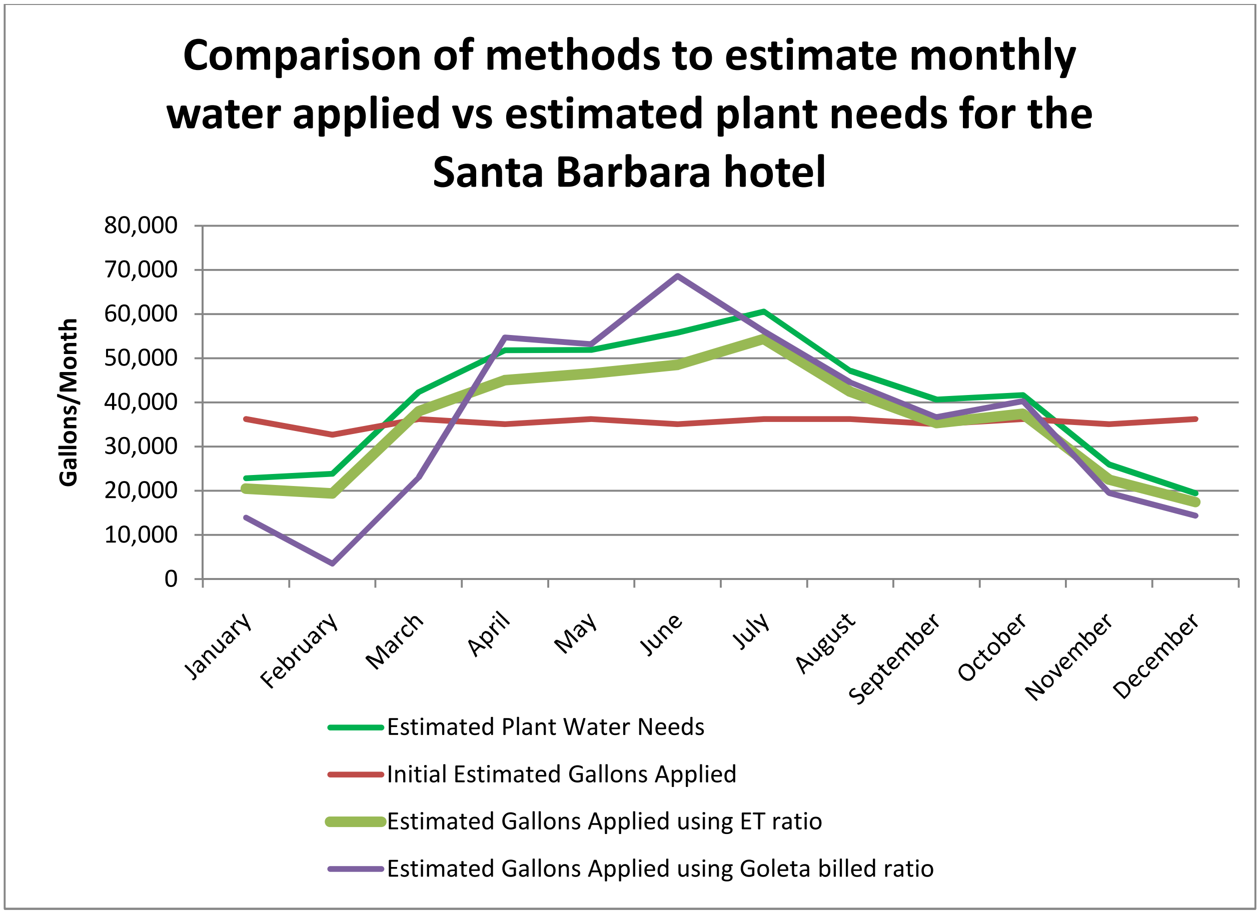

Figure 47 Comparison of methods to estimate monthly water applied vs. estimated plant needs for the Santa Barbara hotel

We then compared our estimates of annual plant water needed vs. irrigation water applied for all three hotels (Figure 48). We estimate the Santa Barbara hotel under applies irrigation water while the Goleta and Moreno Valley hotels apply more water than the plants need. This could be due to an overestimate of plant water needs, an underestimate of actual water applied, or a combination of the two.

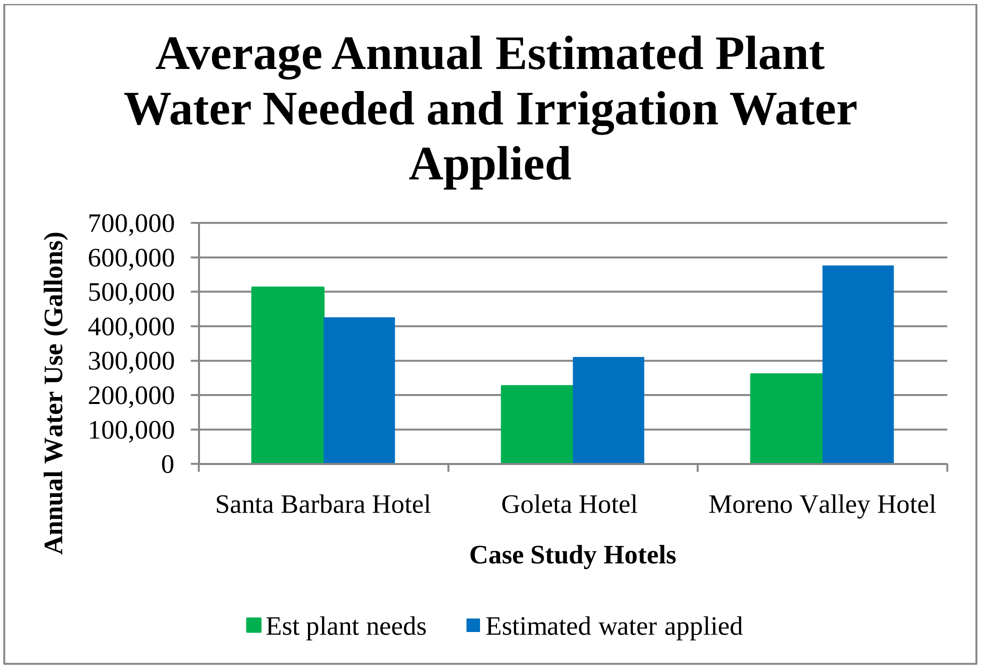

Figure 48 Comparison of plant water needs and irrigation water applied for all three case study hotels

