Codes and Standards Enhancement (CASE) Initiative For PY2009: Title 20 Standards Development

Title:

Analysis of Standards Options for Landscape Irrigation Controllers

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TABLE OF CONTENTS

1 Executive Summary

The Pacific Gas and Electric Company (PG&E) Codes and Standards Enhancement (CASE) Initiative Project seeks to address efficiency opportunities through development of new and updated Title 20 standards. Individual reports document information and data helpful to the California Energy Commission (CEC) and other stakeholders in the development of these new and updated standards. The objective of this project is to develop CASE Reports that provide comprehensive technical, economic, market, and infrastructure information on each of the potential appliance standards. This CASE report examines the potential savings from equipment standards in California that address landscape irrigation controllers.

A significant amount of water in California is used for outdoor landscape irrigation. The California Department of Water Resources (DWR) reported that in 2000, cities and suburbs used about 8.7 million-acre feet (MAF) of water (DWR 2005). Approximately one-third of water used by urban areas – 3 million acre-feet (MAF) – was applied to residential and commercial, institutional, and industrial (CII) landscapes in 2000.[1] In California, the water used to water lawns and gardens generally accounts for anywhere from 30-60% of household's potable water use. A 2003 Pacific Institute study found that significant improvements in landscape irrigation efficiency (25 -40%) could be achieved in California, cost-effectively, through a combination of better management practices, landscape design and improved hardware (Gleik et al. 2003).

Irrigation controllers, which can more efficiently schedule landscape irrigation, have shown strong promise for reducing potable water use, which in turn, can also reduce statewide energy consumption. This is because a significant amount of energy is used, or "embedded" within California's water system. Energy is required a various points along the water-supply chain, e.g., for extraction, conveyance, treatment, distribution to customers, and in some cases, treatment and disposal (e.g., CEC 2006, CEC 2005). The movement and treatment of water is an important component of electrical demand; water-related electrical demand exceeds 2,000 megawatts (MW) on peak days in California (CEC 2007).

In addition to this embedded-energy component, most irrigation controllers either plug-in or are hard-wired to the electricity grid, and consequently, consume electricity at their point-of-use. It is important that any potential appliance standard in California be evaluated from a perspective that considers the potential water savings and associated embedded-energy savings, as well as any potential direct energy savings. The analysis presented in this report has been designed to do this, and considers both potential water savings and net energy savings (where net energy savings is the combination of embedded and direct energy savings).

This report evaluates the potential savings from, and cost-effectiveness of, an appliance standard that would require all new irrigation controllers sold and installed in California to be "smart" irrigation controllers. Based on the analysis presented in this report, which assumes homes on average can achieve a relatively modest 7.3% reduction in irrigation from replacing an existing conventional controller with a smart controller, we find that at this time, such as standard is generally not cost-effective. However, additional water-savings from the status quo can be achieved cost-effectively with rain shut-off devices. We recommend the CEC require that all new landscape irrigation controllers, effective January 1, 2011, be sold with a rain shut off device. This requirement would be cost-effective even in the drier areas of California and will result in significant water and energy savings. Preliminary estimate over the total water and associated embedded-energy savings are also significant: upon full stock turnover, we estimate water savings would be on the order of 45,000 million gallons, along with annual (embedded) energy savings of 135 GWh and a 13 MW reduction in peak demand.

[1] Landscape water use is generally poorly understood and measured as a result of methods of calculation, lack of real data, limited metering, uncertainties in landscape area, and other variables (Gleik et al. 2003).

The findings presented and discussed in this study also suggest that a smart-controller-based standard which does not address the standby use of the controllers, would likely lead to a net *increase* in annual electricity use (about 10 GWh, upon full stock turnover), assuming the average energy-intensity of water applied outdoors in urban areas is about 3.01 kWh per 1,000 gallons. However, we also stress that this finding is highly sensitive to whether an average or a marginal energy-intensity of water is applied in these calculations. If a marginal estimate of energy-intensity is applied, the net increase annual energy consumption we cite above becomes a net *savings* of about 84 GWh upon stock turnover. These results also help highlight that the potential tradeoff between the embedded energy and site energy is a non-trivial issue for this rulemaking. In particular, standby mode power of an irrigation controller is the main determinant of the controller's annual direct-energy consumption, and can range widely from under one watt to nearly ten watts. We recommend the CEC adopt a test and list requirement for irrigation controllers and add-on devices, for standby mode power. This testing should be carried out using the established International Electrotechnical Commission (IEC) test procedure for measuring standby power.

2 Product Description

An automatic in-ground landscape irrigation system consists of four basic components: 1) the timer or controller, 2) irrigation valves, 3) underground piping, and 4) sprinkler heads or other emission devices (see Figure 1). Automatic irrigation systems offer a modern convenience for busy homeowners, but they can also lead to over-irrigation and waste. The Water Conservation in Landscaping Act (Assembly Bill 1881) was enacted in 2006 in California. Among its provisions, AB 1881 requires the California Energy Commission (CEC), in consultation with the DWR, to adopt performance standards and labeling requirements for landscape irrigation equipment "to reduce the wasteful, uneconomic, inefficient or unnecessary consumption of energy or water."[2] In accordance with this directive, the CEC has opened a proceeding to evaluate performance and labeling requirements for certain types of irrigation equipment (CEC 2009). This CASE report addresses several potential standard and test requirements for irrigation controllers.

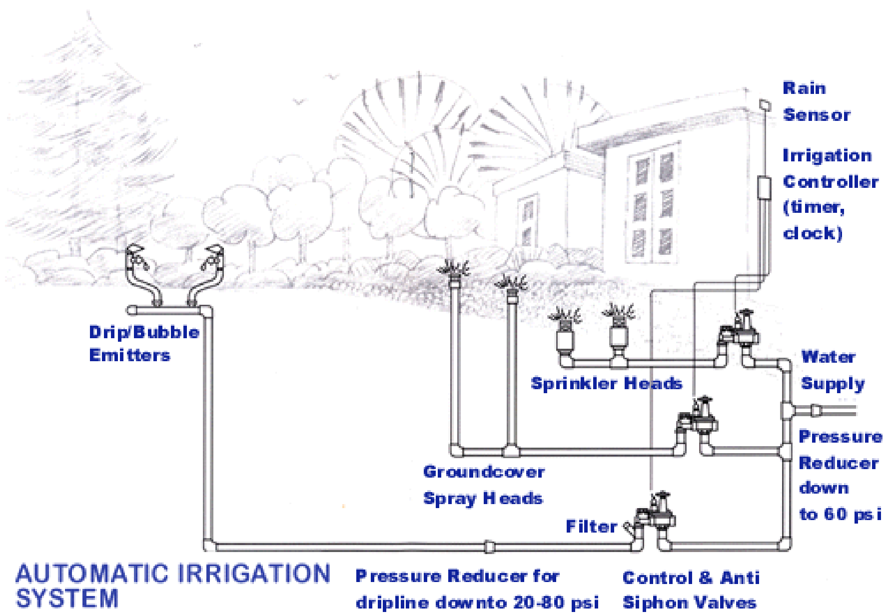

Figure 1. Schematic of a typical in-ground automatic irrigation system.
Source: http://www.portlandct.org/water/Irrigation.htm

Irrigation controllers are often considered the "brains" of an irrigation system and are generally programmed to control the frequency of irrigation, the start time, and the duration of watering, for different stations. Some controllers also offer a shut-down feature that can be activated by a user when it is raining, a rain-delay feature that turns off the irrigation system for a specific number of days, water-budgeting feature which adjusts normal run times without needing to manually reprogram each individual station, and input terminals for connecting external sensors (Rain Bird 2009).

Over time, landscape irrigation equipment has evolved from electromechanical devices that use electrically driven clock and mechanical switching (gears) to activate irrigation systems, to electronic controllers, which use microprocessors to provide the clock/timers, memory and control functions. There

[2] Specifically, this legislation directs the CEC to set performance standards and labeling requirements for landscape irrigation equipment including but not limited to, irrigation controllers and moisture sensors by January 1, 2010 that would be effective January 1, 2012. AB 1881 also requires the CEC to prepare and submit a report to the Legislature by January 1, 2010 with a schedule for adopting performance standards and labeling requirements for emission devices and valves.

are two basic control strategies: open-control loop systems and closed-control loop system (Zasueta, Smajstria and Clark 2008). With open-control loop systems, the controller implements an irrigation schedule that is pre-set by the operator. With a closed-control loop system the operator also typically sets a general irrigation schedule. However, once the general strategy is defined, the control system takes over, and using feedback from one or more sensors or receiving devices, makes decisions on when to apply water and how much water to apply.

The latest generation of irrigation controllers is commonly referred to within the irrigation industry as "smart" or "ET" (short for evapotranspiration) controllers, which are closed-loop systems. These controllers were originally applied nearly exclusively to agricultural or large commercial irrigation applications, but more recently have become affordable enough to be used in residential and lighting commercial applications. Smart controllers use weather and/or site information as a basis for determining the irrigation scheduling, thereby eliminating the need to make manual scheduling adjustments.[3] Studies indicate that replacing a traditional controller or timer with a smart controller can generate significant water savings. On average, smart controllers have been shown to save 7-25% in residential applications, and in non-residential applications (e.g., light commercial, public areas), slightly higher water savings of 21-41% have been reported (DOI 2008).[4] Most recently, the evaluation report from California's weather-based "smart" irrigation controller programs (which included results from over 2,000 smart controller sites across California) found that on average, a sites water use was reduced by about 6.1% after a smart controller was installed (Meyer et al. 2009). Among residential single-family sites, the average savings was somewhat larger, about 7.3%.[5]

In general, smart controllers can be classified into two categories:

> *Weather-based (sometimes also called climate-based) controllers*[6] operate by scheduling irrigation as a function of weather conditions, using real time or pre-programmed historical weather data to schedule irrigation based on evapotranspiration (ET), which is a function of plant type and weather conditions. ET is the quantity of moisture which is evaporated from the soil and plant surface and transpired by the plant. With some controller models, the controller receives regular updates (via radio, telephone, cable, cell, web, etc.) from local weather station or network of weather station. Other controllers use on-site weather sensors to gather site weather data to calculate real time factors (rainfall, humidity, solar radiation, wind), and may also use stored historical information based on the site location (e.g., zip code). Weather-based controllers are available as either a stand-alone controller, which is designed to replace a traditional controller or timer, or as an add-on controller which worked in coordination with an existing, compatible conventional controller.

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[3] The Irrigation Association (2007) defines a smart controller as: "Smart controllers estimate or measure depletion of available plant soil moisture in order to operate an irrigation system, replenishing water as needed while minimizing excess water use. A properly programmed smart controller requires initial site specific set-up and will make irrigation schedule adjustments, including run times and required cycles, throughout the irrigation season without human intervention."

[4] Care should be taken when comparing the results from individual studies, as the study design, scope, and methodology may widely differ.

[5] The evaluation report included results from 2,294 smart controller sites. In the study, 56.7% of sites had a statistically significant reduction in weather-normalized irrigation application ratios, while 41.8% of sites had a statistically significant reduction in weather-normalized irrigation application ratio. The remaining 1.5% of sites had no statistically significant change. Increases in site water use are discussed further in Section 4.2. The Application Ratio is a measure of how closely irrigation application at a site matches the theoretical irrigation requirement, which was estimated from nearby ET weather stations). The level of excess or under irrigation before the smart controller was installed, was the most important factor in whether or not the site increase or reduce water use after installing a smart controller.

