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Response to Invitation to Participate - Landscape Irrigation Controllers

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Landscape Irrigation Controllers

Codes and Standards Enhancement (CASE) Initiative
For PY 2017: Title 20 Standards Development

Response to the California Energy Commission's Invitation to Participate Phase 2 Pre-Rulemaking
Irrigation Controllers
Docket # 17-AAER-10

June 16, 2017

Prepared for:

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1. Executive Summary

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support the California Energy Commission's (Energy Commission or CEC) efforts to update California's Appliance Efficiency Regulations (Title 20) to include new requirements or to update existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), Southern California Edison (SCE), and SoCalGas® – sponsored this effort (herein referred to as the CASE Team). The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve the energy and water efficiency of various products sold in California. The information presented here is a part of the CASE initiative to develop technical and cost-effectiveness information for potential appliance standards, and a response to Energy Commission's Invitation to Participate Phase 2 Pre-Rulemaking for landscape irrigation controllers.

Landscape irrigation is an important topic for consideration because it is the single largest use of potable water in the residential sector and accounts for approximately half of total urban water usage in California (PPIC 2016). Across all sectors, residential and commercial landscape irrigation uses over one trillion gallons of water per year. The extraction and conveyance, potable water treatment, and distribution of landscape irrigation water requires more than 3 terawatt hours of embedded electricity per year. In light of California's recent drought emergency, landscape irrigation is a critical sector for consideration in Title 20 water efficiency standards.

This document provides information supporting water and energy efficiency standards for landscape irrigation controllers, including traditional irrigation controllers, weather-based irrigation controllers, soil moisture sensor-based irrigation controllers, and add-on rain shut-off sensors. The test method for weather-based irrigation controllers referred to in this document is based on the United States Environmental Protection Agency's WaterSense Specification for Weather-Based Irrigation Controllers Version 1.0. This response also includes a test method for rain shut-off devices and provides information about a potential upcoming test method for soil moisture sensors. The energy efficiency test method is based on International Electrotechnical Commission (IEC) 62301 with modifications.

Potential standards would address all product sales including replacement units and complement existing California standards that address newly installed landscapes.

2. Background

2.1 Regulatory Background

2.1.1 Federal Regulatory Background

There are no federal energy efficiency standards that directly affect landscape irrigation controllers. Therefore, California is not preempted from setting standards for controllers. However, there are federal Title 10 Standards that apply to external power supplies (EPS) (10 CFR 430) used in a broad range of consumer appliances. The federal standards require that single-voltage 50-250 watt EPS meet efficiency limits of 87-88 percent, and "no load" losses cannot exceed 0.210 watts. Many irrigation controllers have EPS (as described in Section 3.2 of this response) with power losses that are incidental to landscape irrigation controller energy use (no more than 12-13 percent).[1] EPS are by definition an independent component that is attached to the end use product to reduce voltage and/or convert from alternating current (AC) to direct current (DC) power. Since federal standards do not specifically regulate irrigation controller energy consumption, the EPS standard does not preempt state regulation of irrigation controllers. The federal standard (42 USC 6295(u)(7)) states, "An energy conservation standard for external power supplies shall not constitute an energy conservation standard for the separate end-use product to which the external power supplies is connected."

2.1.2 California Regulatory Background

Several California regulations currently address landscape irrigation controllers for certain types of newly constructed landscapes, though not for existing landscapes.

The California Department of Water Resources (DWR) adopted updated standards for the statewide Model Water Efficient Landscape Ordinance (MWELO) on July 15, 2015 for new landscapes over 500 square feet and rehabilitated landscapes over 2,500 square feet requiring a building or landscape permit, plan check, or design review (California Code of Regulations or "CCR", Title 23, Division 2, Sections 490.1 and 492.7) (DWR 2015). The regulations include a requirement that automatic irrigation controllers utilize either evapotranspiration (ET)[2] data or soil moisture sensors. Evapotranspiration rate is defined in the MWELO (23 CCR Division 2 Section 491) as "the quantity of water evaporated from adjacent soil and other surfaces and transpired by plants during a specified time." The regulation also requires non-volatile memory so that device settings are retained in the event of a power loss.

The MWELO also includes a streamlined compliance option that is available for certain landscapes using graywater (i.e., water collected after use and then re-used on-site) located in Appendix D of the MWELO. MWELO Appendix D also requires that landscape irrigation controllers include a rain shut-off device.

The California Green Building Standards Code, "CALGreen" (CCR Title 24, Part 11), also contains requirements for landscape irrigation controllers. CALGreen residential (24 CCR Division 2 section 4.304.1) and nonresidential (24 CCR Division 2 section 5.304.3.1) codes require that automatic irrigation system controllers installed at the time of final inspection be either weather- or soil moisture-based and automatically adjust irrigation in response to changes in plants' needs as weather conditions change. Weather-based controllers must have an integral rain shut-off device, a separate rain shut-off device, or a communications system that accounts for local rainfall.

In addition, on March 14, 2012, the Energy Commission released an Order Instituting Rulemaking (12-0314-16) that included "irrigation equipment" as a topic for potential standards (CEC 2012). The Water Landscaping Act of 2006 (Assembly Bill 1881, Laird. Chapter 559, Statues of 2006) required that the Energy Commission adopt efficiency performance standards and labeling requirements for landscape irrigation controllers and sensors by January 1, 2010. The Energy Commission had previously initiated a rulemaking in March 2009, in which the CASE Team prepared a CASE Report with proposed standards for irrigation controllers. The Energy

[1] Based on federal limits for efficiency, as well as the comparison of no load losses to total product no load losses described later.

[2] Landscape evapotranspiration or ET is derived by multiplying ETo, the evapotranspiration rate for grass under specific conditions, by the appropriate landscape coefficient for other crops. ETo can be calculated using the Penman-Monteith equation (IA Irrigation 6th Edition) based on solar radiation, wind, air temperature and humidity.

Commission ultimately suspended the rulemaking on July 29, 2009 until "sufficient funding resources become available to pursue and complete the evidence-gathering, studies, and analyses necessary to re-initiate the proceeding" (CEC 2009b). California AB 1928 (Campos 2016) adopted in 2016, updates prior legislation and requires the Energy Commission to establish performance standards and labeling requirements for irrigation controllers and other landscape irrigation products on or before January 1, 2019. The legislation also requires that the Energy Commission consider the Irrigation Association's (IA) Smart Water Application Technology Program test protocols.