To better understand irrigation rates between the hotels, we compared the estimated water applied per irrigated square footage along with the number of minutes we were told the irrigation system operates each week (Figure 49). We note that the relationship between the two values are similar between the three hotels but the actual gallons applied/sq. ft. and minutes applied/week are much greater at Moreno Valley and lowest at Santa Barbara. The low values at Santa Barbara may be due to efforts from on site gardening staff who regularly fine tune water delivery, while the high values at Moreno Valley are likely caused by the improperly adjusted irrigation controller. Despite the Santa Barbara hotel being the only hotel with substantial turf areas and many other high water use plants, they are noted as the hotel with the lowest water use per irrigated area. Without data from a separate irrigation meter, it is difficult to confirm our estimates and leaves the possibility of underestimating the actual water used in landscapes at the Santa Barbara hotel.

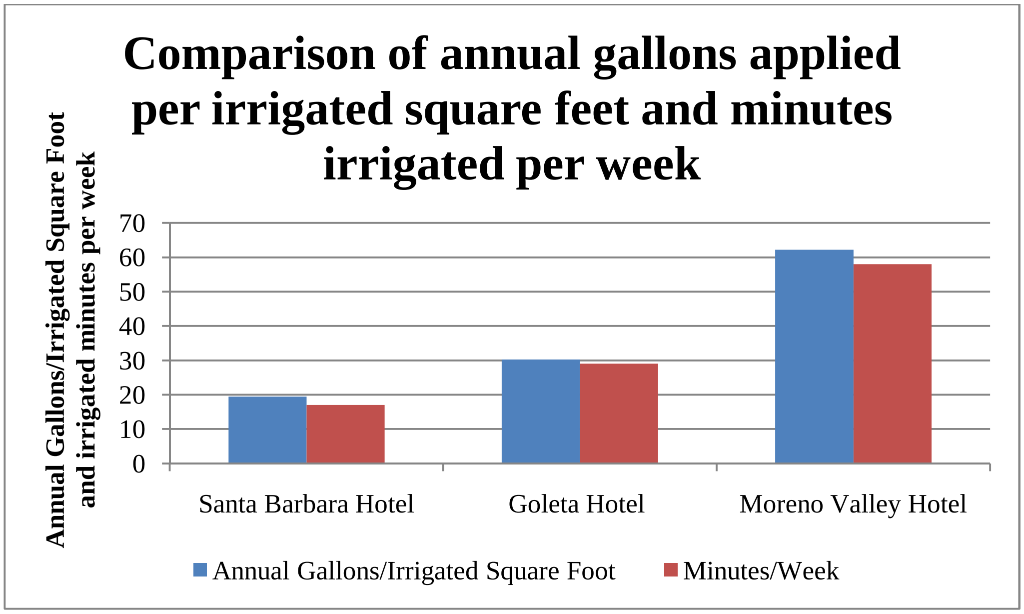

Figure 49 Comparison of annual gallons applied per irrigated square feet and minutes irrigated per week

Methods to Calculate Savings

In order to understand how specific actions to improve efficiency would affect the volume of water needed, we used the existing Excel model to develop savings calculators. Specific variables within the WUCOLS framework that we adjusted include k_s the species factor, and IE the irrigation efficiency (IE).

For hotels that included landscape plants with k_s above 0.5 based on the WUCOLS water use factor within a zone that otherwise contained lower water using plants (University of California Cooperative Extension and California Department of Water Resources, 2000), we considered replacing these high water using plants with species that better matched the existing water needs of the zone. We also estimated the replacement of certain turf areas with low water use plants for zones with mixed turf and non turf areas.

Improvements in irrigation efficiency were calculated separately to obtain new values for IE. For turf zones, this consisted of replacing all spray head nozzles with water saving rotary nozzles, resulting in a 20% improvement in IE. For non turf zones, we considered the conversion of the existing spray heads to either rotary nozzles or a simple and durable drip irrigation system. All retrofit scenarios included the application of mulch to all non-turf areas as an essential piece of any water conservation strategy. While this prevents the independent cost assessment of drip or rotary nozzle retrofits without mulch, this would not be a realistic retrofit scenario and is not considered here. Both drip systems and rotary nozzles have an expected lifetime of 10 years while mulch has an expected lifetime of 3 years.

These factors were adjusted separately using seven different scenarios to document savings potential from separate actions, as seen in Table 73. Note that all scenarios do not apply at all hotels due to only the Santa Barbara hotel having turf that we recommend retaining. Calculated species factor and irrigation efficiency for each hotel and retrofit is shown in Table 74. Note for these that a lower species factor requires less water and a higher irrigation efficiency results in less water waste.

Table 73 Irrigation retrofit scenarios at three case study hotels and effective changes to irrigation efficiency

	Vegetation		**Retrofit**		**Irrigation Efficiency**		**Retrofit Scenarios**		
Scenario	**Non-Turf**	**Turf**	**Non-Turf**	**Turf**	**Non-Turf**	**Turf**	**Santa Barbara**	**Goleta**	**Moreno Valley**
Existing	Existing	Existing	Existing	Existing	Existing	Existing	X	X	X
1	Existing	Existing	Drip	Rotary Nozzles	0.9	Existing IE *1.2	**X**	X	X
2	Existing	Existing	Rotary Nozzles	Rotary Nozzles	Existing IE *1.2	Existing IE *1.2	X	X	X
3	High water plants replaced with low water use plants	Existing	Drip	Rotary Nozzles	0.9	Existing IE *1.2	X		X
4	High water plants replaced with low water use plants	Existing	Rotary Nozzles	Rotary Nozzles	Existing IE *1.2	Existing IE *1.2	X		X
5	High water plants replaced with low water use plants	Turf removed from mixed zones	Drip	Rotary Nozzles	0.9	Existing IE *1.2	X		
6	Existing but add mulch	Existing	Add Mulch	Existing	Existing IE *1.2	Existing	X	X	X
7	High water plants replaced with low water use plants	Existing	Existing	Existing	Existing	Existing	X		X

Table 74 Retrofit scenarios and values for species factor and irrigation efficiency for case study hotels