[6] The Irrigation Association uses the term "climate-based controllers" although they are commonly also referred to as "weather-based controllers"; please note that we use these terms interchangeably throughout this report.

Soil moisture based controllers rely on one or more soil moisture sensors which use a variety of techniques to estimate the water content of soil and adjusts irrigation schedule accordingly, to maintain adequate soil moisture levels. Most soil-moisture based controllers currently available function as an add-on to an existing timer-based controller, although some models are available that function as a stand-alone controller.

Figure 2 shows some examples of commercial available smart controllers.

	**Weather-Based Controller (Signal-Based)** *Example:* Toro Intelli-Sense series includes both indoor models and outdoor models (pictured), for 6,9,12 and 24 zones. These controllers use WeatherTrack-enabled software to zone-specific irrigation schedule, which is updated daily using weather data delivered by the ET Everywhere subscription service. *Source:* http://www.toro.com/irrigation/res/smturfcont/intelli/
	**Weather-Based Controller (On-Site Sensors, Add-on Device)** *Example:* Hunter ET System is an add-on system that is compatible with most Hunter controller models that are less than ten years old. The ET System creates an irrigation program based on weather conditions measured on-site conditions (solar radiation, air temperature, relatively humidity, and optional anemometer). *Source:* http://www.hunterindustries.com/Products/Controllers/etintro.html
	**Soil-Moisture Based Controller** *Example:* Acclima SC6 Indoor Controller designed for residential and light commercial applications, and uses a Acclima Digital TDT® Moisture sensor to control irrigation and save water. *Source:* http://www.acclima.com/item.aspx?Id=10
	**Weather-Based Controller (Signal-Based, Add-On Device)** *Example:* Rain Bird ET Manager is an add-on device that works with almost any existing irrigation controllers. The ET Manager receives weather data in the form of an hourly broadcast, through a local Weather Research Signal Provider, to adjusts watering needs according to real-time weather data. *Source:http://www.rainbird.com/landscape/products/controllers/etmanager.htm*

Figure 2. Select Examples Commercially Available of Smart Controllers

Traditional automatic irrigation systems, as a rule-of-thumb, are generally considered to operate with an efficiency of 50% or less (Hanak and Davis 2006).[7] Smart controllers are designed to better match irrigation to the plant's actual water requirements, thereby in theory, reducing the amount water that is applied, through more precise irrigation scheduling. As a result of improved scheduling, smart controllers seek to eliminate the "wasted" water that is applied but not effectively used by the plant,

[7] According to the California Department of Water Resources, irrigation efficiency is defined as the amount of water beneficially used divided by the amount of water applied. Irrigation efficiency is derived from measurements and estimates of irrigation system characteristics and management practices" (DWR 2009: 5).

and is instead lost to deep percolation, runoff, or evaporation. In practice, smart controllers save water by eliminating or at least reducing the need for people to make constant manual adjustments to achieve a more optimal irrigation schedule. For example, the smart controller can save water by automatically adjusting for changing irrigation requirements as the season changes from late summer into fall (over which time a landscape's ET requirements will significantly decline) and not depending on homeowners or gardener to make that adjustment.

However, proper installation, programming, and even some "tweaking" is critical for fully achieving the water savings potential from a smart controllers. This initial programming step varies in length and complexity for each smart controller and will require the user to input a variety of factors for each station to be programmed into the controller (e.g., plant type, soil type, sun exposure, irrigation type or application rate, root depth, slope, etc.)

Earlier studies have found that residential outdoor water use varies widely both nationally and in California. For example, an average home in Las Virgenes California uses approximately 230 kgal annually for outdoor irrigation. On the other hand, an average home in Lompoc California uses only a fraction of this – about 40 kgal each year – for outdoor irrigation. Outdoor irrigation water use is a function of many different parameters including, but not limited to: landscape size and plant types, plant groupings, geographic location and weather conditions, landscape design, proper equipment installation, operation and maintenance. There are significant opportunities to reduce the amount of potable water applied to landscapes, while still maintaining the health of the landscape. Irrigation controllers can reduce excess water use by improving irrigation scheduling, but they are just one component of an automatic irrigation system.

Electronically-driven irrigation controllers also require energy. Most landscape irrigation controllers are connected to the building's mains power. In the event of a power outage, many irrigation controllers have a back-up battery and/or non-volatile memory to maintain clock and preserve settings, until power is restored, but cannot activate the irrigation system (valves) during this time.[8] Irrigation controllers typically use 24 volt alternating current (VAC) to operate solenoids, which open and close the irrigation valves. When the solenoid is actuated, the water above the diaphragm is relieved when the valve opens. The valve then closes when the controller ceases to send electric current to the solenoid.

Controllers use an AC-to-AC power supply that converts 110-120 VAC line voltage to 24 VAC required by most by solenoid valves. Controllers will have a secondary power supply to convert alternating current to, typically five volts direct current to power the control electronics of the controller.[9] Landscape controllers can be installed either indoors or outdoors. Indoor controllers use external power supplies (sometimes referred to as "wall warts" or "power brick"), while outdoor controllers have a power supply located inside a weather-resistant/tamper-proof metal or plastic controller cabinet (i.e., an internal power supply) and are hard-wired to the mains power (Figure 3). Based on discussions with industry representatives, we estimate that the majority, roughly 75% of landscape irrigation controllers used in residential sector are currently indoor controllers.

[8] Some controllers are battery operated, e.g., Alex-Tronix controller operates on a pulsed 9 volts of direct current from a lithium battery.

[9] e.g., Patent #6694223 "Irrigation controller" Issued February 17, 2004 to the Toro Company. <http://www.google.com/patents?id=GmcSAAAAEBAJ&printsec=abstract&zoom=4&source=gbs_overview_r&cad=0>

Figure 3. Indoor irrigation controller with an exterior power supply (left) and an outdoor irrigation controller with an interior power supply (right).

Rain shut-off devices can be connected to an irrigation controller and are designed to interrupt a scheduled cycle of an automatic irrigation controller when a certain amount of rainfall has occurred. The majority of weather-based irrigation controllers are sold with a rain shut-off device (DOI 2007: 124-125). These devices use a rain gauge or rain sensor to measure the amount of rainfall. The most commonly used method is expansion disk sensors due to their high reliability and low maintenance requirements (Dukes and Haman 2002), and shown in Figure 4. An expansion disk device uses hydroscopic expanding material (cork disks) that expands proportionally to the rainfall amount; this expansion triggers a pressure switch then overrides the irrigation system when adequate rainfall has been detected. The switch will remain open, until the disks begin to dry out. Other types of rain sensors use a receptacle to collect the water and then either weight the water or detect water level with a set of electrodes. A more recent development is for a rain shut-off device to be radio-controlled or wireless, where the wireless rain sensor has a sensor and transmitter which is installed in an area subject to rainfall and a receiver unit is mounted next to, and connected to, the irrigation controller. Wireless sensors can prove a more convenient approach than rain sensors that are designed to be wired directly to the controller and as a result typically need to be mounted in more difficult-to-access location (e.g., near the roof or side of a building).

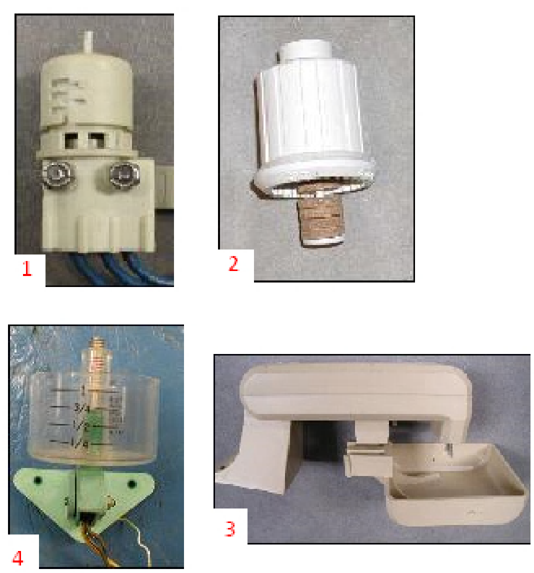

Figure 4. Types of Rain Sensors (*clockwise from upper left*)
(1) rain shutoff device with expanding material; (2) rain shutoff device with expanding material, with cap removed to expose expanding material; (3) weight rain shutoff device that collects water and uses electrodes to detect the amount of water collected in the receptacle; and (4) rain shutoff device that collects water and operates based on water weight. *Source:* [*http://edis.ifas.ufl.edu/AE221*](http://edis.ifas.ufl.edu/AE221)

3 Manufacturing and Distribution Channel Overview

The three largest manufacturers of irrigation equipment – Toro, Hunter, and Rain Bird – all currently offer smart controllers, in addition to conventional controllers (timers). Among the smart controllers offered by the major manufacturers, Toro's Intelli-Sense controller entered the market in 2005, and Hunter's ET System, Rain Bird's ET Manager both came on the market in 2006 (DOI 2007). Rain Bird also recently introduced a Rain Bird ESP-SMT Smart Controller System (Rain Bird 2009a).

In addition to these manufacturers, as of 2007, the U.S. Department of Interior (DOI) Bureau of Reclamation report *Weather and Soil Moisture Based Landscape Irrigation Scheduling Devices, Technical Review Report – 2nd Edition*, provided summaries of products for approximately 25 additional manufacturers. As a point of reference and testament to the growing market for smart controllers, the first DOI technical report (2004) *Weather Based Technologies for Residential Irrigation Scheduling, Technical Review Report* presented summarizes on controllers from only seven manufacturers. A number of smart controller manufacturers are relatively young companies, having been incorporated within the last ten years (DOE 2007).

The Irrigation Association (IA) has organized a Smart Water Application Technologies (SWAT) initiative, which functions as a national partnership between the irrigation industry and water purveyors, to promote more efficient landscape water use through the use of state-of-the-art irrigation technologies. Smart irrigation controllers are the first product that SWAT has begun to develop testing protocols and reporting requirement for. An increasing number of water agencies in California and in other parts of the country currently offer rebates for the smart controllers. For example, East Bay Municipal Water District (EBMUD) currently offers a $100-200 rebate on smart controllers, depending on levels of outdoor irrigation use.[10] Moreover, PG&E and the other California investor owned utilities (IOUs) are currently partnering with water agencies throughout California to implement embedded-energy pilot programs that will document the potential for competitive embedded energy efficiency savings.[11] In conjunction with these California Public Utility Commission (CPUC)-approved pilots, a series of studies are currently being carried out to further examine the relationship of water and energy in California.

As of July 2009, the U.S. Environmental Protection Agency (EPA) WaterSense program is in the process of developing a specification for a new voluntary labeling program that is expected to include both weather and sensor-based irrigation control technology (EPA 2009). This WaterSense program has been modeled on the highly successful Energy Star program, and the EPA reports that products bearing the WaterSense label will generally be 20 percent more water-efficient than similar products in the marketplace. The first draft of the WaterSense specification for irrigation controllers (which is expected to cover both weather- and soil-moisture base-controllers, as well as add-on devices) will likely be released sometime in the second half of 2009 for public comment.