2.2 Utility and Other Incentive Programs

Many water utilities and municipalities provide rebates for water efficient irrigation controllers designed for single family landscapes as well as for multi-family and commercial landscapes. According to a summary by Rain Bird, in California there are at least 129 rebate programs for weather-based controllers, 13 programs for rain shut-off devices, and 10 programs for soil moisture sensors (Rain Bird 2015a, Rain Bird 2015b). Rebates can be issued either per controller or per station, and in some cases, they are bundled with broader programs. In at least some cases, the programs are intended to replace older existing units since they are not subject to water or energy efficiency standards. The CASE Team notes that these incentive programs can complement potential Title 20 standards by encouraging early replacement of inefficient products with equipment that meets the proposed standards. In addition, an incentive program that promotes installation of both a weather-based controller and a rain shut-off device may maximize savings.

2.3 Model Codes and Voluntary Standards

Several government and non-government entities have made substantial progress establishing model building codes and voluntary standards that address water efficiency. Many of these existing codes and standards have been developed through rigorous public vetting processes that included participation by key industry stakeholders. Table 1 below lists various model codes and standards related to landscape irrigation controllers.

Table 1. Model Codes and Standards Related to Landscape Irrigation Controllers

Model Code	Requirements
European Union Commission Regulation 801/2013 requirements for standby and network standby power (2013)	• Covers certain household appliances, information technology equipment, consumer equipment, toys, and leisure and sports equipment that are mains-connected[3]. • Requires equipment to have off or standby mode that draws 0.5 W (1.0 W if information or status display present) or less. • Requires network standby power draw for most end-use equipment (excluding network equipment, such as modems and routers) less than 3 W (effective January 1, 2017) and 2 W (effective January 1, 2019, but currently under review). • Requires power management or similar function to power down equipment to standby, or network standby, states within 20 minutes when the equipment is not providing its main function.
WaterSense Specification for	• Weather-based controllers can qualify for WaterSense certification if they are tested to achieve water application between 80 and 105 percent of the theoretical optimal rate

[3] Complete scope listed in Annex 1 of the regulatory language: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008R1275&from=EN

Model Code	Requirements

Weather-Based Irrigation Controllers Version 1.0 (November 3, 2011)	via the IA's Smart Water Application Technologies protocol (as modified by WaterSense). They must also have the following supplemental capabilities in both smart mode and standard mode.
	• The controller shall be capable of preserving the contents of the irrigation program settings when the power source is lost and without relying on an external battery backup.
	• The controller shall either be capable of independent, zone-specific programming or storing a minimum of three different programs to allow for separate schedules for zones with differing water needs.
	• The controller shall be capable of indicating to the user when it is not receiving a signal or local sensor input and is not adjusting irrigation based on current weather conditions.
	• The controller shall be capable of interfacing with a rainfall device.
	• The controller shall be capable of accommodating watering restrictions as follows:
	  ○ Operation on a prescribed day(s)-of-week schedule (e.g., Monday-Wednesday-Friday, Tuesday-Thursday-Saturday; any two days; any single day, etc.).
	  ○ Either even day or odd day scheduling or any day interval scheduling between two and seven days.
	  ○ The ability to set irrigation runtimes to avoid watering during a prohibited time of day (e.g., between 9:00 a.m. and 9:00 p.m.).
	  ○ Complete shutoff (e.g., on/off switch) to accommodate outdoor irrigation prohibition restrictions.
	• The controller shall include a percent adjust (water budget) feature.
	• If the primary source of weather information is lost, the controller shall be capable of reverting to either a proxy of historical weather data or a percent adjust (water budget) feature.
	• The controller shall be capable of allowing for a manual operation troubleshooting test cycle and shall automatically return to smart mode within some period of time as designated by the manufacturer, even if the switch is still positioned for manual operation.

ASHRAE Standard 189.1-2014 Standard for the Design of High-Performance Green Buildings (2014)	6.3.1.3. Controls. Any irrigation system for the project site shall be controlled by a qualifying smart controller that uses evapotranspiration (ET) and weather data to adjust irrigation schedules and that complies with the minimum requirements or an on-site rain or moisture sensor that automatically shuts the system off after a predetermined amount of rainfall or sensed moisture in the soil. Qualifying smart controllers shall meet the minimum requirements as listed below when tested in accordance with IA's Smart Water Application Technologies "Climatological Based Controllers: 8th Draft Testing Protocol." Smart controllers that use ET shall use the following inputs for calculating appropriate irrigation amounts: a. Irrigation adequacy – 80 percent minimum ETc.[4] b. Irrigation excess – not to exceed 10 percent. Exception: A temporary irrigation system used exclusively for the establishment of a new landscape shall be exempt from this requirement. Temporary irrigation systems shall be removed or permanently disabled when the landscape establishment period has expired.

[4] US EPA uses ETc to mean "Crop Evapotranspiration (ETc) Specific crop moisture requirements as determined by lysimeter studies or calculated by formulas." WaterSense 2011a.

Model Code	Requirements
Draft ASHRAE Standard 191 Standard for the Efficient Use of Water in Building, Site and Mechanical Systems (2012, public review draft v.1)	4.3.3 Irrigation System Design. If a permanent irrigation system is required on the site, all irrigation systems shall meet the IA's Best Management Practices "Turf and Landscape Irrigation Best Management Practices" Section 2, 3, and Appendix B. 4.3.4 Controls. Any irrigation system for the project site shall be controlled by a WaterSense labeled irrigation controller. All such control systems shall also incorporate a properly installed on-site rain or moisture sensor that automatically shuts the system off after a predetermined amount of rainfall or sensed moisture in the soil.
IAPMO Green Plumbing & Mechanical Code Supplement (2012)	413.4 Irrigation Control Systems. Where installed as part of a landscape irrigation system, irrigation control systems shall: 413.4.1 Automatically adjust the irrigation schedule to respond to plant water needs determined by weather or soil moisture conditions. 413.4.2 Utilize sensors to suspend irrigation during a rainfall. 413.4.3 Utilize sensors to suspend irrigation when adequate soil moisture is present for plant growth. 413.4.4 Have the capability to program multiple and different run times for each irrigation zone to enable cycling of water applications and durations to mitigate water flowing off of the intended irrigation zone. 413.4.5 The site-specific settings of the irrigation control system affecting the irrigation shall be posted at the control system location. The posted data, where applicable to the settings of the controller, shall include: (1) Precipitation rate for each zone. (2) Plant evapotranspiration coefficients for each zone. (3) Soil absorption rate for each zone. (4) Rain sensor settings. (5) Soil moisture setting. (6) Peak demand schedule including run times for each zone and the number of cycles to mitigate runoff and monthly adjustments or percentage.
International Green Construction Code (IgCC) (2012)	404.1.2.3 Where an irrigation control system is used, the system shall be one that regulates irrigation based on weather, climatological or soil moisture status data. The controller shall have integrated or separate sensors to suspend irrigation events during rainfall.