	Santa Barbara		**Goleta**		**Moreno Valley**	
Retrofit Scenarios	**Species Factor (ks)**	**Irrigation Efficiency (IE)**	**Species Factor (ks)**	**Irrigation Efficiency (IE)**	**Species Factor (ks)**	**Irrigation Efficiency (IE)**
Existing	0.62	0.62	0.52	0.60	0.50	0.54
Scenario 1	0.62	0.86	0.52	0.90	0.50	0.90
Scenario 2	0.62	0.75	0.52	0.75	0.50	0.75
Scenario 3	0.55	0.86	-	-	0.49	0.90
Scenario 4	0.55	0.75	-	-	0.49	0.75
Scenario 5	0.51	0.86	-	-	-	-
Scenario 6	0.62	0.73	0.52	0.72	0.50	0.66
Scenario 7	0.55	0.62	-	-	0.49	0.54

For each hotel, the results from the retrofit scenarios are presented in Tables 75-77, with the chosen retrofit in bold. Tables include existing and projected water use and percent savings, total cost of retrofit and cost per gallon saved, savings over the retrofit lifetime, and estimated payback period at current water rates. This allows for a comparison of the relative resource savings, cost, and value of each retrofit option. We expect that often retrofits will not be evaluated using only economic considerations of payback period. Other capital improvement and maintenance projects will compete for limited investment dollars, staff time needed to implement and whether retrofits can be implemented over time may be considered, as will how the retrofits fit into emerging corporate efficiency programs, and broader long term strategies may also be considered. We hope the savings projections for each retrofit provide a guide for overall cost effectiveness to factor into decision making.

While some payback periods were quicker, we chose Scenario 1 for each hotel as the recommended retrofit. Recommendations for each hotel were for conversion to drip irrigation, addition of mulch, and addition of a rain sensor. Recommendations for rotary spray heads are included for turf zones in Santa Barbara but are not as ideal for shrubs as drip irrigation. Mulch offers the quickest paybacks of all retrofits but larger water savings are accomplished with addressing the irrigation system. For all hotels, these conversions could take place all at once or zone by zone depending on resources. While we make specific recommendations for turf and non turf areas, in some cases, specific zones for non turf areas might be best converted to drip while others converted to rotary nozzles. Drip systems are best for plantings with large perennials and rotary nozzles would be more effective for zones with extensive groundcover and root zones. For the purposes of comparing different irrigation methods to understand savings potential, we did not consider each zone separately except to differentiate between turf and non turf zones. If investments are to be made in improving irrigation efficiency, some mix of drip and rotary nozzles may be appropriate.

Table 75 Savings and cost effectiveness of retrofit options for the Santa Barbara hotel

Scenario	Water Use (Gallons)	Projected Water Saved (Gallons)	Water Saved (%)	Total Cost after Rebate ($)	Cost/Gallon Saved after Rebate ($)	Lifetime Savings ($)	Payback Period (years)
Existing	512,487	-	-	-	-	-	-
Scenario 1	**395,127**	**117,360**	**22.90%**	**$5,947**	**$0.05**	**$3,498.71**	**6.30**
Scenario 2	420,497	91,990	17.95%	$4,680	$0.05	$2,723.59	6.32
Scenario 3	377,209	135,278	26.40%	$7,947	$0.06	$2,940.82	7.51
Scenario 4	398,996	113,491	22.15%	$6,680	$0.06	$2,454.12	7.31
Scenario 5	312,045	200,442	39.11%	$9,947	$0.05	$6,185.66	6.31
Scenario 6	427,167	85,321	16.65%	$742	$0.01	$1,549.68	0.97
Scenario 7	483,789	28,699	5.60%	$1,000	$0.03	-$229.20	3.89

For the Santa Barbara hotel, many retrofits had similar payback periods despite different costs and lifetime savings. The drip system was selected due to the high cost of water and many long and narrow zones which are ideal for drip. Consideration should be given for a separate landscape meter to be installed. Besides being able to better track landscape water use, separately metering will eliminate sewer charges from landscape water (Santa Barbara County Water Agency, 2009c), reducing the cost of water moving forward. However, meter costs, connection charges, and trenching should be discussed directly with the City of Santa Barbara, and future city plans for extension of recycled water lines should be discussed.

Table 76 Savings and cost effectiveness of retrofit options for the Goleta hotel

Scenario	Water Use (Gallons)	Projected Water Saved (Gallons)	Water Saved (%)	Total Cost after Rebate ($)	Cost/Gallon Saved after Rebate ($)	Lifetime Savings ($)	Payback Period (years)
Existing	225,771	-	-	-	-	-	-
Scenario 1	**148,792**	**76,979**	**34.10%**	**$3,785**	**$0.05**	**$2,761**	**5.78**
Scenario 2	176,492	49,279	21.83%	$1,342	$0.03	$4,093	2.47
Scenario 3	-	-	-	-	-	-	-
Scenario 4	-	-	-	-	-	-	-
Scenario 5	-	-	-	-	-	-	-
Scenario 6	188,143	37,629	16.67%	$656	$0.02	$1,002	1.19
Scenario 7	-	-	-	-	-	-	-

The Goleta hotel has the fewest retrofits to choose from because they generally have only low and medium water use plants. Scenario 6 has the quickest payback period but has a much shorter lifetime of 3 years. Scenario 2 also had a quicker payback period than the recommended Scenario 1 but was not chosen for a few reasons. First, many zones are long and narrow which is ideal for drip but is difficult for sprinklers in general to avoid overspray outside the zone and provide a uniform application of water. Second, we estimate that the price of water for the Goleta hotel has a greater likelihood to increase than other districts. The Goleta water district has the lowest price of water in the South Coast region and does not have an effective tiered rate structure in place, unlike most other districts. Additionally, recent news about financial difficulties due to increased customer conservation has led to significant revenue shortfalls (Preston, 2010) and increases the uncertainty of the current pricing model in the future. The low cost of water for non-critical commercial irrigation appears to be a potential target for increases. Either across the board increases in water rates or a shift to a conservation rate structure would result in an increase to the cost of water, which would favor scenarios that result in greater savings and a lower payback period that projected under existing constant utility cost projections. A mixed approach to convert some zones to drip and others to rotary nozzles may be an alternative approach but was not modeled.