4 Energy and Water Usage

4.1 Test Methods

4.1.1 Current Test Methods

[10]See program details here: http://ebmud.com/conserving_&_recycling/residential/WSIC/default.htm

[11] For more information on embedded-energy pilots and studies, see < http://www.pge.com/includes/docs/pdfs/shared/edusafety/training/pec/water/mikhail-haramati_cpuc_water_energy_pilot_presentation_3_24_09.pdf >

The IA SWAT initiative has completed testing protocols for climate-based controllers, and is currently developing testing protocols for soil-moisture sensor-based controllers, add-on controllers and rain sensors.[12]

The latest version of the protocol for climate-based controllers (8th Testing Protocol) was published in September 2008 for public comment. Under this protocol, climate based irrigation controllers are tested using a virtual landscape with six individual zones to represent a range of exposure, soil types and agronomic conditions, which is subjected to a representative climate. After initial programming, the controller is evaluated on how well it performs without further human intervention. The performance results indicate how well the controller has maintained the root zone moisture within an acceptable range. Following from this test procedure irrigation adequacy and irrigation excess are calculated. Irrigation adequacy represents how well the irrigation met the needs of the plant material. This is the percentage of required water for turf or plant materials, which is supplied by rainfall and controller-scheduled irrigation. Generally, research has suggested that the quality of vegetation can be maintained with irrigation adequacy of between 80 and 100%.

The second SWAT metric, irrigation access, represents the percent of water that is applied to the zone, in excess of 100% of the required water according to data from a specified California Irrigation Management Information System (CIMIS) station.[13] Thus, irrigation excess conveys how much extra water was applied, beyond the needs of the plant. The California Institute of Technology in Fresno currently serves as the testing center for climate based controllers. As of June 2009, testing resulting from 20 climate-based controllers have been posted on the SWAT website (testing results are posted at the discretion of manufacturers, so some controllers may have been tested but the results have not been made public; some controllers may also been tested, and then re-tested, before the results are posted). Some water agency rebate programs for smart controllers have required the SWAT testing results be made public for the controller to qualify for the rebate program, which has incented manufacturers to make these reports publicly available.

A protocol for testing the soil-moisture based controllers is also being developed in two phases. Phase 1 testing protocol evaluates how well the soil-moisture sensor functions over a range of conditions that affect moisture (e.g., soil type, temperature, salinity). The latest test protocol is Phase 1, Draft 7. Phase 2 of this test procedure, currently under development, will focus on the soil-moisture sensor based controller. A protocol for rain-sensors is also currently being developed by SWAT.[14]

There currently is no established test method for measuring the direct energy use of a landscape irrigation controller. External power supplies used with irrigation controllers, used to convert line voltage to 24 VAC, are covered under the federal standard for Class A external power supplies that operate consumer products and the California standard for state-regulated external power supplies (CEC 2008), and it is assumed most external power supplies are being sold with irrigation controllers are regulated under this standard. The test method for Class A federally regulated and state-regulated power supplies is U.S. EPA *Test Method for Calculating the Energy Efficiency of Single-Voltage External AC-DC and AC-AC Power Supplies*, dated August 11, 2004 except that the test voltage specified in Section 4(d) of the test method is 115 volts, 60 Hz (CEC 2008). The efficiency of internal power supplies is not currently regulated by either federal or state appliance efficiency standards. A test procedure for internal power supplies has been developed, *General Internal Power Supply Efficiency Test Protocol (Rev 6.4.2)*, although this test

[12] SWAT also plans to develop similar programs for a variety of water-efficiency irrigation equipment products on the market, including matched precipitation rate nozzles, flow control nozzles, pressure regulators, multi-stream rotating nozzles, high flow shut-offs and drip and micro irrigation technologies (SWAT 2008).

[13] CIMIS is a program within the CA Department of Water Resources that manages a network of over 120 automated weather stations in the state of California. < http://wwwcimis.water.ca.gov/cimis/welcome.jsp >

[14] < http://www.irrigation.org/SWAT/Industry/default.aspx?pg=drafts-rainsensor.htm >

procedure currently only covers AC-DC and DC-DC power supplies, while most irrigation controllers use an AC-AC power supplies. [15]

The International Electrotechnical Commission (IEC) has a test procedure for measuring standby power entitled, 62301 *Household electrical appliances – Measurement of standby power* (First edition, 2005-06).[16] This test procedure provides method of test for determining the power consumption of a range of appliances and equipment, when operated in standby mode. The standard defines "standby" mode as the lowest power consumption when connected to the mains. This testing protocol can be applied to measuring a variety of household appliances and electrical devices.

4.1.2 Proposed Test Methods

For irrigation controller scheduling and water application related-requirements, we recommend the CEC use the most recent version of the SWAT test procedure for climate-based irrigation controllers (8th Testing Protocol) discussed above which was developed through a industry consensus process, and also consider future SWAT protocols for soil-moisture sensor-based irrigation controllers, rain-sensors, and add-on devices, if they are finalized by industry by the end of 2009 in time to be relevant to the current CEC rulemaking proceeding.

Currently, there is no test method specifically for measuring controller energy use, either in standby or active mode. However, the IEC 62301 test procedure discussed in the previous section provides a general approach applicable to measuring the power consumption of household electrical appliances when in standby mode. We propose that this procedure, along with definitions specific to irrigation controllers be used to test standby power of irrigation controllers and recommend the CEC require a "test and list" under which manufacturers would be required to test the standby power of irrigation controller models offered for sale in California, and submit this data to the CEC.

4.2 Baseline Energy and Water Use Per Product

Irrigation controllers are an integral part of any automatic irrigation system. They automatically operate an automatic irrigation system and provide a means for setting an irrigation schedule (i.e., frequency and duration of irrigation, time of day, etc.). Our baseline in this analysis is an irrigation controller installed at a single-family residential home in California; we've analyzed small (< 1 acre) single-family lots and large (1-20 acres) single-family lots separately, since the size of the landscape has a significant impact on the water savings potential and economic analysis. The analysis presented in this report is focused exclusively on single-family residential homes since they are the largest end-use of for outdoor water (Hanak and Davis 2006) and represent approximately 70% of all housing units in California (US Census 2000).

The total water use for landscape irrigation of single-family homes in California was developed through a water budgeting approach, using data on average single-family home lot size throughout 22 counties in California, estimated reference evapotransporation rate (ET_o) for each county, and some further assumptions on plant types and irrigation efficiency. This methodology, in part, leverages the data and approach applied in a 2006 study by the Public Policy Institute of California entitled *Lawns and Water Demand in California* (Hanak and Davis 2006).

Data on small-and large- single-family home lots in California are presented in a separate appendix Hanak and Davis (2006) study. This dataset was developed from county assessors' office records; Hanak

[15] Test method available online at < http://www.efficientpowersupplies.org/methods.asp >
[16] The IEC is also close to completing a revised version of this test procedure; it's anticipated the new version will be available sometime in August 2009, and if it is published on schedule, we will most likely recommend this version be cited.

and Davis made some further assumptions to compensate for missing information and these assumptions are discussed in the abovementioned appendix.

In this study, calculations were performed at the county level and then aggregated over the 22 counties using weighted averages based on housing stock. Specifically, results for a small-lot single family home in California and a large-lot single-family homes across California were computed from individual county calculations that were weighted by a county's share of housing within the 22 counties. Results for a typical average single-family home in each county were calculated based on the mix of small- and large-lots in that county,[17] and then aggregated over the 22 counties using the weighted average based on housing stock. According to the 2000 U.S. Census, the single-family housing stock in the 22 counties that have been explicitly modeled in this analysis represent about 88% of California's single-family homes. A simple linear extrapolation was applied to calculate statewide results from the results for the 22 counties, using an adjustment factor of 1.14 (calculated by taking 1.0/ 0.88).

Yard size was estimated as the lot-size minus an estimated building footprint of 1,500 sq-ft.[18] Following from Hanak and Davis, we also assumed 35 percent and 10 percent of small-and large-lot yards, respectively, are irrigated (the remainder covered by either hardscape or non-irrigated landscape). Accordingly, our assumed irrigated landscape, per home was approximately 3,000 square feet (small lots), and 12,300 square-feet (large lots).

The annual irrigation requirements for an average small and an average large single-family lot in each county were calculated separately by multiplying the irrigated area for each size lot, by a reference crop evapotranspiration rate (ET_o, an indicator of how much water a standardized grass requires for healthy growth and productivity, expressed in gallons per square foot of landscaped area[19]) and then by an ET adjustment factor (ETAF). The ETAF is used to estimate the amount of water the landscapes actually use by taking into account plant type (i.e., not everyone plants the standardized cool-season turf grass) and irrigation efficiency (i.e., not every drop of water applied to the landscape is used productively by the plant; some is wasted as run-off, deep percolation into the soil, etc.). This adjustment factor is calculated by dividing the plant factor by the irrigation equipment efficiency.

In this report, an irrigation efficiency rate of 62.5% and a plant factor of 50% (which reflects a landscape with a mixture of 1/3 high-, 1/3 medium-, and 1/3 low-water using plants) were assumed based specifications in the existing California Model Water Efficient Landscape Ordinance (DWR 1992). As a result, an ETAF of 80% has been used throughout the analysis (calculated from 0.50/0.625). Average irrigation needs were calculated by multiplying ETAF by the average county-specific ET_o rate, and irrigation area. Finally, we assumed 25% of the annual irrigation requirement was met with rainfall (Hanak and Davis 2006), in order to calculate the baseline irrigation per landscape.

While California law requires an irrigation efficiency rate of 62.5%, discussions with industry professionals indicate the majority of these systems do not currently meet these requirements.[20] Based on

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[17] The share of large lots of total lots in any of the given 22 counties varied widely from 0% in San Francisco County, to 49.7% in El Dorado County. Across the 22-counties that have been analyzed explicitly in this report, an average of 8.5% of residential single-family lots falls into the large lot (1-20 acre) category.

[18] Hanak and Davis (2006) reported in their appendix that estimated building footprints (estimated from building square footage divided by the number of stories) across the state were similar across all regions of the state, and were generally between 1,400 and 1,500 sq-ft. This appendix is available online at: < http://www.ppic.org/content/other/706EHEP_web_only_appendix.pdf>

[19] Note that ET_o is typically reported in inches per year, but Hanak and Davis reported this in gallons per square foot of landscaping.

[20] California Assembly Bill 1881 required that the state Model Water Efficient Landscape Ordinance be revised; the revised ordinance, which becomes effective in all localities on January 1, 2010, increases irrigation efficiency from 0.625 to 0.71 and maintains plant factor at 0.50.

the conservative nature of this and other assumptions made in this analysis, the baseline annual irrigation water used by a single-family residential controller and irrigation system shown in Table 1 is conservative.