2.4 Impetus to Pursue Water and Energy Efficiency and Conservation

2.4.1 State Policy Goals

Water is essential to supporting and sustaining the environmental, economic, and public health needs of the state. Ongoing drought, shifts in regional climate patterns, and the state's population growth are leading to concerns about the sustainability of ever-growing demands on a limited (and shrinking) water supply. Since water security is critically important to the state, improving water efficiency is a well-established statewide policy goal. Legislation enacted in 2009 (Senate Bill X7-7, Steinberg 2009) established the goal of achieving a 20 percent reduction in urban per capita water use in California by 2020.

The California Public Utilities Commission (CPUC) has also directed the IOUs to pursue water efficiency activities, such as rebate programs and codes and standards advocacy, as part of their energy management portfolios. As discussed in Section 2.4.4, a significant amount of energy is used to fulfill California's water supply needs. CPUC has directed the energy utilities to pursue initiatives that aim to reduce the amount of energy associated with water use, including pursuing water efficiency measures.

2.4.2 Stringent Water Efficiency Standards Will Reduce the Need for Costly Water Supply Development

Establishing more stringent water efficiency standards is a cost-effective intervention for reducing California's water demand. It may be the most cost-effective intervention when compared to solutions that aim to increase and maintain reliable water supplies. For instance, projects, such as ocean water desalination, dams, or new water conveyance cost billions of dollars.[5] On the other hand, water efficiency standards will reduce Californians' expenditures on water and energy bills, while supporting manufacturers and builders that offer high efficiency devices. Additionally, in contrast to large-scale water supply projects, efficient water use is expected to result in significant environmental benefits.

2.4.3 Long-Term Energy Efficiency Initiatives

California has several long-term polices in place to enhance energy efficiency, curb greenhouse gas emissions (GHG), and reduce the demand on energy resources and the electricity grid. This section briefly describes some of the many policies adopted across the state in recent years.

The Global Warming Solutions Act of 2006 (AB 32), requires California to reduce its GHG emissions to 1990 levels by 2020 — a reduction of approximately 15 percent below emissions expected under a "business as usual" scenario (CARB 2015). Implementation of AB 32 is laid out in the "Climate Change Scoping Plan," last updated in May 2014. One of the key elements of the scoping plan is to expand and strengthen energy efficiency programs, including Title 20, and improve the efficiency of water use as described further below. To date, California is on target to meet the goals of AB 32 (CARB 2014). In response, Governor Brown issued Executive Order B-30-15 on April 29, 2015, which established a California greenhouse gas reduction target of 40 percent below 1990 levels by 2030 (CA Exec. Order No. B-30-15). The Executive Order calls for the most aggressive greenhouse gas reductions policy in national history. This goal was subsequently adopted into state law via SB 32 (Pavley 2016).

On October 18, 2007, the California Public Utilities Commission (CPUC) published Decision 07-10-032, which created a framework for long-term strategic planning of energy efficiency and other demand-reducing programs (CPUC 2007a). Through Decision 07-10-032, CPUC adopted the state's zero net energy (ZNE) goals, which call for all new residential and commercial construction in California to be ZNE by 2020 and 2030, respectively. These ZNE goals have encouraged the Energy Commission's adoption of more stringent energy efficiency standards for appliances and buildings in California over the past few years. The state's building and appliance energy efficiency standards have saved Californians $74 billion in energy costs since 1977 (CARB 2014).

On October 11, 2009, the California Legislature adopted Assembly Bill 758. AB 758 requires the Energy Commission to develop a comprehensive energy efficiency program to achieve greater energy savings in the state's existing residential and commercial building stock (AB 758, 2009).

[5] Though it can produce a reliable source of water, desalination is a very expensive and energy-intensive technology. It also has an impact on the local aquatic environment, as well as electric consumers and ratepayers, since energy is the largest single cost for a desalination plant (Pacific Institute 2013). Further, upgrading infrastructure for water conveyance and storage can cost tens of billions of dollars.

In his inaugural address on January 5, 2015, Governor Brown proposed the goal of doubling the efficiency of existing buildings by 2030 along with other goals for increasing renewable energy use and decreasing fossil fuel consumption in the transportation sector by 50 percent (Brown 2015). California SB 350 (De León 2015) calls for annual targets for statewide energy efficiency savings and demand reduction that will achieve a cumulative doubling of statewide energy efficiency savings in electricity and natural gas by January 1, 2030, furthering California's commitment to energy efficiency.

In addition to the state's energy efficiency policies, the IOUs have a long history of implementing residential and commercial energy efficiency programs to spur market transformation of energy efficient technologies. The IOUs' Statewide Codes and Standards Enhancement program has also had a significant impact on the adoption of various appliance and building efficiency standards both in California and nationally, which have led to substantial energy and water savings, as well as meaningful GHG and cost reductions for the state.

2.4.4 Water-Energy Nexus

The term "water-energy nexus" refers to the interdependent relationship between water use and energy use in California. The relationship between water, energy, and GHG emissions helps to further justify additional water efficiency standards. An Energy Commission study found that nearly 20 percent of electricity use and 30 percent of non-power plant-related natural gas use in California is associated with water pumping, treatment, heating, and disposal (CEC 2006).[6] California consumes about 2.9 trillion gallons of water per year for urban uses (Christian-Smith et al 2012).[7] According to Christian-Smith, Heberger & Allen 2012, these 2.9 trillion gallons of water correspond to approximately 26.4 terawatt hours (TWh) of embedded electricity though the CASE Team analysis uses a lower assumed value. Additionally, water is required to produce electricity (2012). If electricity demand increases, so does the demand for water (California Sustainability Alliance 2013).

As noted earlier, the California Climate Change Scoping Plan recognizes that this water-energy nexus has significant potential implications for achieving climate change avoidance goals since the embedded energy in water results in GHG emissions (CARB 2008). The plan calls for the establishment of indoor and outdoor water efficiency standards, and water recycling initiatives to help achieve California's GHG reduction goals. Specifically, the plan (Volume I p. C-132) calls for the Energy Commission and other state agencies to adopt standards, including Appliance Efficiency Standards and Landscape Water Standards. The CASE Team also notes that climate change is likely to increase the frequency and severity of California's drought cycles. Thus, water efficiency standards are also a vital step towards adaptation in response to climate change.