Table 77 Savings and cost effectiveness of retrofit options for the Moreno Valley hotel

Scenario	Water Use (Gallons)	Projected Water Saved (Gallons)	Water Saved ($)	Total Cost after Rebate ($)	Cost/Gallon Saved after Rebate ($)	Lifetime Savings ($)	Payback Period (years)
Existing	274,898	-	-	-	-	-	-
Scenario 1	**165,907**	**108,991**	**39.65%**	**$4,484**	**$0.04**	**$21,754**	**1.71**
Scenario 2	199,089	75,809	27.58%	$2,944	$0.04	$22,332	1.16
Scenario 3	164,683	110,215	40.09%	$4,484	$0.04	$21,790	1.71
Scenario 4	197,619	77,278	28.11%	$2,944	$0.04	$22,375	1.16
Scenario 5	-	-	-	-	-	-	-
Scenario 6	222,812	52,086	18.95%	$1,184	$0.02	$2,695	0.92
Scenario 7	272,894	2,003	0.73%	$40	$0.02	$23,095	0.02

For the Moreno Valley hotel, many scenarios had similar payback periods with excellent lifetime savings. Scenario 1 was chosen as it is close to maximizing the water savings and benefits from the long and narrow zones which favor drip irrigation. While Scenarios 2 and 4 had a quicker payback period, the uncertainties with supply reliability and reliance on imported water provide meaningful background to recommend scenarios that maximize savings. Existing stage 2 water shortage restrictions due to drought provide for greater flexibility and reduced likelihood of runoff which can result in fines for non compliance (Eastern Municipal Water District, 2010). Lastly, landscape water pricing was shifted to a tiered rate in 2009 with steeply increasing costs for use greater than budgeted. Maximizing efficiency is the most effective way to reduce the marginal cost increases of pricing within the higher tiers. Examining two monthly bills for the irrigation account shows the Moreno Valley hotel has significant use in the Excessive and Wasteful tiers since the inception of tiered rates (Table 78) which presents opportunity for substantial cost savings.

Table 78 Irrigation water use (HCF) for two months at the Moreno Valley hotel based on billed data

			Tier 2	**Tier 3**	**Tier 4**
		Cost/ HCF	**$2.71**	**$4.86**	**$8.90**
Bill Date	**Days**	**Total Outdoor Use**	**Outdoor**	**Excessive Use**	**Wasteful Use**
6/15/2009	29	213	57	29	127
12/16/2009	32	98	42	21	35

Calculating Electricity Needed by Landscaping

Landscape irrigation typically uses existing water pressure to deliver water through the system without additional inputs of pressurizing, heating, or other processing that would contribute significant amounts of electricity or natural gas to the end use of irrigation water. There is a small amount of electricity used by irrigation controllers and valves that we considered for our case studies. Where problems with inadequate pressure occur, booster pumps electricity use should also be accounted for but were not used by our case study hotels. We used the irrigation controller model to identify the voltage and amperage and daily hours of operation for controllers and valves to estimate the number of kWh of electricity consumed by the irrigation system and annual cost of operation using:

$$AnnualCost = \left(\left(\frac{(Voltage * Amps) * DailyHrsOperated}{1000 * \#\_Valves / Controllers} \right) * 365 * \frac{Cost(\$)}{Kwh} \right)$$

The irrigation controllers at the Santa Barbara hotel have been non-functional since the middle of 2009 but estimated electricity requirements for these models are included. Irrigation valve types were not recorded during the audit process so specific electricity demand of valves was estimated using specifications for valves using models from the same brand of irrigation controller (Table 79). With the controllers for the Goleta and Moreno Valley hotel being sufficient to operate either the existing or planned retrofit system, no electrical savings are expected for these hotels. We recommend the Santa Barbara hotel purchase and install a modern weather based irrigation controller, which will result in projected annual electricity costs in the $40-$50 range.

Table 79 Electricity use for irrigation systems

Hotel	Quantity	Device	Voltage	Amps	Watts	Daily Time of operation (hours)	Daily kWh	Annual kWh	Estimated annual cost @ $.12/kWh ($)
Santa Barbara	6	RainJet Classic RJ46 Controller	24	0.28	6.72	24	1.0	353.2	$42.38
Santa Barbara	42	Valve	24	0.2	4.8	1.57	0.3	115.3	$13.83
							Total	**468.5**	**$56.22**
Goleta	1	Irritrol MC-12E Controller	24	1.24	29.76	24	0.71	260.7	$31.28
Goleta	12	Hunter PGV Valve	24	0.2	4.8	0.77	0.04	16.2	$1.95
							Total	**276.9**	**$33.23**
Moreno Valley	1	Hunter ICC Controller	24	1.5	36	24	0.9	315.4	$37.84
Moreno Valley	14	Hunter PGV Valve	24	0.37	8.88	1.93	0.2	87.4	$10.48
							Total	**402.7**	**$48.33**

Ice Machines

Ice machine use could not be partitioned out by month. Rather, it was assumed that ice machines operated at 75% of capacity across the year (Pacific Gas and Electric Company, 2006). As ice machines do not consume hot water, only electricity and water costs were modeled. The water rate per 1000 gallons was averaged across the most recent 24 months of billing periods. Monthly electricity utility costs were averaged over the most recent two complete years of billing (2007 and 2008). Purchase costs for an energy efficient commercial ice machine replacement were assumed to be $3905.00 (United States Environmental Protection Agency and United States Department of Energy, 2008a). Expected lifetime of an ice machine was assumed to be seven years (United States Department of Energy, 2009f).

In 2009, Southern California Edison offered a variety of rebate packages for commercial ice machine purchases, outlined in Table 81. CEE Tier II ice machine heads require an upper bound on electricity use of 9.23-0.0077H kWh/100lbs ice and less than 25 gallons of water/100lbs of ice for harvest capacities less than 450lbs/day and 6.20-0.001H kWh/100lbs ice and less than 25 gallons of water/100lbs of ice for harvest capacities greater than 450lbs/day (where H represents harvest capacity). Tier III ice machine heads require an upper bound on electricity use of 8.72-0.0073H kWh/100lbs ice and less than 20 gallons of water/100lbs of ice for harvest capacities less than 450lbs/day and 5.86-0.0009H kWh/100lbs ice and less than 20 gallons of water/100lbs of ice for harvest capacities greater than 450lbs/day (Consortium for Energy Efficiency, 2005a).