The baseline water use for a typical residential single-family home in California (based on a weighted average of both small- and large-size lots), with an in-ground irrigation system and traditional irrigation controller is presented in Table 1. This table also shows the baseline water use, broken out for average small-and large-lots. Applying the approach described above, we estimate a single-home on an average small lot with an automatic irrigation system will use 59 kgal of water per year for irrigation, while a single-family home a average large lot will over four times as much, or 243 kgal. Considering both small lots and large lots together, we estimate the annual water use per home with an automatic irrigation system and conventional controller is approximately 69 kgal. It is important to note these estimates are rough at best; there is considerable variability across single-family homes in California with in-ground irrigation systems, and this variability will dramatically affect the annual outdoor water use.[21]

Table 1. Baseline Water Use, Embedded-Energy Use Per Controller

Traditional Controller	Average Et_o[b] (gal/sq-ft of landscaped area)	Average Yard Size (sq-ft)[c]	Per Controller Water Use (kgal./yr)[d]	Per Controller Embedded Energy Use (kWh/yr)[e]
Single-Family Home[a]	32.7	15,018	69	209
Average Small Lot	32.7	8,567	59	177
Average Large Lot	32.7	123,189	243	730

Source:
[a] Assumed one-irrigation controller is installed, per single-family home. Information presented in this table for a single-family home was calculated taking a weighted average of the percent of single family homes on lots <1 acre (small lots) and percent of single family homes on lots 1-20 acres (large lots), calculated from data in Davis and Hanak 2006. The percent of large lot in single-family homes ranged from 0% (San Francisco county) to 49.7% (El Dorado county).
[b] Calculated taking a weighted average of estimated ET_o rates in each 22 counties in California (Davis and Hanak 2006), where the weighting was based on the counties' proportion of all single-family housing units throughout the 22 counties (US Census 2000).
[c] Calculated from county data from Davis and Hanak 2006. In addition, we assume 35% and 10% of small and large lot yards, respectively, are irrigated.
[d] Calculated using approach described in Section 4.2, using {[(ET_o x ETAF x 0.75] x Average Landscaped Area } / (12 in./ft x 0.1337 ft^3/gal.)
[e] Assumes an average embedded energy-intensity of 3.01 kWh per 1,000 gal (PG&E 2003).

Table 1 also presents the amount of embedded-energy that is associated with this baseline water use. This calculation of embedded-energy was performed assuming an average energy-intensity of 3.01 kWh for each 1,000 gallons of water used, based on data and analysis used in an earlier PG&E CASE report for clothes washers (PG&E 2003). The statewide estimate for embedded-energy that was derived in this report was 4.1 kWh per 1,000 gallons of indoor water use, of which 1.09 was for wastewater treatment.[22] Since water used for irrigation does not typically undergo wastewater treatment processes on the back-end, we have subtracted the energy-intensity for wastewater treatment, leaving 3.01 kWh per 1,000 gallons.

[21] In the recently published evaluation report of the statewide controller rebate program, Mayer et al (2009) reported for residential sites, a median pre-smart controller annual water use of 111 kgal, and a mean of 287 kgal, considerably higher than the estimates we have developed, which also confirms the conservativeness of baseline water use estimates developed and used in this report.
[22] This was calculated through a top-down approach that assumed the total energy used to pump and treat water statewide, and estimates of statewide urban water use.

In reality, the energy-intensity of water varies considerably throughout the state, depending on its end-use and location. In particular, the energy-intensity of water used in the Northern California is about one-third that of Southern California, due to Southern California's heavy reliance on imported water and the associated high-energy requirements for conveyance. Currently, several water-energy studies are being conducted to further examine California's water-energy relationship at a more granular level; results from these studies will be valuable for further CASE studies and CEC appliance standard proceedings where there are potable water savings at stake.

For the purpose of this report, we used the *average* (as opposed to marginal) energy-intensity of water to estimate both the statewide baseline of embedded-energy associated with residential landscape irrigation, as well as the associated potential embedded-energy savings. The average energy-intensity represents the energy associated with the average water supply (i.e., the mix of water supplies currently being used in the state), while the marginal energy intensity reflects the energy that is embodied in the marginal water supply (i.e., in this case, the water source at the economic margin for the group of statewide water suppliers). The marginal energy intensity will generally be much higher than the average energy-intensity over the entire water supply. In developing our baseline embedded energy estimates, we applied the estimate of average energy-intensity in this section, since it is more appropriate than using a marginal estimate. However, due to the large difference between average and marginal energy-intensities (and the implication this has for the calculated potential statewide energy savings), we have also included embedded-energy savings estimates using *marginal* energy-intensity values.

The baseline direct energy use of an irrigation controller (Table 2) was estimated assuming an irrigation controller is connected to the grid continuously throughout the year and that a typical controller spends about 3% of time in active mode (operating the solenoid valve to irrigate) and 97% of the time in standby mode (Foster-Porter et al. 2006). According data collected by the Lawrence Berkeley National Laboratory (LBNL) and presented at a CEC technical workshop on irrigation equipment standards in 2009 (Brown 2009), a conventional residential controller uses about 2.1 watts in standby mode (Figure 5). The standby power of traditional controllers measured by LBNL ranged from just under 1 watt to approximately 3 watts. Assuming the duty cycle noted above and an average active mode power use of 8.8 watts, the annual energy use of an irrigation controller used at a single-family home is 20.3 kWh.

Table 2. Baseline Energy Use Per Controller

Traditional Controller	Power Draw (Standby)[b] (W)	Annual Operating Hours	Annual Electricity Consumption (kWh/yr)
Single-Family Home[a]	2.1	8766	20.3

Source:
[a] Assumed one-irrigation controller is installed, per single-family home.
[b] Standby power used based on Brown (2009); See Figure 5.

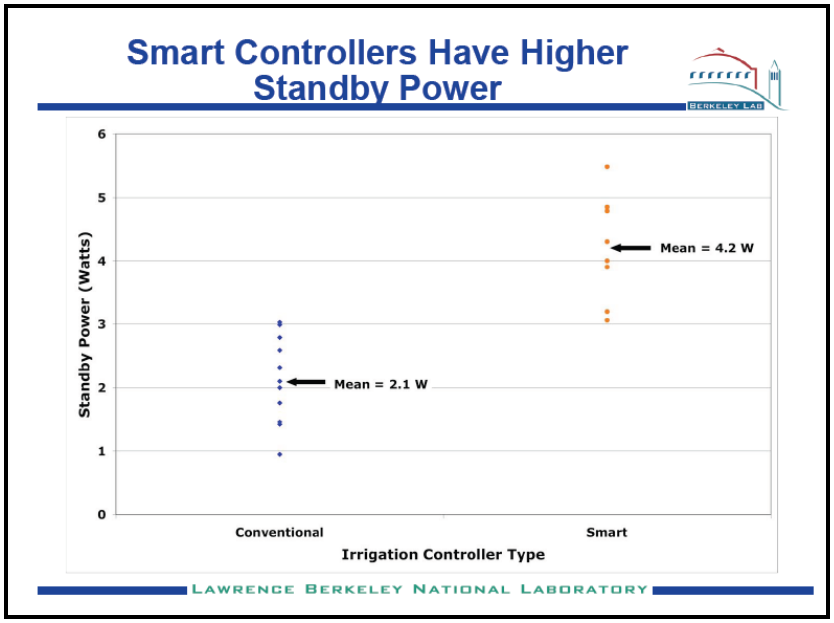

Figure 5. Standby Power Draw of Irrigation Controllers
Source: Brown 2009

4.3 Efficiency Measures

Smart controllers use weather and/or site-specific data to determine an irrigation schedule, thereby, eliminating or at least reducing the need for people to make constant manual adjustments to achieve a more optimal irrigation schedule. As discussed in Section 2, there are three primary types of smart controllers: 1) Weather-based controllers which accesses weather station data via a signal, 2) Weather-based controllers which rely upon on-site sensors and/or pre-programmed historical weather data, and 3) Soil-moisture based controllers which uses soil moisture sensors to estimate or measure moisture depletion in the soil. While these three types of controllers have fundamentally different approaches to estimating irrigation requirements, there is no data at this point in time to suggest a specific approach or design is better than another, from a water conservation perspective. Therefore, in this report, we've applied a average savings estimate of for all smart controllers, based on the average residential site savings reported in the recently published report *Evaluation of California Weather-Based "Smart" Irrigation Controller Programs* (Mayer et al 2009), and shown in Table 3. Since the scope of this analysis is single-family residential homes, we have used the average savings of 7.3%, which was the average weather-normalized change in outdoor water use for residential sites in this report.[23] The mean annual irrigation savings from residential sites was about 21 kgal (but with a large standard distribution of nearly 200 kgal), while median savings across residential sites was reported to be 4.8 kgal.

While we've used an average water savings in this report to manage the analytical complexity, it is also important to acknowledge that the actual water savings estimates for smart controllers vary widely from site-to-site. The single-biggest factor that influenced savings in the recent statewide evaluation report was found to be the pre-existing level of excess irrigation at a site. Meyer et al (2009) found that one year after replacing a traditional controller with a smart controller, 56.7% of sites reduced their water use

[23] The Mayer et al. (2009) study is the largest smart controller evaluation study conducted to date, and took place over the time period from 2004-2008. It includes results for 3,112 controllers in southern and northern California installed at 2,294 sites statewide. Each site met fundamental data requirements such as one full year of pre-and post installation billing data, corresponding climate data, measurements of landscape area, and other basic information about the site, controller, and installation process.

(statistically significant reduction weather-normalized irrigation application ratio) , 41.8% of cases i*ncreased* water use (statistically significant increase in weather-normalized irrigation application ratio), and 1.5% did not change use (no statistical change one way or another). It is also important to highlight that water savings were heavily influenced by the pre-smart controller application ratio. Sites watering above the theoretical ET requirements had an average pre-application ratio of 236.6%, while sites watering below the theoretical ET requirements had an average pre-application ratio of 55.2%.[24] Generally, sites with high application ratios and water use were more likely to save water than those with lower application ratios, who were usually watering at or below the theoretical plant requirement.

Table 3. Summary of the Weather-Normalized Change in Outdoor Water Use Found in the Evaluation of California Weather-Based Irrigation Controller Programs

	% Change	Mean (kgal./yr)	Std Deviation.	Median (kgal./yr)	Sample Size (n)
Residential	-7.3%	-21.1	197.0	-4.8	1987
Commercial	-5.6%	-228.9	1783.8	-49.2	297
Irrigation[a]	10.9%	108.3	231.1	39.7	11
All Sites	**-6.1%**	**-47.3**	**669.5**	**-6.5**	**2294**

Source: (Mayer et al. 2009: 103-4)
[a] Irrigation was the only category that did not have a statistically significant reduction.