2.4.5 Direct Energy Savings

In addition to the embedded energy, the direct energy use of irrigation controllers presents a savings opportunity. The CASE Team reviewed two studies that measured the standby power of

[6] Water-related energy uses include energy consumed by water agencies for water collection, extraction, conveyance, treatment, distribution prior to use (potable water), and treatment and disposal after use (wastewater). It also includes energy used by the end-user after the water agency has delivered water, such as energy used to pump and heat water on site.

[7] Urban uses include outdoor and indoor residential water use; water used in commercial, institutional, and industrial applications; and unreported water use, which is primarily attributed to leaks.

irrigation controllers, which ranged from 1 W to 8 W (LBNL 2009, NRDC 2015). Irrigation controllers are essentially small, simple computers, with timers, network connections, and sensors to wake them from standby to active mode. Sleep mode power draw of ENERGY STAR-qualified desktop computers, in which the computer is powered down, preserving its session in volatile memory and waiting to be reactivated by the network or user, is as low as 0.1 W and averages 1.6 W (Figure 1).

ENERGY STAR audio-video products, which also contain sophisticated electronics and functionality, average less than 0.5 W in their sleep mode. Although these products serve very different applications from irrigation controllers when operating, their power consumption when providing minimal functionality is indicative of what may be technologically achievable and illustrates significant potential for irrigation controller products to reduce standby power. The wide range of standby power measured within the irrigation controller category itself shows that these products have not yet been fully optimized for energy efficiency.

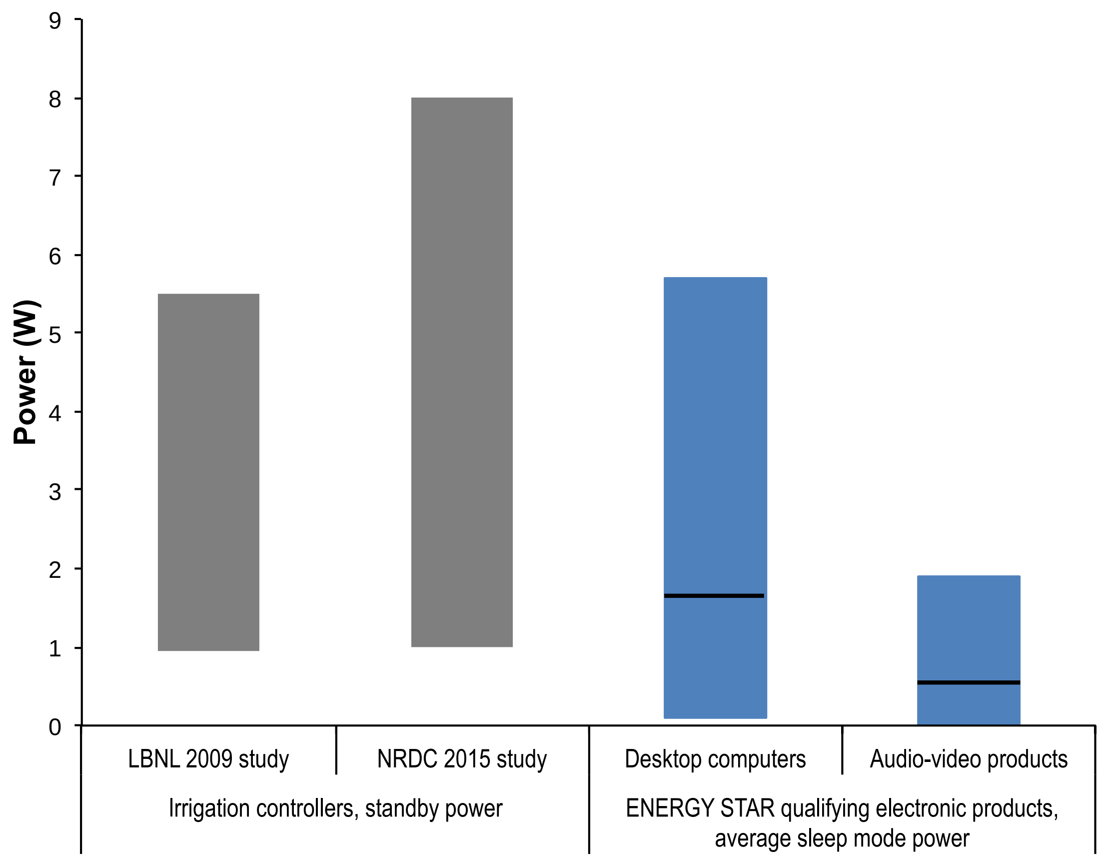

Figure 1. Measured standby power of irrigation controllers compared to sleep power in ENERGY STAR qualified desktops and audio-video products shows significant potential for

power reduction. Average sleep mode power for ENERGY STAR computers and A/V products indicated by black lines.

3. 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 2). Traditional automatic irrigation systems are generally considered to operate with an irrigation efficiency of 50 percent or less (Hanak and Davis 2006).[8]

Irrigation controllers are often considered the "brains" of an irrigation system. Automatic irrigation systems offer a modern convenience for busy homeowners and business operators, but they can also lead to over-irrigation and wasted water and associated energy.

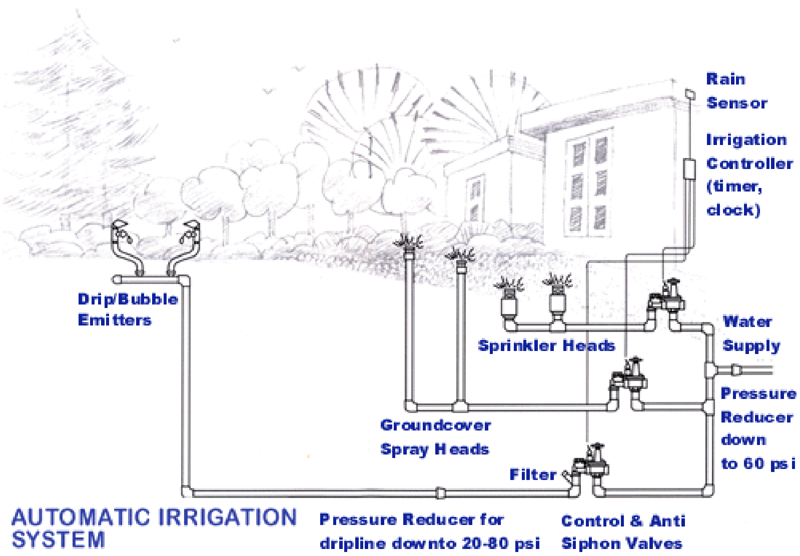

Figure 2. Schematic of a typical in-ground automatic irrigation system.
Source: Town of Portland Connecticut

Traditional irrigation controllers are typically timers that control the frequency, start times, and duration of watering for several irrigation stations (i.e., zones). Over time, landscape irrigation controllers have evolved from electromechanical devices that use electrically driven clock and mechanical switching (i.e., gears) to activate irrigation systems, to electronic controllers with microprocessors to provide the clock/timers, memory, and control functions.