Ice machine upgrades were modeled assuming agreement with CEE Tier III standards. The relevant rebates were subtracted from the assumed purchase price and the resulting initial cost was then subtracted from the time discounted lifetime cost of the ice machine upgrade. Available rebates are presented in Table 80.

Table 80 Rebates available from SCE for commercial ice machine upgrades in 2009.

	CEE Tier	
Harvest Rate (pounds/day)	II	III
200-300	$ 50.00	$ 100.00
400-500	$ 75.00	$ 150.00
500-1000	$ 125.00	$ 250.00

Source: (Southern California Edison, 2009b)

Domestic Fixtures

Toilet, faucet, and shower fixture uses were modeled according to historical monthly occupancy and staffing trends. Monthly electricity and natural gas utility costs were averaged over the most recent two complete years of billing (2007 and 2008). Water utility costs were obtained from the most recent 24 months of billing history.

Installation costs for toilet upgrades were assumed to be $250/toilet based on prior projects involving large scale toilet replacements in southern California (Kim O'Cain, City of Santa Monica, 2010). Installation of faucets and showerhead upgrades were assumed to be conducted by hotel maintenance staff and therefore cost of installation would be captured under normal maintenance costs. Table 82 shows the fixture retrofits recommended to our hotel case studies along with initial purchase and installation costs and available rebates.

The relevant rebates were subtracted from the assumed purchase price and the resulting initial cost was then subtracted from the time discounted lifetime cost of fixture upgrade. Showerhead and faucet expected lifetimes were assumed to be ten years (United States Department of Energy, 2009f). Expected lifetime of a toilet was assumed to be 20 years (California Urban Water Conservation Council, 2009a). Fixture upgrades, purchase and installation costs, and rebates are presented in Table 81.

Table 81 Fixture retrofit recommendations, initial costs, and available rebates.

Fixture	Type of Upgrade	Cost/unit	Installation	Rebate
Toilet	1.28 gpf	$ 236.00	$ 250.00	$ 200.00
Faucet	0.5 gpm aerator	$ 1.80	$ -	$ -
Shower	1.75 gpm	$ 37.00	$ -	$ -

Dish Washers

Dish washer use could not be partitioned out by month. Rather, it was assumed that dish washers ran one cycle/day for the Moreno Valley hotel and two cycles/day for the Goleta hotel (Contreras, 2010). The natural gas rate per therm and electric rate per kWh were averaged across the most recent 24 months of billing periods. Purchase costs for an energy efficient commercial dish washer replacement were assumed to be $6000.00. Expected lifetime of a dish washer was assumed to be ten years (United States Environmental Protection Agency and United States Department of Energy, 2008b).

Ice machine upgrades were modeled assuming agreement with ENERGY STAR requirements. For the dish washers at our hotel case studies, the relevant energy and water consumption thresholds for an efficient ENERGY STAR upgrade are 0.5 kW idle rate and 1.70 gallons/rack, respectively (United States Environmental Protection Agency and United States Department of Energy, 2008b).

Washing Machines

Ozone washing systems were recommended for all three of our case study hotels. Further, a management practice to discontinue triple sheeting beds was made to the Santa Barbara hotel. Ozone washing systems can be installed at an assume cost of $16,320 and reduces the consumption of hot water per cycle down to 5% (Articlean, 2010). Ozone systems were assumed to have an average life expectancy of 15 years (NuTek International, Inc, 2009).The triple sheeting management practice comes at no additional cost, yet can save natural gas, electricity, and water consumption by one-sixth.

Monthly electricity and natural gas utility costs were averaged over the most recent two complete years of billing (2007 and 2008) for all hotels. Water utility costs were obtained from the most recent 24 months of billing history.

Pools and Spas

Retrofit recommendations for hotel pools and spas consisted of energy efficient variable speed pumps, efficient water heaters, reduced pool pump hours, and cover systems. Table 82 summarizes the retrofit upgrades and associated costs. Life expectancies were assumed to be 10 years. The natural gas rate per therm and electric rate per kWh were averaged across the most recent 24 months of billing periods. The water rate per 1000 gallons was averaged across the most recent 24 months of billing periods for the Goleta and Santa Barbara hotels. The water rate for the Moreno Valley hotel was averaged over 2009 monthly billing history because of a outdoor water use rate change that took place after the fiscal year 2008. Sewer rates were included in the water rate used for the Santa Barbara hotel because only one water meter is located on site. Outdoor water use rates were employed to calculate water costs for both the Moreno Valley and Santa Barbara hotels. Reduced pool pump operation hours were assumed to come at no additional cost.

Table 82 Pool and spa retrofit costs

Retrofit	Cost	Source
Pool Cover	$ 229.99	http://www.lesliespool.com
Spa Cover	$ 21.99	http://www.lesliespool.com
Variable Speed Pump	$ 1,250.00	http://www.h2opoolproducts.com
Efficient Water Heater	$ 1,699.99	http://www.lesliespool.com

Irrigation

Irrigation water for the Moreno Valley hotel is delivered via an independent landscape meter, allowing for a more accurate assessment of water use. Water rates at Moreno Valley changed drastically from a uniform rate to tiered rate beginning in 2009. We used the 2009 rates to account for existing cost moving forward. The Goleta hotel also has a separate irrigation meter and for this and the Santa Barbara hotel, we averaged water rates across the most recent 24 monthly billing periods. For the Santa Barbara hotel, there is no separate irrigation meter so any water used in landscapes also has costs associated with sewer fees even though this water does not make it into the sewer. Monthly electricity costs were averaged over the most recent two complete years of billing (2007 and 2008) for all hotels.

Retrofits varied slightly at all hotels but were assumed to have a 10 year life expectancy for the technological components. Mulch is recommended at each hotel and does have a shorter life span (~3 years before breaking down) but only initial costs are included here. Costs for retrofits to drip irrigation were calculated based on square footage of each landscaped area, providing one run of drip for each two feet of width and emitters placed every foot. The different costs and retrofit recommendations are shown below in Tables 83-85.