In addition to the savings associated with smart controllers, rain shut off devices have also been shown to be a useful technology for achieving cost-effective water conservation (Cardenas-Lailhacar and Dukes 2008).[25]

4.4 Standards Options Energy and Water Use Per Product

Smart controller water use and embedded energy requirements, shown in Table 4, are calculated using the method described in Section 4.1 and assuming an average 7.3% per-site reduction in irrigation from replacing a traditional controller with a smart controller. Using a smart-controller, an average single-family home is estimated to annually use 64 kgal of water for irrigation, which requires an estimated 193 kWh of embedded-energy. [26]

Based on the data shown in Figure 5, smart controllers generally have a higher power draw in standby mode. The reason for this is not fully understood, but may be partially due to the larger power supplies that tend to be used by more of the smart controllers (i.e., higher maximum rated current, power), which would tend to result in higher standby losses than a controller that uses a smaller power supply. Brown (2009) reported that most of the smart controllers tested did not have external sensors attached, so the standby power load when these peripheral devices are wired to the irrigation controller and operational, may be higher in some cases. The effect of sensors and networking may vary between controller models. In this report it is assumed that a smart controller has an average power draw of 4.2 watts in standby, and an average energy consumption of 37.9 kWh (Table 5).[27]

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[24] The Application Ratio is a measure of how closely irrigation applications at a site matched the theoretical irrigation requirement determined from proximal ET weather stations (Mayer et al 2009).
[25] In addition, see further research and discussion on the savings potential of rain sensors, see < http://irrigation.ifas.ufl.edu/RS/RS.htm >
[26] Single-family home results are based on a distribution-weighted average of water savings and embedded-energy of single-family small lots (55 kgal/yr, 165 kWh/yr) and single-family large lots (225 kgal/yr, 667 kWh/yr).
[27] Further information and study may be necessary to make these findings statistically significant. For smart controllers, the time in standby or "ready" mode (the lowest power state, without being switched "off") will depend on how frequently the controller's sensors or receivers "wake up" to either download data from remote sources or take a process log/process a sensor reading, and whether or not these devices power down after they have finished downloading/processing this data. This could potentially impact power draw and its significance is currently not well understood.

Table 4. Standards Options Water Use, Embedded Energy Use Per Controller

Smart Controller	Average Et_o[b] (gal/sq-ft of landscaped area)	Average Yard Size (sq-ft)[c]	Unit Water Use (kgal./yr)[d]	Unit Embedded Energy Use (kWh/yr)[e]
Single-Family Home[a]	32.7	15,018	64	193
Average Small Lot	32.7	8,567	55	164
Average Large Lot	32.7	123,189	225	677

Sources:
[a] Assumed one-irrigation controller is installed, per single-family home. See Table 1, footnote a for additional assumptions.
[b] Calculated taking a weighted average of estimated ET_o rates in each 22 counties in California (Davis and Hanak 2006), where the weighting was based on the counties' proportion of all single-family housing units throughout the 22 counties (US Census 2000).
[c] Calculated from county data from Davis and Hanak 2006. In addition, we assume 35% and 10% of small and large lot yards, respectively, are irrigated.
[d] Calculated using approach described in Section 4.2, using {[(ET_o x ETAF x 0.75] x Average Landscaped Area } / (12 in./ft x 0.1337 ft^3/gal.)
[e] Assumes an average embedded energy-intensively of 3.01 kWh per1,000 gallons of water (PG&E 2003).

Table 5. Standards Options Energy Use Per Controller

Smart Controller	Power Draw (Standby)[a] (W)	Annual Operating Hours [b]	Unit Electricity Consumption (kWh/yr) [c]
Single Family Home	4.2	8766	37.9

Source:
[a] Brown 2009.
[b] Units are assumed to be plugged in 100% of the time.
[c] Note that although the estimated standby of a smart controller (4.2 W) is twice the standby of a conventional controller (2.1 W), the calculated annual energy use of a smart controller is less than 2x that of a conventional controller, due to assumptions on active mode power use and duty cycle. (We have assumed the duty cycle, and power in active mode is same for both conventional and smart controllers).

Currently, there is only limited data on the power consumption of irrigation controllers. Based on data collected by LBNL, the standby mode power of an irrigation controller (both conventional and smart controllers) ranges from just under 1 watt to approximately 5.5 watts (Figure 5). There are several additional data points on irrigation standby energy use that have been collected under prior studies funded by the CEC Public Interest Energy Research (PIER). First, as part of a PIER study on plug loads in California, Foster-Porter (2006) found that the average power use in standby mode of three (conventional) irrigation controllers metered at residential homes was 2.5 watts (Foster-Porter et al 2006). An additional study by LBNL by Nordman and McMahon (2004) measured three irrigation controllers (or "irrigation timers" as they were referred to in the report) and reported standby wattages of 2.2, 3.69 and 9.68 watts. (Information as to the type of irrigation controller – conventional or smart – was not presented in the report). Collectively, it is evident there are significant differences in the standby power of irrigation controllers ranging from less than 1 watt to nearly 10 watts.

This standby power data suggests that absent a requirement addressing the standby mode power use of irrigation controllers (e.g., a maximum rated wattage in standby mode), a smart controller-based standard in California would increase the direct energy use associated with landscape irrigation equipment. Even absent a standard that specifically requires that landscape irrigation controllers sold in California be smart controllers, we anticipate that labeling and rebate programs which will continue to accelerate the adoption of smart controller technology over the less decade by residential and other end-users – albeit at a lower rate of market penetration than would result from the standard scenario we've discussed and analyzed in this report. Accordingly, we recommend CEC begin to take steps that will address standby mode of irrigation controllers, and to this end, Section 9 contains initial recommendations for testing and reporting requirements.

5 Market Saturation and Sales

5.1 Current Market Situation

5.1.1 Baseline Case

We have estimated a stock of 4.9 million irrigation controllers are currently in operation in single-family homes in California. This estimate was derived based on an estimated 8.2 million single-family homes in California (U.S. Census 2000) and by assuming 61% of single-family homes in California water their lawns and gardens using an automatic sprinkler/irrigation system and controller (CUWCC 2007).[28] Using data collected through the 2007 California Landscape Marketing survey, we've assumed 88% of these controllers used by single-family homes are conventional timers, our baseline case, while the remaining 12% are smart controllers (CUWCC 2007).

Based on the estimated stock of 4.9 million controllers and assuming a ten year expected useful life (EUL) of an irrigation controller (discussed further in Section 7.2), we estimate that about 500,000 controllers are sold in California each year for application to residential single-family homes (Table 6).[29] The annual water use and energy use data presented in Table 6 reflects the assumption that 12% of homes already use smart controllers, while the remaining 88% use a conventional controller.[30] In total, we estimate that residential single-family homes in California at present, use about 340 billion gallons (equivalent to about 1.04 million acre-feet, or MAF), of water each year for landscape irrigation.

Assuming an average energy-intensity of 3.01 kWh per 1,000 gallons of water (PG&E 2003) California uses roughly 1,023 gigawatt hours (GWh) per year to per year to extract, convey, treat, and supply the water used for single-family home irrigation.[31] Put into perspective, this is about 14% of the electricity used for urban water supply and treatment in 2001 (CEC 2005: 8), or about 2% of the total water-related electricity use in California (CEC 2005: 8). Assuming a load factor of 1.18 (based on data presented in CEC 2007), we estimated that the peak demand associated with this energy use is about 99 MW. By comparison, we estimate the direct annual energy-use of irrigation controllers is about 111 GWh – roughly 10% of the estimated embedded-energy use; and has a peak demand of 18 MW.

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[28] According to the statewide survey, 68% of single family homes use an automatic sprinkler. Of these homes, 89% of them have a timer that controls the irrigation schedule (CUWCC 2007). From this, we estimate approximately 61% (68% x 89%) of single family homes through the states have an automatic irrigations system controlled using an irrigation controller/timer.

[29] Note that these calculations mean that we have implicitly accounted only for replacement controllers. Savings from controllers sold for new-construction have not been included in this analysis, in part, because many of these new landscapes will be required to install a self-adjusting controller, under the latest California Model Water Efficient Landscape Ordinance (under revision as of July 2009).

[30] Although we could find no other source of data to support this assumption, based on conversations with manufacturers, we felt the percent of smart controllers was probably more like 5-10%. However, to err conservatively when estimating the potential savings from adopting smart controllers, we've used the 12% in this analysis.

[31] It is important to note we have adopted to use average estimates for the energy-embedded values in outdoor water use, rather than marginal estimates.

Table 6. California Baseline for Irrigation Controllers used by Single-Family Homes
Stock, Annual Sales, Energy and Water Use

California Stock[a]	California Annual Sales[b]	California Statewide Water and Energy Use				
Units (millions)	Units (1,000s)	Annual Water Use (Mgal/yr)	Annual Embedded Energy Use[c] GWh/yr	Embedded-Peak Demand[d] (MW)	Annual Direct Energy Use[e] GWh/yr	Direct-Peak Demand[f] (MW)
4.9	495	340,022	1,023	99	111	18

Sources:
[a] Based on an assumed 8.2 million single-family homes in CA (U.S. Census 2000) and assuming 61% of these homes have an automatic irrigation system/controller.
[b] Assumes the effective useful life (EUL) of a controller is 10 years.
[c] Assumes an average embedded-energy intensity of 3.01 kWh per 1,000 gallons (PG&E 2003).
[d] Assumes load factor of 1.18 based on data in CEC (2007).
[e] Calculated using existing stock and an assumed 88%-12% split between conventional controllers (20.3 kWh/yr), and smart controllers (37.9 kWh/yr).
[f] Assumes100% of irrigation controllers are plugged-in, and operating at standby load during peak hours (most irrigation controllers are programmed to run in early morning/evening hours).

It is important to recognize that the calculations for energy-use and water-use presented in Table 6 are only for single-family residential homes, and do not include multi-family units, nor commercial, industrial and institutional (CII) landscapes. Available data regarding outdoor residential outdoor water use suggests the total residential water use is about 19% of total urban water use (1.34 MAF) and that CII landscapes account for another about 14% (1 MAF) in 2000 (see Eilert and Stevens 2009). Consequently, this urban water data suggests the estimate statewide residential irrigation water use developed in this report (1.01 MAF) is conservative.

5.1.2 High Efficiency Options

We have assumed 12% of single-family homes in California single-family households with automatic irrigation systems are already using a smart controller (CUWCC 2007).

5.2 Future Market Adoption of High Efficiency Options

We expect that the market adoption of smart controllers among residential customers, especially those with high outdoor water use (who tend to be targeted by water agencies as attractive candidates for smart controller rebate program) will, even in the absence of any equipment standards, continue to increase over the next decade. The forthcoming EPA WaterSense label for smart irrigation controllers will also enable customers and irrigation professions to better distinguish among irrigation controllers on the market, enabling customers to more confidently select and install controllers that can provide greater savings (assuming proper programming and installation).

However, customers have low awareness of the magnitude of their outdoor water use and, at least at this point in time, are generally unaware or unfamiliar with smart controller technology (CUWCC 2007). While the water utility smart controller rebate programs implemented have had some success in raising public awareness of the technology, a recent survey conducted as part of the statewide evaluation suggests most customers still have almost no knowledge of this technology (Meyer et al. 2009: 131). Therefore, we expect that absent standards, smart controllers will persist at least in the near term (i.e., 3-5 years), to be relatively small share of irrigation controller sales for residential homes in California.[32]

6 Savings Potential

6.1 Statewide California Energy and Water Savings

We estimate that an appliance standard requiring all controllers to be smart controllers, would lead to water savings of approximately 2,200 million gallons in the first year of the standard, and an estimated 22 million gallons of water at full stock turnover (Table 7). The savings estimates presented are based on existing stock of irrigation systems/controllers, and do not take into account future irrigation systems built with new home construction or new irrigation systems installed at existing homes.