Controllers use the flow of electricity to activate solenoid valves that release water for irrigation for different landscape zones. Hose-end timers, which can directly control a garden hose with an attached moveable sprinkler or single zone permanent irrigation system, are not addressed in this response. Solenoid valves are named for the cylindrical shaped mechanism that is screwed into the valve. At the center of the solenoid is a rod supported by a spring. When the solenoid is closed, the rod covers the inlet port hole that allows water through the main line. The solenoid has two wires

[8] 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 2015).

connected to its internal coil and to the landscape irrigation controller. Applying electricity through the two wires energizes the coil and causes the rod to contract into the solenoid, opening the valve to allow water to flow. Removing the voltage causes the rod to revert to its original position and close the valve.

3.1 Water Efficiency Features

Water efficient controllers are designed to better match irrigation schedules and rates to actual landscape water requirements, thereby reducing the amount of water that is applied while maintaining plant health. As a result of improved scheduling, water efficient controllers seek to eliminate irrigation water that is lost to deep percolation, runoff or evaporation (i.e., "wasted" uses). In practice, efficient 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 controller can save water by automatically adjusting to changing irrigation requirements as the season changes, such as from summer to fall and fall to winter (over which time a landscape's ET requirements will significantly decline) and does not depend on homeowners or gardeners to make that adjustment.

Some water saving features can be achieved based on operator inputs without the need for sensors or off-site data. Examples of these features include the following:

- Non-volatile memory to retain programming information in the event of a power outage
- Independent programming by station
- Multiple station start times per day
- Advanced internal calendars that can implement municipal restrictions into the watering schedule
- A water-budgeting feature that adjusts normal run times by a percentage without needing to manually re-program each individual station. "Optimal" ET values that may not consider the benefits of water conservation and associated cost savings can typically be reduced somewhat while maintaining landscapes with an acceptable appearance.

Additional water savings features use feedback from one or more sensors or off-site data sources and adjust schedules for when to apply water and/or how much water to apply. This type of equipment, often referred to as "smart" controllers, may have inherent capabilities or input terminals for connecting external sensors, such as weather, soil and shut-off device, thereby eliminating the need to make manual scheduling adjustments.[9] Studies indicate that replacing a traditional controller or timer with a controller that uses external data can generate significant water savings. In a 2014 review of 47 distinct reference sources, Lawrence Berkeley National Laboratory (LBNL) researchers found water savings of about 15 percent for weather-based controllers and about 21 percent for rain shut-off devices. In nonresidential applications (e.g., light commercial, public areas), higher water savings of about 21 percent are possible from weather-based irrigation controllers (LBNL 2014).

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[9] The Irrigation Association (2008) 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."

Weather-based (also called climate-based) controllers operate by scheduling irrigation as a function of weather conditions. These controllers gather weather information in a variety of ways. Some controllers use on-site weather sensors to gather weather data in real-time, such as rainfall, humidity, solar radiation, wind, and temperature. Other controllers receive regular location-specific updates from a local weather station or network of weather stations via a cellular, internet or other cloud connection. These "connected" controllers upload data to a remote central server or cloud to conduct system analytics. Connected devices have continuous connection with the Internet and run numerous ancillary functions in standby mode, such as pulling weather information from nearby weather stations, interacting with mobile applications, and performing diagnostics to check that the system is working properly. Connected controllers may also receive or send alerts, receive software updates, and upload run time data to a remote central server or cloud for analyzing irrigation needs. Finally, some controllers use stored historical weather information based on site location (e.g., zip code or latitudinal and longitudinal coordinates). In each case, weather information is used to schedule irrigation based on a target landscape ET, which is a function of plant type and weather conditions. ET is the quantity of moisture that is evaporated from the soil and plant surface and transpired by the plant. Weather-based controllers are available both as stand-alone controllers with integrated weather features, which are designed to replace a traditional controller or timer, and as an add-on controller module or sensor which works in coordination with a compatible base controller.

Soil moisture-based controllers rely on one or more soil moisture sensors. The controllers use one or more parameters measured by the sensor(s) to calculate the water content of soil. They then adjust the irrigation schedule accordingly to maintain adequate moisture levels for the soil and plant types. Most of the currently available soil moisture sensor-based controllers function as an add-on to an existing irrigation controller, although some models are available that function as a stand-alone controller. Soil moisture sensors and controllers are currently uncommon in the landscape irrigation market, despite significant technical potential to determine soil moisture at specific point(s) and provide data for irrigation scheduling.[10]

Irrigation controllers, especially controllers with water savings features, are commonly designed to accept inputs from a rain shut-off device or rain gauge and may be sold with this device (DOI 2015). Rain shut-off devices are designed to interrupt a scheduled cycle of an automatic irrigation controller when a certain amount of rainfall has occurred. Some devices even allow consumers to adjust the rainfall detection level that will trigger a shut-off in increments of 1/8 inch or 3 mm of precipitation, though some research indicates that small differences in shut-off thresholds, such as the 3 mm (1/8 inch) and 6 mm (1/4 inch) settings, will not significantly affect performance (Meeks 2012). Every device with adjustable settings tested by Meeks (2012) could be set for a detection level of 6 mm or less (i.e., 1/4 inch), and each demonstrated the ability to consistently shut-off irrigation at 6 mm or lower when set for a 6 mm shut-off over a period of 1,150 to 1,182 days.[11] Another study found that one device (Hunter Wireless Rain-Clik) was extremely consistent and suspended irrigation at extremely low levels, on average below 3 mm (Cardenas-Lailhacar B. and M. Dukes 2008). A second common device, the Hunter Mini-Clik, detected more than 97

[10] Soil moisture sensing products are more common in the agricultural market.