Table 83 Moreno Valley hotel retrofit costs

Retrofit	Quantity	Cost/Unit	Total Cost	Source
Mulch	114 cubic yards	$10.00	$1,143.58	http://www.santabarbaraca.gov/Recycling-Trash/pdf/Mulch.pdf
Drip system*	5028 feet		$3,300.81	Aqua Flo Supply, Goleta
Rain Sensor	1	$40.00	$40.00	Aqua Flo Supply, Goleta
Rebates			$0.00	
Total			$4,484.39	

*Drip system includes 1/2" poly drip line, pressure compensating emitters, fittings, stakes, and for each zone, pressure regulators, filters, and backflow devices

Table 84 Goleta hotel retrofit costs

Retrofit	Quantity	Cost/Unit	Total Cost	Source
Mulch	127 cubic yards	$10.00	$1,271.30	http://www.santabarbaraca.gov/Recycling-Trash/pdf/Mulch.pdf
Drip system*	5324 feet		$3,435.25	Aqua Flo Supply, Goleta
Rain Sensor	1	$40.00	$40.00	Aqua Flo Supply, Goleta
Rebates			-$1,000.00	Goleta Water District
Total			$3,746.55	

*Drip system includes 1/2" poly drip line, pressure compensating emitters, fittings, stakes, and for each zone, pressure regulators, filters, and backflow devices

Table 85 Santa Barbara hotel retrofit costs

Retrofit	Quantity	Cost/Unit	Total Cost	Source
Mulch	148 cubic yards	$10.00	$1,483.89	http://www.santabarbaraca.gov/Recycling-Trash/pdf/Mulch.pdf
Drip system*	5195 Feet		$4,378.44	Aqua Flo Supply, Goleta
Rotary Nozzles	167	$6.50	$1,084.83	Ewing Irrigation, Santa Barbara
Rebates			-$1,000.00	City of Santa Barbara
Total			$5,947.16	

*Drip system includes 1/2" poly drip line, pressure compensating emitters, fittings, stakes, and for each zone, pressure regulators, filters, and backflow devices

Appendix H: Rate Increase Comparisons and Summary

In the interest of discerning what impact increased utility rates would have on our retrofit recommendations, cost saving calculations were performed using water, natural gas, and electricity rates that increased at a rate of 5%, 10%, and 15% annually. The calculation used to determine the future value of the utility costs was:

$$FV = \sum_{t=1}^{L} rate(1+it) \, ,$$

where t represents years, L represents the expected lifetime of the retrofit, i represents the rate at which the utility rate increases annually, and *rate* is the utility rate per unit. Future values were then discounted to present value using:

$$PV = \frac{FV}{(1+discount)^{L}} \, ,$$

where *discount* is the annual rate of discount (3.2%).

For the Goleta hotel, payback period for the feasible retrofits was shifted forward by a range of 0.1 years for faucet retrofits to more than seven years for laundry retrofits when the constant utility rate model is compared with the 15% linearly increasing model. Retrofit options that were unfeasible under the constant utility rate model remained unfeasible under the linearly increasing utility model with the exception of laundry. Under the 15% rate increase scenario, laundry retrofits nearly provide a feasible payback for the Goleta hotel.

Likewise, retrofits that were unfeasible for the Santa Barbara and Moreno Valley hotels under the constant utility model remained unfeasible under the linearly increasing utility model. Therefore, retrofit feasibility scenarios for our three case study hotels are believed to be relatively insensitive to utility increases ranging from 5% to 15% annually. Thus, the constant utility rate model is believed to adequately capture natural gas, water, and electricity rates through time. Tables 86 through 88 summarize the lifetime costs, savings from retrofits, and payback periods for feasible upgrades for the constant utility rate model and linearly increasing utility rate models respectively.

Table 86 Summary of lifetime retrofit savings and payback period for four different utility rate projection scenarios for the Goleta hotel

	Utility Projection Scenarios							
	Constant		5% Annual Increase		10% Annual Increase		15% Annual Increase	
End Use Retrofit	Savings	Payback (yrs)	Savings	Payback (yrs)	Savings	Payback (yrs)	Savings	Payback (yrs)
Toilets	-$21,857	80.0	-$21,036	71.7	-$18,235	53.3	-$15,434	42.5
Showers	$2,915	5.5	$3,582	5.0	$5,137	4.1	$6,692	3.5
Faucets	$10,246	0.2	$11,310	0.2	$13,789	0.1	$16,268	0.1
Dish Washer	Efficient upgrade not applicable							
Ice Machines	Efficient upgrade not applicable							
Laundry	-$4,993	21.6	-$3,717	19.4	-$116	15.1	$3,485	12.4
Irrigation	$2,761	5.8	$3,428	5.2	$4,984	4.3	$6,540	3.7
Pools and Spas	$53,067	0.8	$58,971	0.8	$72,729	0.6	$86,488	0.5

Table 87 Summary of lifetime retrofit savings and payback period for four different utility rate projection scenarios for the Santa Barbara hotel

	Utility Projection Scenarios							
	Constant		5% Annual Increase		10% Annual Increase		15% Annual Increase	
End Use Retrofit	Savings	Payback (yrs)	Savings	Payback (yrs)	Savings	Payback (yrs)	Savings	Payback (yrs)
Toilets	$30,679	11.9	$39,125	10.7	$67,953	7.9	$96,782	6.3
Showers	$9,624	3.8	$10,774	3.4	$14,295	2.8	$17,816	2.4
Faucets	$7,697	0.4	$8,510	0.3	$10,406	0.3	$12,302	0.2
Dish Washer	Not present							
Ice Machines	-$5,795	30.7	-$5,641	28.1	-$5,330	24.1	-$5,018	21.1
Laundry	$49,701	3.7	$57,138	3.3	$78,126	2.6	$99,114	2.1
Irrigation	$3,499	6.3	$4,459	5.7	$6,705	4.7	$8,949	4.0
Pools and Spas	$125,340	0.6	$138,986	0.6	$170,791	0.5	$202,595	0.4

Table 88 Summary of lifetime retrofit savings and payback period for four different utility rate projection scenarios for the Moreno Valley hotel