As discussed in previous sections of this report, there is some tradeoff of energy savings between embedded energy saved due to water savings and the increased site energy use due to the higher standby mode power consumption of a smart controller.[33] This smart controller's increased standby power would increase annual energy (depicted as "negative savings" in Table 7) use by about 77 GWh upon full stock turnover, and would increase peak demand by about 9 megawatts (MW). On the other hand, a smart controller would decrease the embedded-energy use by about 66 GWh upon full stock turnover, and would also reduce the associated peak electrical demand by about 6.4 MW. The net savings (embedded energy savings + direct energy savings) are therefore negative. In other words, the net energy impact would be an increase of 10.5 GWh in annual energy use, and an increase in peak demand of about 2.6 MW.

Table 7. California Statewide Energy and Water Savings from Smart Controllers, Single-Family Homes

		Embedded-Energy Savings		**Direct Energy Savings**		**Net Energy Savings**	
	Annual Water Savings[a] (Mgal./yr)	Annual Energy Savings[b] (GWh/yr)	Peak Demand Savings[c] (MW)	Annual Energy Savings (GWh/yr)	Peak Demand Savings (MW)	Annual Energy Savings (GWh/yr)	Peak Demand Savings (MW)
First Year Sales	2,204	6.6	0.6	-7.7	-0.9	-1.0	0.1
Stock Turnover[d]	22,036	66.3	6.4	-76.8	-9.0	-10.5	-2.6

Sources:
[a] Estimated annual water savings based on water savings data from 22 counties in Hanak and Davis 2006 using an adjustment factor of 1.18 to scale savings to represent all counties in California.
[b] Assumes an average embedded-energy intensity of 3.01 kWh per 1,000 gallons (PG&E 2003).
[c] Assumes load factor of 1.18 based on data in CEC (2007).
[d] Stock turnover savings based on an assumed ten year expected useful life for a controller.

From these calculations, we find that while a smart controller would save a significant amount of water across the state (about 22,000 million gallons or roughly 0.07 MAF, upon stock turnover), unless the standby energy of controllers is addressed, there will be a net increase in energy use. However, we stress that this finding is highly sensitive to changes in assumptions on the energy-intensity of embedded-energy. As we discussed in Section 4.2, we've applied an average statewide estimate for the energy-

[32] The DWR's revised Model Water Efficient Landscape Ordinance which is currently being finalized requires that the irrigation controllers installed with all new landscapes meeting a threshold square-feet, to be self-adjusting.
[33] However, these numbers are highly sensitive to embedded energy values and should be taken as a conservative estimate. See Section 5.1.1

intensity of water. If one assumes a *marginal* energy-intensity of water instead of the *average* energy-intensity, the embedded-energy savings increase substantially, and the net energy savings become positive. For example, if one assumed a population weighted, embedded energy value of 8.1 kWh per 1,000 gallons of water applied outdoors (based on population-weighted marginal energy-intensity estimates for Northern- and Southern-California presented in CEC 2006), the annual net energy savings upon full turnover becomes 84 GWh (rather than the net increase in energy use of 10.5 GWh), since the embedded-energy savings increases dramatically from only 66 GWh (Table 7) to approximately 161 GWh. Similarly, the net peak demand impact change from an increase of 2.6 MW to a reduction of about 6.5 MW upon full stock turnover.

6.2 Other Benefits and Penalties

In addition to water and energy savings, water utilities and customers may experience additional benefits from smart irrigation controllers (Mayer et al. 2009), which have not been quantified in this analysis. For water utilities, some of these benefits include:

a) Reduced runoff from urban landscape;
b) Adaptation of customer demands to calculated water budget allotments;
c) Potential for peak demand reduction; and
d) Improved health and condition of urban landscapes through more proper irrigation applications.

Customers may also benefit from:

a) Convenience of not having to manually periodically adjust controller settings;
b) Improved landscape health and appearance; and
c) Better feedback about other problems in the irrigation system.

California currently faces some of the most serious water challenges seen in the last half-century. A significant fraction – approximately one-third – of the water used by California's urban areas is used for landscape irrigation. In addition to the benefits associated with reduced embedded energy, improving the efficiency of the landscape irrigation sector and reducing California's water use may have far-reaching social, environmental, and agricultural benefits.

7 Economic Analysis

7.1 Incremental Cost

Given the wide array of smart controller specifications and functionalities of models that are currently on the market, not surprisingly there is significant variation in the current cost of a smart controller (Table 8). From this data we estimate the incremental equipment cost of replacing a controller with a weather-based controller or soil-moisture based controller, instead of a traditional controller, is approximately $307 and $197, respectively.

In addition to the incremental equipment cost, a number of weather-based controllers with signals typically have monthly subscription fees, while controllers that rely solely on historical pre-programmed data and/or on-site sensors, do not. We've assumed an annual service fee of $48 for weather-based controllers used at small or average-sized single-family residential landscapes that rely on a signal (DOI 2007). Discounted over ten years at a three percent discount rate, the present value of this incremental cost is about $409. For larger landscapes, we've assumed an annual service fee of $84 (DOE 2007), which in present value terms (with a three percent discount rate), is about $717.

Table 8. Price of Irrigation Controllers

Models	Price
Traditional Controller	
Hunter Pro-C, 3-Station Indoor Plus 3-Station Expansion Module	$94.42
Rain Bird ESP, 4-Station Indoor Plus 3-Station Expansion Module	$99.45
Toro Irritrol Rain Dial Series, 6-Station Indoor	$91.46
Average	**$95.11**
Weather-Based Controller	
Accurate Weatherset, 8-station Indoor	$222.00
Aqua Conserve, ET-6, 6-station Indoor	$264.00
Cyber-Rain, 8-station	$295.00
ET Water Systems, 6-station	$499.00
HydroPoint WeatherTRAK ET, Residential 9-station	$549.00
Irritrol, 6-station indoor	$399.00
Rain Master, RME Eagle, 6 station	$640.00
Toro Intellisense, 6-station indoor	$399.00
Weathermatic, SmartLine (SL800), 4-station indoor Plus 2 2-Station Modules, and Wired Res. Weather Monitor	$349.80
Average	**$401.87**
Soil-Moisture Based Controller	
Acclima, SC residential controller plus digital TDT soil moisture sensor	$292.00
Average	**$292.00**

Sources:
[a] Weather-and Soil-Moisture based controllers prices are from DOI (2007). Prices for conventional controllers are from sprinklerwarehouse.com.

Many weather-based smart controllers require fairly time-intensive programming when they are installed, to input factors such as plant/soil type, slope conditions, sun/shade conditions, or other site-specific variables (DOI 2007). Accordingly, we have assumed incremental installation costs of: $50 for weather-based controllers, on small or average sized lots with about 6 stations, and $100 for weather-based controllers, on large sized lots with approximately 12 stations, to account for the additional time an irrigation contractor would need to collect and program the data for each station, into the irrigation controller. A number of manufacturers report recommend some periodic maintenance (e.g., wiping the sensors clean every 30 days); we have not included this cost in the economic analysis, since similarly, we have not attempted to monetize the benefits that smart controllers provide over an irrigation controller, in greater convenience (i.e., fewer manual adjustments).

7.2 Design Life

Most manufacturers estimate the design life of irrigation controllers to be between seven and ten years.[34] Hanak and Davis (2006) assumed a controller lifetime of 15 years (2006). Mayer et al. (2009) assumed a lifetime of ten years. As a mid-range estimate, we have adopted a ten year effective useful lifetime (EUL) for an irrigation controller in this report. We have also assumed the peripheral devices, including rain sensors, also have a EUL of ten years. For some types of devices, EUL have not been verified since the products have been available and operational for less than ten years.

7.3 Lifecycle Cost / Net Benefit

To determine whether a standard that requires all irrigation controllers purchased and installed to be used in existing, residential homes to be a smart controller is cost-effective, we have calculated the total net present value (NPV) of the lifecycle costs and lifecycle benefits, over the ten year lifetime of a controller. In addition, later in this section we present lifecycle cost estimates regarding mandatory use of rain sensor with an irrigation controller. The lifecycle costs including any incremental equipment cost, installation cost, and additional costs incurred over the lifetime of the controller (specifically, here we include any signal/service fees the customer would incur to operate a smart controller, as well as expected change in energy use from the direct energy use of a controller). If the weather-based controller requires this subscription fee, then the lifecycle costs are significantly higher that a weather-based controller with historical and/or onsite sensors, or a soil-moisture based irrigation controller. All types of smart controllers are assumed to provide equal water savings of 7.1%.

Table 9 presents the results of the lifecycle cost analysis, for an average single-family residential home. This analysis assumes a discount rate of three percent. For average single-family home, the benefit-to-cost ratio varies from non-cost effective (with a benefit-cost ratio of 0.32 for weather-based controllers with a signal) to moderately cost-effective (with a benefit-cost ratio of 1.15 for soil-moisture based irrigation controller). Table 10 also presents these findings, disaggregated for single-family residential homes on both small- and large-lots. For smaller lots, none of the smart-controller options provide a benefit-cost ratio that is greater than 1.0, while for larger lots, both weather-based controller with on-site sensors and a soil-moisture based controller are cost-effective.

Figures 5 and 6 also show the relative present value (PV) benefits versus the range of the PV costs, for an average small- and large-lot in each of the 22 counties. The range of costs reflects the difference in total lifetime costs among different types of smart controllers (i.e., a soil-moisture based controller in this analysis has the lowest lifecycle cost, while a weather-based controller with an annual service fee has the highest cost over the lifetime of the controller). As Figures 5 and 6 indicate, the cost-effectiveness varies widely throughout the 22 counties we considered. Lot size strongly influences the cost-effectiveness of irrigation smart controllers. For small-lots, in 15 out of 22 counties, the economic benefits of a smart controller would not equal even the lowest costs. For large lots, however, the estimated lifecycle savings in all counties exceed the lowest estimated lifecycle cost. These findings indicate that given the set of assumptions made in this analysis, smart controller will tend to be more cost-effective when applied to larger landscapes. It is also important to recognize we have used average water prices in all 22 counties; in reality, water rate structures and prices vary significantly throughout the state. We did not find sufficient data to estimate average water prices for individual counties.

[34] Estimated lifetime based on submitted industry comments in response to CEC's "Key Questions for Setting Efficiency Standards and Labeling Requirements for Landscape Irrigation Equipment. http://www.energy.ca.gov/appliances/irrigation/documents/2009-06-30_workshop/comments/.

Table 9. Costs and Benefits Per Unit for Standards Options for a Single-Family Home in California

		Lifecycle Costs per Unit (Present Value $)				Lifecycle Benefits per Unit (Present Value $)		Lifecycle	Net
Smart Controller Design Options	Design Life (years)	Incremental Upfront Cost[a]	Add'l Cost(s)[b]	Add'l Cost (Direct Energy Cost)[c]	**Total PV Costs**	Water Savings[d]	**Total PV Benefits**	**Benefit / Cost Ratio[a]**	**Present Value ($)**
Weather Based (Signal)	10	$357	$409	$18	**$784**	$247	**$247**	0.32	-$536
Weather Based (On-Site Sensors)	10	$357	NA	$18	**$374**	$247	**$247**	0.66	-$127
Soil Moisture Based	10	$197	NA	$18	**$214**	$247	**$247**	1.15	$33

Source:
[a] Includes incremental equipment and installation costs.
[b] Includes annual-service fee for signal (where applicable) of $48 over lifetime of controller (10 years) discounted at 3 percent.
[a] Accounts for increase in annual energy use, assuming 10 year lifetime of controller and using CEC (2004) Average Statewide Present Value of Electricity and Natural Gas.
[d] Calculated using annual water savings from Section 4.4, and using DOE (2008) projections for nation water prices, beginning at $5.20 per 1000 gal., increasing at rate of approx. 2% per year.