[11] Meeks (2012) recommended replacement of one model after a year for highest accuracy. As noted earlier, the product still provides the capability to shut-off irrigation after a 6 mm rainfall event at the end of the study period.

percent of significant rainfall events (the study does not report data specific to the potential 6 mm shut-off threshold for this device).[12]

The most commonly used type of rain shut-off device is an expansion disk sensor (Dukes and Haman 2002). An expansion disk device uses hydroscopic expanding material (cork disks) that expands proportionally to the rainfall amount. This expansion triggers a pressure switch and 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 shut-off devices use a receptacle to collect the water, and then either weigh the water or detect water level with a set of electrodes. Rain gauges can measure and report the quantity of rain rather than providing an "on/off" rain interruption capability. Certain types of controllers can use rain shut-off device data as an input and suspend irrigation for a specific amount of time, such as 24 or 48 hours, rather than relying on the amount of time that is necessary for a disk to dry out.

Modern rain shut-off devices are either wired or wirelessly-controlled via a radio or other connection. Wireless sensors can provide a more convenient approach than devices that are designed to be wired directly to the controller. Wireless devices have a sensor and transmitter that is mounted at an optimal location and a separate receiver module that is wired to the controller. The sensor is installed at an unobstructed location that can detect rainfall, but away from irrigation spray or rain accumulation and submersion. Rain shut-off devices are commonly mounted next to a roof gutter. The receiver unit is then mounted either indoors or outdoors in a location with a strong signal with the sensor and wired to the irrigation controller, typically through a designated location on the controller. In Florida, rain shut-off devices have been required for new systems since 2010 under Florida statute.[13] In addition, "A licensed contractor who installs or performs work on an automatic landscape irrigation system must test for the correct operation of each … device."

Table 2 below shows some examples of commercially-available traditional and water efficient irrigation controllers.

Table 2. Select Examples of Commercially Available Irrigation Controllers

	**Traditional Irrigation Timer** Example: Orbit Easy Set Logic Timer. Allows for irrigation scheduling by day, time and duration. Also, allows for user programmable rain delay scheduling of 24, 48 or 72 hours. No onsite or historical weather data considered when scheduling irrigation. The device will not automatically adjust for weather conditions or data; the user must manually adjust the device to account for weather. **Source:** https://www.orbitonline.com/products/sprinkler-systems/timers/timers/easy-set-logic-all-weather-sprinkler-timer/4-station-outdoor-swing-panel-timer

[12] 174 days of rainfall occurred at four units set at 3 mm and four units set at 13 mm. These eight units failed to detect 35 large rainfall events (typically from 11 to 42 mm with a few higher) from 1380 total rainfall events in aggregate across the eight units. The failure rate was comparable for units with both settings. The study does not separately report response rate of events of 6 mm or greater.

[13] Florida Statutes Title XXVIII Chapter 373 Section 62.

  	**Weather-Based Controller (add-on on-site ET/Weather Sensor)** Example: Hunter Solar Sync. The Solar Sync evapotranspiration (ET) sensor measures data that can be used to calculate ET and adjust irrigation scheduling daily based on local weather conditions and estimated plant water needs. The Solar Sync product measures solar radiation, temperature, and includes rain and freeze sensors. The Solar Sync is compatible with most Hunter controllers. Sensor is sold packaged with compatible controller or separately. **Source**: http://www.hunterindustries.com/irrigation-product/sensors/solar-syncr
	**Weather-Based Controller (Signal-Based, Standalone Device)** Example: Rachio Iro. The Iro device is connected to the Rachio cloud platform securely through home Wi-Fi. Rachio will monitor the Iro device(s) and the local weather forecast around a home over the internet, continually adjusting the irrigation schedule to use the optimal amount of water for specific zones based on the current season and home location. **Source**: https://rachio.com/store
	**Soil Moisture Sensor-Based Controller (add-on on-site Soil Moisture Sensor)** Example: Acclima SC6. The SC6 uses Acclima digital Time Domain Transmissometry (TDT) moisture sensors to control irrigation based on measured soil moisture levels. Sensor sold packaged with compatible controller. **Source:** http://acclima.com/wd/index.php?option=com_content&view=article&id=14&Itemid=11

Proper installation, programming, and adjustment are critical for fully achieving the water savings potential of landscape irrigation controllers with water saving features. The initial programming step varies in length and complexity for each controller, and requires the installer to input a variety of factors for each watering station to be programmed into the controller. These factors may include plant type, soil type, sun exposure, irrigation type or application rate, root depth, and/or slope. Many consumers self-install landscape irrigation controllers. Mayer (2009) found that self-installed weather/ET controllers could achieve at least as much or potentially greater savings as contractor-installed units. Section 8.1 of this response further addresses consumer education.

3.2 Direct Energy Use

Electronically-driven irrigation controllers also require energy from household or similar power supplies. Battery-powered units are available but are less common. Electronically-driven controllers use an AC-to-AC power supply that converts 110-120 voltage alternating current (VAC) to 24 VAC required by most solenoid valves for landscape watering. Controllers have a secondary power supply to convert alternating current to (typically) five-volt direct current, which powers the control electronics of the controller. Although landscape controllers can be installed either indoors or outdoors, most residential controllers are installed indoors (Hunter 2005). Indoor controllers typically use EPS (sometimes referred to as “wall warts” or “power bricks”), while outdoor controllers typically have a power supply located inside a weather-resistant/tamper-proof controller cabinet (i.e., an internal power supply) and are either plug-based or hard-wired to the mains power (Figure 3).

Figure 3. Indoor irrigation controller with an exterior power supply (left)[14] and an outdoor irrigation controller with an interior power supply (right).[15]

The CASE Team defines the energy consumption of a controller performing its primary function of energizing a solenoid valve or valves for watering as *active mode* energy consumption. Traditional controllers and weather-based controllers behave differently in *standby* mode. Traditional controllers largely do not perform any active or information-transferring functions in standby mode until the timer or program initiates watering. On the other hand, weather-based controllers can have standby-passive and standby-active modes. The standby-passive mode is defined as the controller not performing any functions but remaining available to be activated through a remote activation signal. Standby-active mode is defined as the controller accessing environment and weather data to calculate any needed adjustments in watering schedules or performing other exchange of information through the internet. Weather-based controllers are also either localized or connected. Localized water-efficient controllers may have higher power use in standby mode to conduct collection and analysis of on-site weather data to determine the amount of irrigation that is needed.