	Utility Projection Scenarios							
	Constant		5% Annual Increase		10% Annual Increase		15% Annual Increase	
End Use Retrofit	Savings	Payback (yrs)	Savings	Payback (yrs)	Savings	Payback (yrs)	Savings	Payback (yrs)
Toilets	-$58,346	628.5	-$58,131	565.1	-$57,397	420.4	-$56,663	334.7
Showers	-$3,035	31.6	-$3,250	37.3	-$2,993	30.7	-$2,737	26.1
Faucets	$1,460	1.7	$1,263	1.5	$1,584	1.2	$1,905	1.0
Dish Washer	-$5,002	60.1	-$4,853	52.3	-$4,606	43.0	-$4,359	36.6
Ice Machines	-$6,596	52.6	-$6,603	52.9	-$6,435	45.3	-$6,267	39.7
Laundry	-$7,078	26.5	-$6,037	23.8	-$3,100	18.5	-$162	15.2
Irrigation	$21,790	1.7	$19,943	1.8	$25,212	1.5	$30,481	1.3
Pools and Spas	$31,202	0.9	$34,702	0.8	$42,860	0.7	$51,018	0.6

Appendix I: Error and Confidence

In statistical prediction and modeling of change, there is always inherent error as well as error added in analysis. Our analytical error stems from uncertainty in actual water end use (except for landscaping water use, only total facility water use in known through billing data) in our case study hotels, and the assumptions used to model water use. As Figures 50, 51 and 52 show, our model ranges from fairly close to metered water use at the Moreno Valley hotel to as much as 3 million gallons less than actual annual water use at Santa Barbara hotel according to billing history. The peak in actual water usage in the summer months suggests an increase in water use due to higher occupancy during the peak tourist season in the summer. It also could be indicative of increased water use for landscaping in the summer, however workers maintain that the irrigation zones were watered the same amount of time throughout the year.