Table 10. Costs and Benefits Per Unit for Standards Options for Single Family Homes on Average Large- and Small-Lots

			Lifecycle Costs per Unit (Present Value $)				Lifecycle Benefits per Unit (Present Value $)		Lifecycle	Net
Lot-Size	*Smart Controller Design Options*	Design Life (years)	Incremental Upfront Cost[a]	Add'l Cost(s)[b]	Add'l Cost (Direct Energy Cost)[c]	**Total PV Costs**	Water Savings[d]	**Total PV Benefits**	**Benefit / Cost Ratio[a]**	**Present Value ($)**
Average Small-Lot (8,600 sq-ft)	Weather Based (Signal)	10	$357	$409	$18	**$784**	$210	**$210**	0.27	-$574
	Weather Based (On-Site Sensors)	10	$357	NA	$18	**$374**	$210	**$210**	0.56	-$164
	Soil Moisture Based	10	$197	NA	$18	**$214**	$210	**$210**	0.98	-$4
Average Large-Lot (123,000 sq-ft)	Weather Based (Signal)	10	$506	$717	$18	**$1,240**	$865	**$865**	0.70	-$375
	Weather Based (On-Site Sensors)	10	$506	NA	$18	**$524**	$865	**$865**	1.65	$342
	Soil Moisture Based	10	$263	NA	$18	**$280**	$865	**$865**	3.09	$585

Sources:
[a b, c, and d] – See references in Table 9.

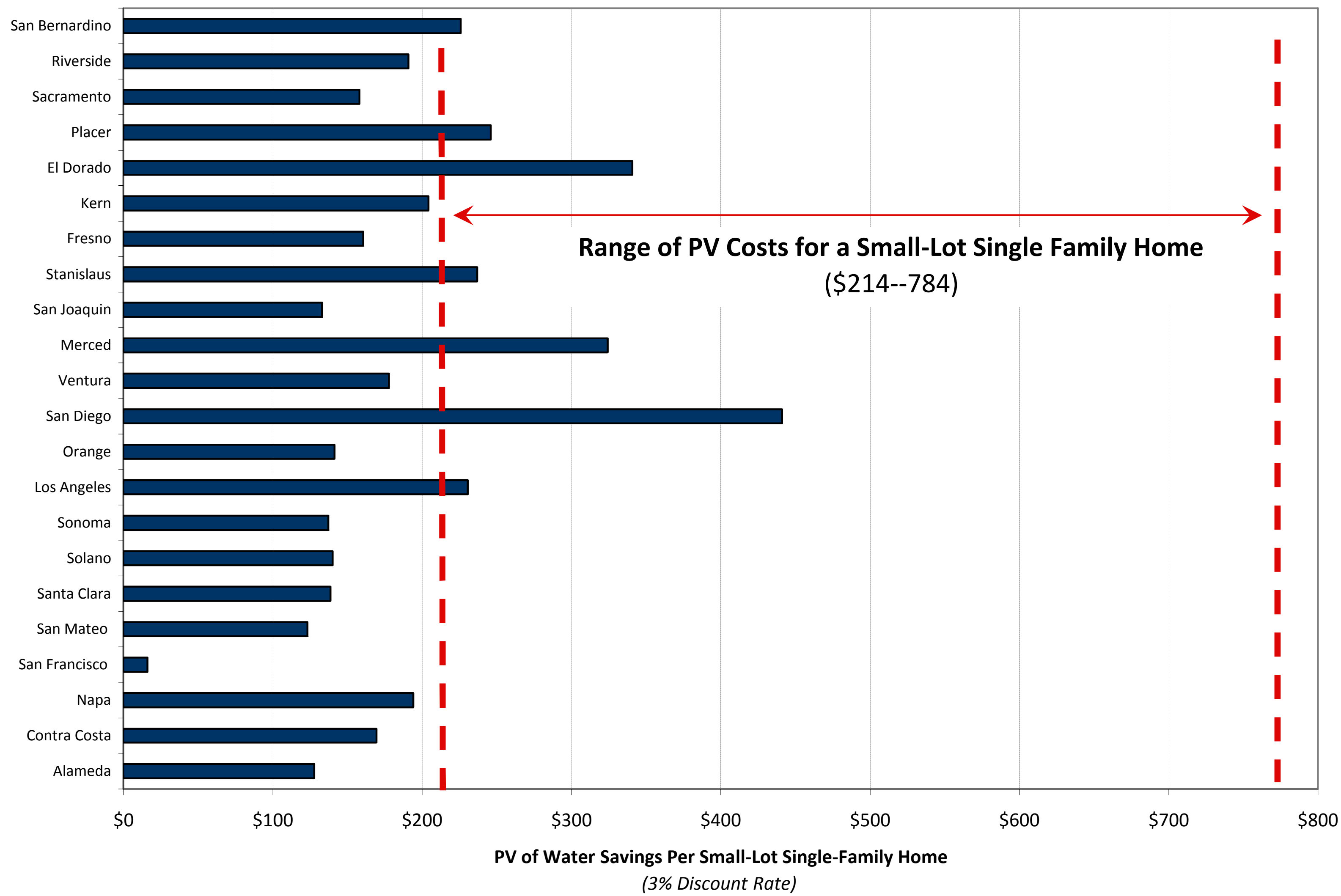

Figure 5. Present Value (PV) Costs and PV Benefits for Small-Lot Single-Family Homes, by County

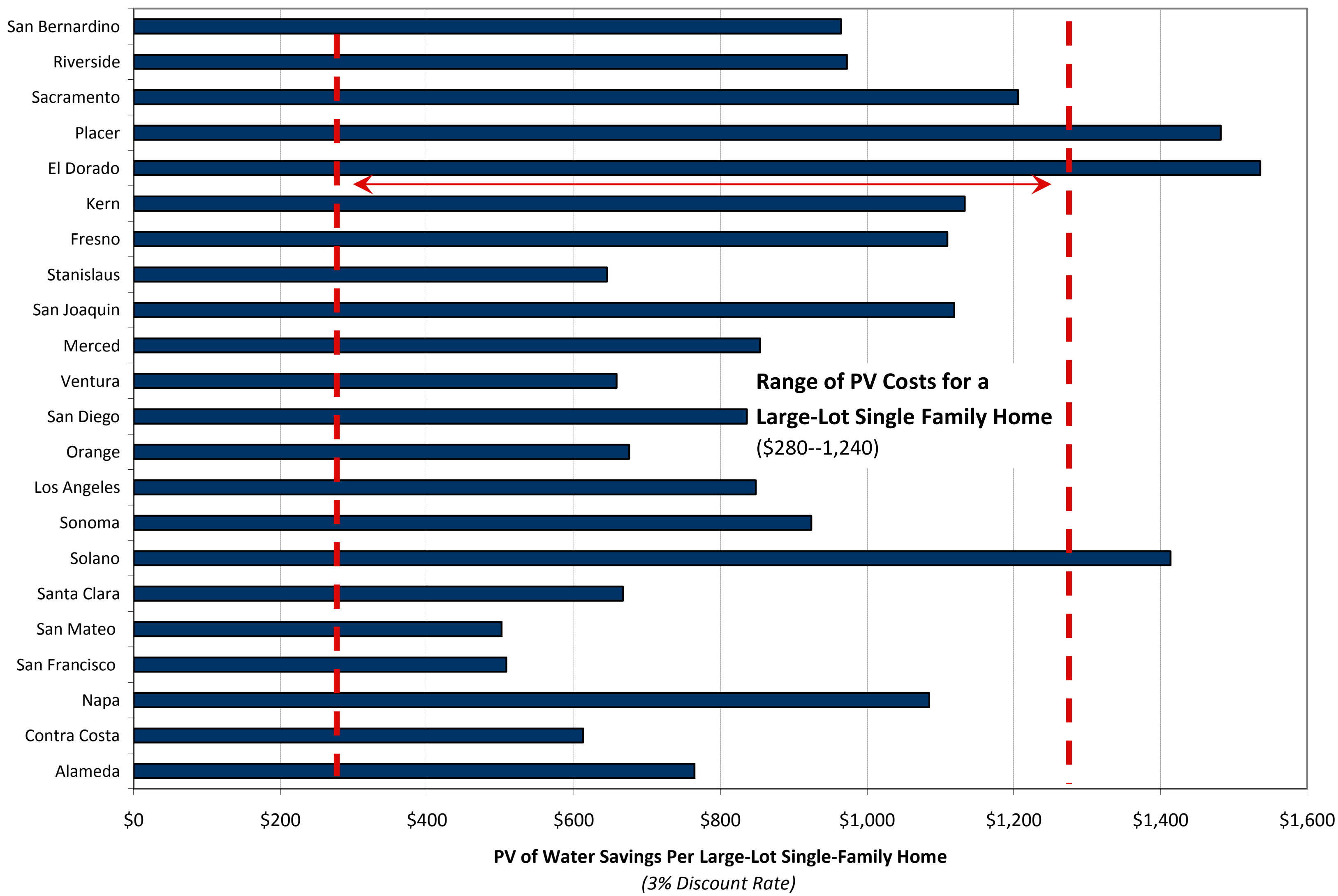

Figure 6. Present Value (PV) Costs and PV Benefits for Large-Lot Single-Family Homes, by County

These estimates are highly sensitive to variation of their parameters. Two such variables are water savings and embedded energy values. A 7.3% water savings has been assumed in this analysis, based on the average per-site residential water savings found by Mayer et al. (2009). However, previous studies estimate residential savings to range from 7-25% (DOI 2008). Table 11 indicates, the lifecycle cost-benefit ratio changes substantially as the percent of water savings increases, showing that for sites that do attain higher water saving, a smart controller is cost-effective.

Table 11. Sensitivity Analysis of Costs and Benefits of Smart Controllers for Single Family Homes

	7.3% Water Savings		15% Water Savings		25% Water Savings	
Smart Controller Design Options	**Lifecycle Benefit / Cost Ratio**	**Net Present Value ($)**	**Lifecycle Benefit / Cost Ratio**	**Net Present Value ($)**	**Lifecycle Benefit / Cost Ratio**	**Net Present Value ($)**
Weather Based (Signal)	0.32	-$536	0.65	-$276	1.08	$63
Weather Based (On-Site Sensors)	0.66	-$127	1.36	$134	2.26	$473
Soil Moisture Based	1.15	$33	2.37	$294	3.95	$633

Overall, these results demonstrate that smart controller-based standard as a standard is not presently cost-effective in California as an appliance standard. However, in addition, we developed some complementary analysis to consider the cost-effectiveness of a standard requiring that all irrigation controllers must be sold with a rain shut-off device, which are widely available. The results shown in Table 12 document this requirement would be cost-effective. If a rain shut-off device prevented the irrigation system from watering each day that rained more than 0.01,"[35] it would save roughly 8,000 gallons of water per year for small lots and 33,000 gallons of water per year for large lots. Tables 11 and 12 below show water and cost savings based on a statewide population-weighted average, in addition to a low and high case. As Table 12 demonstrates, small lots in would save from $24-98 annually and $229-922 over the sensor lifetime (assumed to be 10 years, savings discounted at 3 percent). For an average small lot, the savings would be on the order of $42 annually and $397 over the sensor lifetime.[36]

The current prices of a rain shut-off device rain sensors range from $20-125,[37] and assuming an incremental installation cost of about $50, the total associated incremental cost of this requirement would be $75-195. The savings shown in Tables 12 and 13 suggests that even in California's drier climates, rain sensors would be extremely cost effective over their lifetime. Preliminary estimates over the total water and associated embedded-energy savings are also significant: upon full stock turnover, we estimate water savings would be on the order of 45,000 million gallons, along with annual (embedded) energy savings of 135 GWh and a 13 MW reduction in peak demand.