4. Market Analysis

4.1 Market Structure

The three largest manufacturers of landscape irrigation equipment in the California market are Rain Bird, Hunter, and Toro. All three of these companies offer base model irrigation timers as well as models with a range of water saving products and features. They also manufacture add-on devices, such as rain shut-off devices. Weather-based irrigation controllers are offered by a variety of smaller manufacturers including: Cyber-Rain, ETWater, HydroPoint, Rachio, Signature, and Weathermatic. Soil moisture sensor-based controllers are a more specialized product often offered

[14] Source: http://www.irrigationstore.com.au/Library/xc%20indoor.jpg Source: http://www.irrigationstore.com.au/Library/xc%20indoor.jpg

[15] Source: http://www.rainbirdrn.com.br/img/ESP-LXModular_open.jpg Source: http://www.rainbirdrn.com.br/img/ESP-LXModular_open.jpg

by niche manufacturers in addition to the major ones. Soil moisture sensor-based controller manufacturers include Acclima, Baseline, Decagon, Irrometer, and UgMo.

The number of landscape irrigation controller models with water-saving features has expanded significantly since weather-based products entered the market in the early 2000s. As of 2015, the U.S. Department of Interior's (DOI) Bureau of Reclamation report "Weather- and Soil Moisture-Based Landscape Irrigation Scheduling Devices, Technical Review Report – 5th Edition" provided summaries of products for approximately 18 weather-based controller manufacturers as well as nine soil moisture-based controller manufacturers. For reference, the first DOI technical report on weather-based controllers (2004) presented summaries on controllers from only seven manufacturers. Furthermore, a WaterSense specification for weather-based irrigation controllers was released in 2011. Over time, the number of WaterSense labeled irrigation controllers has steadily increased, from 67 in 2012, to 153 in 2013, to over 400 and growing in 2017.

Landscape irrigation controllers are distributed through several outlets including direct sales (e.g., manufacturers sell directly to homebuilders or other volume purchasers), sales from irrigation product distributors, and retail sales (e.g., Home Depot, Lowes, or online retailers). Retail sales are common for do-it-yourself irrigation projects. Large retail stores, such as Lowes and Home Depot, and online retailers, such as Amazon.com, Sprinkler Warehouse and Sprinkler Supply Store, process many of the retail sales. These retailers have a significant influence on which products reach the mainstream market. Price, performance, features, and ease of use and installation play a role in which products retailers choose to stock. In addition to large manufacturers and distributors, small irrigation contractor businesses also play a role in the market, as these companies often provide the product to end-use consumers.

Although some irrigation controllers can be installed and programmed by do-it-yourself homeowners, most manufacturers recommend professional installation and programming of controllers that have advanced water saving features (DOI 2015). In the case of professional installations, irrigation product distributors process many of the sales. Some manufacturers have localized distribution channels that utilize wholesale distributors to deliver a tailored distribution strategy for different regions. Wholesale distributors may work with builders, contractors, water utilities, or retail stores. The wholesaler distribution option is most common for larger manufacturers that offer a wide variety of products. Sales representatives from the wholesaler can offer personalized messaging to interested customers. Wholesalers also tend to target markets with high sales or markets that have an appetite for the specialty products they carry.

4.2 Market Share of Qualifying Products

4.2.1 Current Market Share

Currently, weather-based irrigation controllers or those equipped with a rain shut-off sensor comprise a minority of the landscape irrigation controller market in California. Soil moisture sensor-based units are considerably less common. U.S. EPA estimates that on a national level, less than ten percent of installed irrigation controllers are weather-based (U.S. EPA 2011). Given existing California mandates for installation of these units, the CASE Team believes that ten percent is also a reasonable estimate for the California market share of weather-based controllers.

The CASE Team reviewed data from a variety of sources to glean information about the availability of products that comply with potential standards. As noted earlier, a wide variety of products are available to meet potential water efficiency standards, even if products with water efficiency features are not currently a majority of the market.

Market data related to the standby power consumption of landscape irrigation controllers are not widely available. However, the CASE Team reviewed data showing that existing traditional controllers consume between one and three watts in standby mode and weather-based controllers consume between three and eight watts in standby mode (LBNL 2009, Delforge 2015). Furthermore, interviews with several manufacturers revealed that connected smart controllers, require additional energy because of ongoing background functions, such as checking weather information, receiving software updates, and monitoring system for alerts.

4.2.2 Future Market Adoption of Qualifying Products With and Without Standards

The CASE Team anticipates that a potential standard would steer the California landscape irrigation controller market to more efficient products. The standards may also increase the popularity of rain shut-off sensors due to their low cost and ease of addition to most controllers.

The CASE Team assumes that without standards, market adoption will remain low. Due to the recent drought, water prices have increased in some areas around the state. However, the CASE Team does not believe that the drought emergency converted the market for irrigation controllers. Potential market barriers include historical stocking decisions, lack of customer information regarding expected savings, and the lack of any certification process for shut-off devices.

Utility incentive programs that aim to replace traditional irrigation timers with more efficient models could increase the shipments of qualifying products. The CASE Team estimates that irrigation controllers will be replaced at the end of their useful life (11 years). However, utility incentive programs could result in irrigation controllers being replaced more quickly, especially with increased stocking of qualifying products due to new Title 20 Standards. If this happens, stock turnover will occur sooner than anticipated and California will realize the full savings potential at an earlier date.

5. Test Methods

5.1 Current Test Methods

5.1.1 Weather-based Irrigation Controllers

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. This initiative includes promoting more efficient landscape irrigation through the use of state-of-the-art irrigation technologies. The WaterSense program relies on the IA's SWAT "Turf and Landscape Irrigation System Smart Controllers Climatologically Based Controllers: 8th Testing Protocol" (September 2008) to determine irrigation adequacy and irrigation excess values (see Section 2.2 for more background on the WaterSense Specification). Products are tested across six zones with variations in soil type, grade, vegetation type, and irrigation emitter type. The test method itself does not mandate efficiency levels.

5.1.2 Soil Moisture Sensors

WaterSense does not currently label soil moisture sensors due to the lack of an established test method. CALGreen and the MWELO also do not contain test methods for this type of equipment. The IA has developed testing protocols for soil moisture sensors in two phases. The Phase 1 testing protocol evaluates how well the soil moisture-based sensor functions over a range of conditions that affect moisture (e.g., soil type, temperature, salinity).[16] The Phase 2 testing protocol focuses on the ability of the soil moisture sensor-based controller to schedule irrigation adequately and efficiently. In addition, WaterSense is currently working with the American Society of Agricultural and Biological Engineers (ASABE) to develop a more robust soil moisture sensor test method.