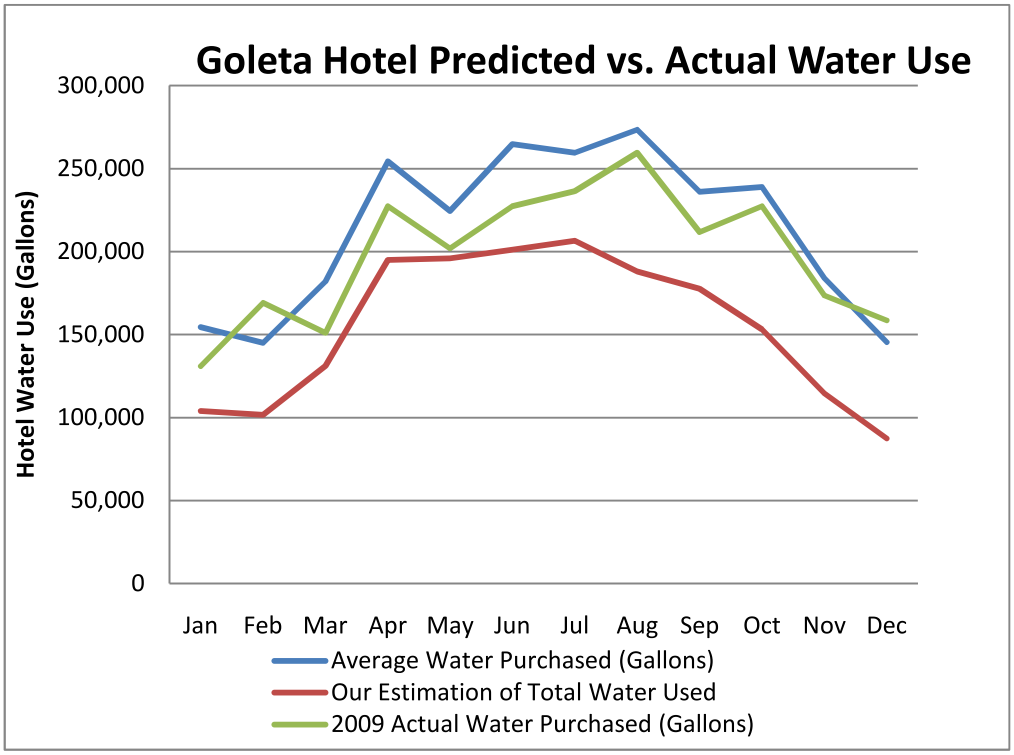

Figure 50 Modeled versus actual Goleta hotel water use

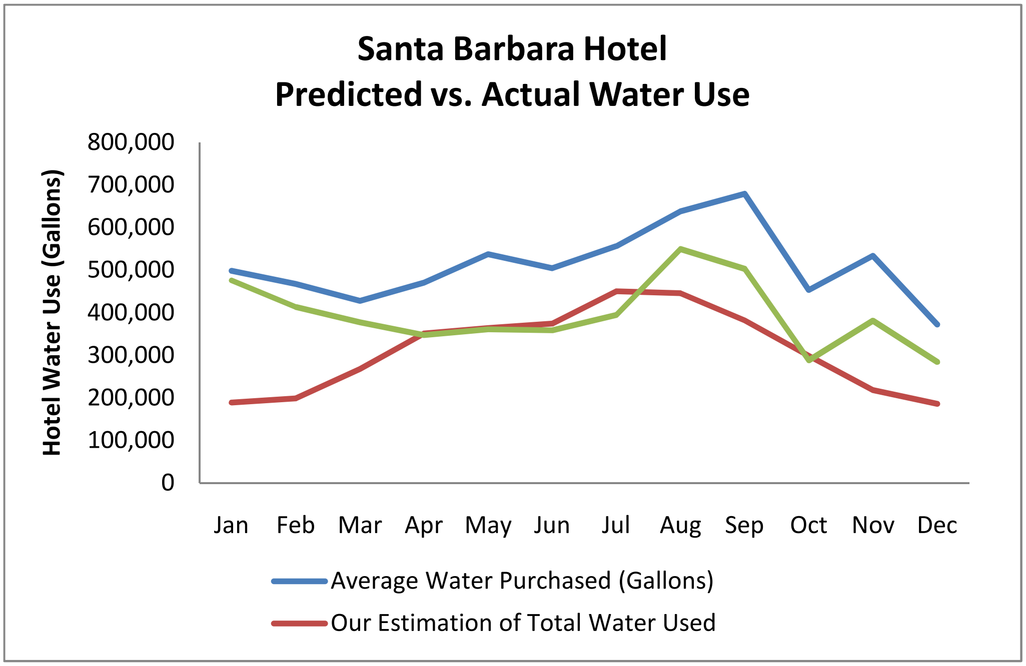

Figure 51 Modeled versus actual Santa Barbara hotel water use

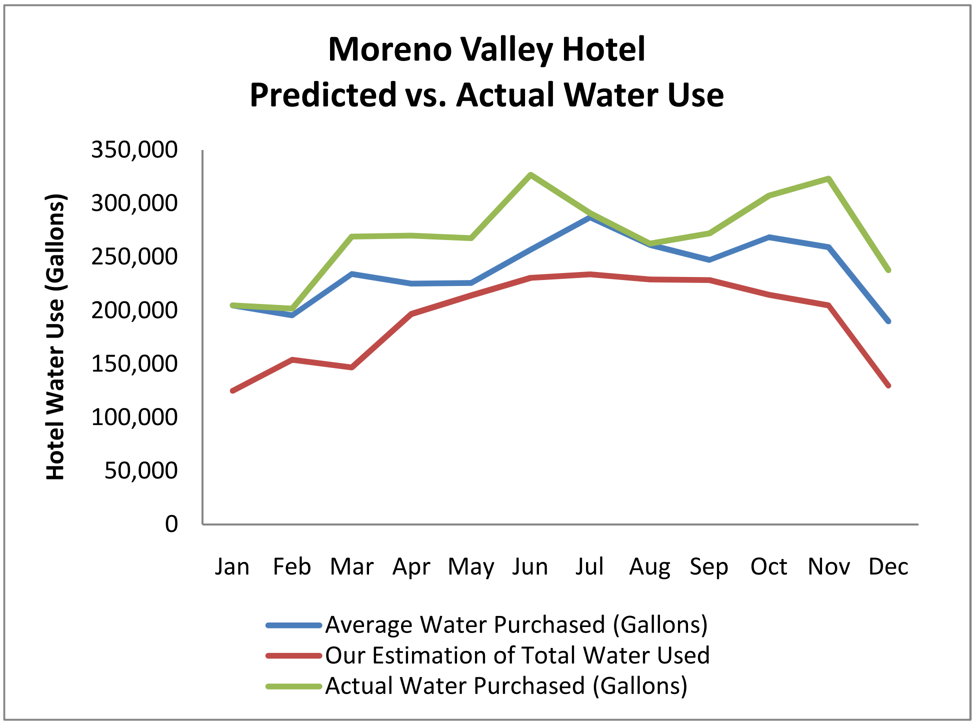

Figure 52 Modeled versus actual Moreno Valley Hotel water use

A large source of variation comes from mismatching and averaging of data. Often times collecting water, energy, natural gas, and occupancy information resulted in non-overlapping data sets or instances in which some information was more complete than others (for example three years of occupancy information and 1.5 years of water use for the same hotel). As a result, our analysis averaged all data available in order to produce the best approximation of normal usage. However being that at best we received 3 years of utility and occupancy information, and more often we received much less; it's natural that with the small amount of available data the variance between the mean of our monthly water data and model based on averaged data will be large. As Figure 53 below shows, the yearly variation in water use is in some cases as large as the discrepancy between our modeled hotel water use and the actual water use.

Figure 53 change in actual monthly water use versus percent difference in modeled use

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**TOTAL**
Goleta Hotel	Percent Change in Actual Water Use from 2008-2009	-36%	28%	-41%	-24%	-22%	-33%	-20%	-11%	-23%	-10%	-12%	17%	-14%
	Percent Difference Between Modeled and Average Water Use	-33%	-30%	-28%	-23%	-13%	-24%	-20%	-31%	-25%	-36%	-38%	-40%	-28%
	Percent Difference Between Modeled and 2009 Water Use	-21%	-40%	-13%	-14%	-3%	-12%	-13%	-28%	-16%	-33%	-34%	-45%	-23%
Santa Barbara Hotel	Percent Change in Actual Water Use from 2008-2009	-10%	-26%	-27%	-71%	-98%	-81%	-82%	-32%	-70%	-115%	-80%	-62%	-59%
	Percent Difference Between Modeled and Average Water Use	-62%	-57%	-37%	-25%	-32%	-25%	-18%	-30%	-43%	-34%	-59%	-50%	-39%
	Percent Difference Between Modeled and 2009 Water Use	-60%	-52%	-28%	2%	2%	5%	15%	-19%	-24%	4%	-42%	-34%	-21%
Moreno Valley Hotel	Percent Change in Actual Water Use from 2008-2009	65%	6%	26%	33%	31%	43%	3%	1%	18%	25%	40%	40%	28%
	Percent Difference Between Modeled and Average Water Use	-39%	-21%	-37%	-13%	-5%	-10%	-19%	-12%	-8%	-20%	-21%	-32%	-19%
	Percent Difference Between Modeled and 2009 Water Use	-39%	-24%	-46%	-27%	-20%	-30%	-20%	-13%	-16%	-30%	-37%	-45%	-29%

Secondly, while our model attempted to include most major water usage, a small portion of the discrepancy between our model and actual use can be attributed to water leakage and "miscellaneous" – a category which equaled 6 percent of the total hotel water use in Ploeser et al.'s survey of water use at seven hotels, including one in Ventura, California. Possible inclusions in this category could be related to extra water use from cleaning guest rooms and facility areas, as well as use associated with conference and events at the hotel for which guests do not stay overnight.

Finally, our modeled hotel water use deviates from actual water usage in part because we designed it using deliberately conservative assumptions. It is because of this we would expect our modeled usage to generally conform to the monthly change in actual usage, but always be less than the actual usage – an expectation which Figures 50, 51, and 52 above validate.
A close but conservative estimate to water usage is important because it helps produce confidence in our calculations of energy usage that are based on modeled water use, such as natural gas used for heating water, and energy used to produce, sanitize, transport, and treat waste water. See relevant appendices for confidence in assumptions governing water-related direct electricity use related to laundry machines, pool pumps, and dishwashers.

In sum, while our analysis deviates from our case study hotels' actual water use, our conservative assumptions regarding end use have consistently caused us to consistently under-predict water usage across all three case study hotels, but within the boundaries of the percent change in actual yearly water use based on billing data.

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