[35] Population weighted average based on populations of between Northern and Southern California and corresponding weather station records (n=17), based on data from the University of Utah Department of Atmospheric Sciences . Number of rainfall events range from Bishop (29) and Eureka (117). < http://www.met.utah.edu/jhorel/html/wx/climate/daysrain.html >.

[36] This savings estimate assumes that in the absence of a rain sensor, the irrigation system will continue its normal watering cycle. This estimate also assumed an estimated useful life (EUL) of 10 years, which is the same as the irrigation controller design life described in Section 7.2.

[37] Search for "rain sensor" at < http://www.sprinklerwarehouse.com/ > conducted July 6th, 2009.

Table 12. Water and Cost Savings of Rain Shut-Off Devices for Small Lots

	Rainfall Events	Annual Water Savings (kgal/yr)	Annual Cost Savings ($)	Lifetime Water Savings (kgal)	PV of Lifetime Cost Savings ($)
Pop. weighted Average	50	8	42	81	397
Bishop, CA	29	5	24	47	229
Eureka, CA	117	19	98	189	922

Table 13. Water and Cost Savings of Rain Sensors for Large Lots

	Rainfall Events	Annual Water Savings (Gal/yr)	Annual Cost Savings ($)	Lifetime Water Savings (gal.)	PV of Lifetime Cost Savings ($)
Pop. weighted Average	50	33	174	334	1,634
Bishop, CA	29	19	100	193	942
Eureka, CA	117	78	404	777	3,799

8 Acceptance Issues

Infrastructure issues

During times of drought, water districts may impose mandatory water restrictions. These restrictions often require that customers can only water lawns on specific days of the week. In order to comply with these restrictions, any landscape irrigation controller standard must allow irrigation controllers to carry a lock-out feature or capability, which allows the user to manually override the system on specific days of the week.

8.1 Existing Standards

There are no existing appliance efficiency standards for landscape irrigation controllers or for any other irrigation equipment. There product-based ordinances throughout the countries, most of which require rain or moisture sensors, either in all new or all irrigation systems (Dickinson 2009). For example, the State of Florida has required rain sensors on all irrigation systems installed after May 1, 1991. There are also mandates for the use of rain sensors in various other municipalities throughout the country, in New Jersey, North and South Carolina, Georgia, Texas, Minnesota, and Connecticut (Cardenas-Lailhacar and Dukes 2008).

There are also a variety of other ordinances that affect irrigation water use, including time of day water restrictions, day of week watering restrictions, overspray and runoff prohibitions, as well as turf limitations.

The California Model Water Efficiency Landscape Ordinance includes provisions to minimize landscapes irrigation overspray and runoff; have a landscape water budget component; use of automatic irrigation systems and irrigation scheduled based on climatic conditions; and for landscape maintenance practices that foster long-term landscape water conservation (Frame and Eching 2009).

8.2 Stakeholder Positions

TBD

9 Recommendations

9.1 Recommended Standards and Testing Options

Based on the analysis presented in this report which assumes homes can achieve a relatively modest 7.3% reduction in irrigation from replacing an existing conventional controller with a smart controller, we find that at this time, such a standard would generally not be cost-effective. Moreover, the recent statewide evaluation study of smart controller rebate programs has shown that at many sites, installing a smart controller can actually *increase* water use in cases where sites applied less than the theoretical water needs before the smart controller was installed (Meyer et al. 2009). There is significant variability in potential water savings from using a smart controller is, in part, due to variations in landscape size, plant types, weather conditions, landscape design, proper equipment installation, operation and maintenance.

While the statewide water savings from a smart-controller standard would be on the order of 22,000 million gallons per year, upon full stock turnover, the considerable variability from site-to-site (which has not been fully captured in this analysis) makes this standard opportunity less viable from an economic perspective. In particular, a relatively significant number of households (roughly 40%) of customers would be required to pay an incremental cost of $100-300 to purchase a smart controller, and would then also face higher water bills (due to increased water use for irrigation) and modestly higher electric bills (due to the higher standby load from a smart controller). Consequently, at this point in time a smart controller-based appliance standard does not appear to be cost-effective in California. Still, from a water-conservation perspective, the outlook for smart controllers remains quite promising in the near-term, especially when they are targeted to sites that have historically applied more water than theoretically needed.

Recommendation 1: We recommend the CEC require that all landscape irrigation controllers be sold with a rain shut-off device, effective January 1, 2011. Water-savings can be achieved cost-effectively with rain shut-off devices. In addition to any the potential design requirements the CEC staff discussed at the Jun 30th workshop, we also recommend the CEC require all new irrigation controller sold in California come with a rain shut-off device. [38] A rain sensor requirement would be cost-effective even in the drier areas of California, and will result in significant water and energy savings over their lifetime throughout the state. Preliminary estimate over the total water and associated embedded-energy savings are also significant: upon full stock turnover, we estimate water savings would be on the order of 45,000 million gallons, along with annual (embedded) energy savings of 135 GWh and a 13 MW reduction in peak demand.

[38] http://www.energy.ca.gov/appliances/irrigation/documents/2009-06-30_workshop/presentations/ Some of the specific design requirements discussed where for: tracking time (date, day of week, sunrise/sunset); allowing blackout days to be set and displacing watering to next available day; allowing a manual weather override that does not disrupt scheduling; not watering between specific daytime hours; adjust watering based on date; and retaining settings if power is interrupted

Draft Recommendation 2: We recommend CEC adopt a test and list requirement for all irrigation controllers and add-on devices, requiring manufacturers to measure and report the power of controllers in standby mode.

The findings of this study suggest that a smart-controller standard which does not address the standby use of the controllers, would lead to a net *increase* in annual electricity use (about 10 GWh, upon full stock turnover), assuming the average energy-intensity of water applied outdoors in urban areas is 3 kWh per 1,000 gallons. However, we also stress that this finding is highly sensitive to whether an average or marginal energy-intensity of water is applied in used in these calculations. If a marginal (instead of average) estimate of energy-intensity is applied, this net increase annual energy consumption becomes a net *savings* of about 84 GWh upon stock turnover. These results demonstrate that the potential tradeoff between the embedded energy and site energy is a non-trivial issue for irrigation controllers.

Currently smart controllers have higher standby power (average 4.2 watts) than conventional controllers (average of 2.1 watts), and about 90% of a controller's annual energy consumption is from standby mode. The standby mode power of an irrigation controller can range widely from just under one watt to almost ten watts, which suggests there is opportunity to reduce the standby power of many of these irrigation controllers. The testing requirements should be based on and reference IEC 62301 *Household electrical appliances – Measurement of standby power.* We propose a set of relevant definitions and other language, related to this recommendation in the following section. The proposed test and list requirement would generate a dataset of irrigation controller standby power, which would be valuable to homeowners, other manufactures, rebate program managers, as well as other regulatory and voluntary labeling programs through the world. This data is not currently available. Public disclosure and access to this information through the CEC's database could encourage manufacturers to place more consideration into the standby power of a controller and available design options for reducing standby. Currently, no such incentive exists. The data set developed under this test and list requirement will also enable the CEC and interested stakeholders to assess the potential savings, feasibility, and cost-effectiveness from a future Title 20 standard that addresses landscape irrigation controller standby power.

9.2 Draft Proposed Changes to the Title 20 Code Language

Definitions[39]

A *landscape irrigation controller* is a device that is designed to remotely control valves to operate an irrigation system. The irrigation controller is designed to connect to the mains power by either a hard-wired connection or a flexible cord and an attachment plug for connection to a nominal 120-volt, 15 or 20-ampere branch circuit.

A *smart irrigation controller* is a type of landscape irrigation controller that is designed to estimate or measure depletion of available plant soil moisture, in order to operate an irrigation system, replenishing water as needed while minimizing excess water use.

A *conventional irrigation controller* is an irrigation controller that is not a smart irrigation controller.

[39] These definitions were developed based on reviewing the Irrigation Association Glossary < http://irrigation.org/gov/default.aspx?pg=glossary.htm#valve> , the latest version of SWAT testing protocols, and the California Model Water Efficient Landscape Ordinance < http://www.owue.water.ca.gov/docs/final_reg_text.pdf >.

An *add-on irrigation controller device* is a device that when operated in conjunction with a compatible conventional irrigation controller, the add-on irrigation controller device plus the conventional irrigation controller, becomes a smart irrigation controller.

Landscape irrigation controller standby passive mode means that the landscape irrigation controller is connected to a power source, is not activating any valves or receiving or sending any signals, but can be switched into another mode with direct user input, an internal signal, or a remote control device.

A *rain shut-off device* (also called a rain sensor or rain switch) is a device designed to interrupt a scheduled cycle of automatic irrigation system controller when a certain amount of rainfall has occurred.

Testing Requirements

The test procedure that shall be used to test landscape irrigation controllers and add-on landscape irrigation controller devices for the purposes of reporting shall be IEC 62301 *Household electrical appliances – Measurement of standby power (First edition, 2005-06).*

- This testing shall be performed with all electrically-connected peripheral devices (e.g., external sensors, receiver devices) that are sold with the irrigation controller, attached to the controller and fully operational.
- Add-on landscape irrigation controller devices for the purposes of reporting shall be tested when set up and connected to the compatible landscape irrigation controller. This compatible landscape irrigation controller shall also be tested separately, without the add-on landscape irrigation control device connected.

Standard Requirements

Landscape Irrigation Controllers sold on or after January 1, 2011 shall be sold with a rain shut-off device.

Data Submittal Reporting Requirements

Landscape Irrigation Controllers and Add-On Irrigation Controller Devices:

- Manufacturer Name, Brand Name, and Model Number
- Type
    - Conventional Controller;
    - Smart Controller: Weather-Based;
    - Smart-Controller: Soil-Moisture Based;
    - Smart Controller: Other;
    - Add-On Irrigation Device: Weather-Based;
    - Add-On Irrigation Device: Soil-Moisture Based;
    - Add-On Irrigation Device: Other
- For Irrigation Controllers: Power Usage in Landscape Irrigation Controller Standby Passive Mode (watts)
- For Add-on Devices: Power Usage of both (1) and (2) in Irrigation Controller Standby Mode (watts)
    1. Add-On Irrigation Device fully connected to the Compatible Conventional Controller
    2. Compatible Conventional Controller

Rain Shut-Off Device Type

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