5.1.3 Rain shut-off devices

The IA has also developed a SWAT testing protocol for rain shut-off devices to determine their ability to respond to rainfall events (Turf and Landscape Irrigation Equipment Rainfall Shut-Off Devices Testing Protocol Version 3.0, October 2008). The protocol requires testing eight replicates of each model.[17] Precipitation data is recorded at 0.01 inch intervals by calibrated tipping bucket gauges. The device is then dried at 30 degrees Celsius prior to the next test. The protocol does not include variation of simulated precipitation rates below 0.80 inches per hour nor specifications for pH and salinity of water used to simulate rainfall.

The protocol provides performance data without setting performance standards. It also requires reporting test results, such as accuracy, precision, and coefficient of variation.

5.1.4 Power Draw

There is currently no established test method specifically for measuring the direct energy use of a landscape irrigation controller. However, the International Electrotechnical Commission (IEC) has a test procedure for measuring standby power titled "62301 Household Electrical Appliances – Measurement of Standby Power" (Second edition, 2011). This test procedure provides a method for determining the power consumption of a range of appliances and equipment when operated in standby mode. See Section 3.2 of this response for standby power definitions. Although the CASE team finds IEC 62301 sufficient for measuring standby power once the unit under test (UUT) is prepared for testing, the test procedure lacks set-up instructions for secondary functions, such as network connections or sensors. Several ENERGY STAR specifications, including those for small network equipment, electric vehicle supply equipment with communications features, TVs, and displays specify UUT set-up conditions. The CASE Team is currently evaluating the applicability of the ENERGY STAR language to irrigation controllers.

EPS used with irrigation controllers, which convert line voltage to 24 VAC, are covered under the federal standard for Class A EPS that operate consumer products and the California standard for state-regulated EPS (CEC 2008). The CASE Team assumes that EPS sold with irrigation controllers are regulated under this standard. The test method for Class A federally regulated and state-regulated power supplies is contained in the Title 10 Subpart B Appendix Z "Uniform Test Method for Measuring the Energy Consumption of External Power Supplier."

5.2 Proposed Test Methods

The sections below describe the test methods for measuring water and energy use proposed by the CASE Team.

[16] See https://www.irrigation.org/SWAT/About/Testing-Protocols/Soil%20Moisture-based-Controllers/SWAT/About/Soil-Moisture-Based-Controllers.aspx

[17] More than one model could potentially be included in a test batch.

5.2.1 Weather Based Controllers

For weather-based controllers, the CASE Team proposes that the Energy Commission adopt the test procedure used in the WaterSense Specification Version 1.0.[18] The WaterSense Specification relies on the IA's SWAT test protocol with a few modifications, as stated in the WaterSense Specification.

5.2.2 Soil Moisture Sensors

ASABE is working to develop a test method, which if adequate, could be used as a basis to test soil moisture sensors for a potential Title 20 standard. An inherent challenge in creating an adequate test method for soil moisture sensors is determining a representative location during testing since a soil moisture sensor can only be placed in one specific location. Any proposed soil moisture sensor test method should address this barrier.

5.2.3 Rain shut-off devices

The CASE Team also proposes that the Energy Commission adopt the IA SWAT test method for rain shut-off devices with certain modifications to the protocol that address additional specifications. First, the product should be tested to detect rainfall levels of 1/4 inch (comparable to 6 mm). A wide variety of products have demonstrated through testing that ability to detect rainfall at this level or lower levels over an extended time period (Meeks 2012). The product should also be tested at different simulated precipitation rates. The test method also includes reporting test results for accuracy, precision, and coefficient of variation. While these metrics (accuracy, precision, and coefficient of variation) are not directly related to a potential standard, the Energy Commission could require reporting of this information to provide additional performance data for consumers.

In addition, the proposed test method addresses ambient humidity and water pH and salinity levels. For instance, pH and salinity levels could affect the performance of units that detect rain based on conductivity between two receptors, while humidity could affect the performance of units based on disk expansion and affect the ability to detect a rainfall event. In addition, the test method specifies the accuracy of the water flow rate similar to the IA's SWAT Protocol for Pressure Regulating Spray Head Sprinklers Testing Protocol Version 3 (May 2012).

A potential water efficiency standard would address the ability of rain shut-off sensors to detect a measurable quantity precipitation so that irrigation can be suspended. For the purposes of a standard, it is less important for a sensor to detect exactly how much rainfall has occurred. Therefore, testing for units with multiple settings would only be required for the default setting rather than each setting as stated in the IA protocol. This would result in a shorter testing period (i.e., four weeks). An additional four weeks would be allowed for preparation of the test report (IA 2009).

5.2.4 Power Draw

The CASE Team proposes the use of IEC 62301, with additional UUT set-up instructions for network connections, sensors, and other secondary functions (see Section 5.1.4), to test standby power of traditional irrigation controllers, and standby-active and standby-passive power of weather- or soil moisture-based controllers. The CASE Team also proposes to include a method to

[18] *WaterSense Specification for Weather-Based Irrigation Controllers*. Volume 1.0. November 3, 2011.

measure the transition time from both active mode and standby-active mode to standby-passive mode.

6. Marking and Labeling Requirements

The CASE Team proposes that manufacturers mark landscape irrigation controllers with the manufacturing date to facilitate determining whether an individual unit was manufactured after a compliance deadline for the standards. The CASE Team notes that several manufacturers currently certify and label weather-based controller products for the voluntary WaterSense program, which will assist with standards implementation.

In addition, the CASE Team recommends requiring that manufacturers include consumer information with controllers to improve installation practices. The CASE Team assumes that the cost would be very minor on a per unit basis.[19]

7. Per Unit Water & Energy Usage

7.1 Efficiency Measures

According to the MWELO, 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 2015 b). Greater irrigation efficiency can be expected from well-designed and maintained systems. For more information about product efficiency, see Section 3.1.

7.2 Per Unit Energy Savings Information

This section describes the information the CASE Team finds useful to estimate water, energy, and environmental impacts.

7.2.1 Annual Per Unit Energy Use Methodology

Landscape irrigation controllers affect on-site energy usage (typically household current) in several ways. First, controllers often consume electricity in both standby and active mode. Second, they use electricity to control a solenoid that allows irrigation to occur.

Equations for annual per unit energy use are given below.

Equation 1. Product Annual Energy Use Calculation

$$\begin{aligned} &\mathit{Annual\ Energy\ Use}\ (\mathit{kWh\ per\ Year}) \\ &\quad = \text{standby mode power x hours in standby mode} \\ &\quad + \text{active mode power x hours in active mode} \end{aligned}$$

[19] For information on the potential cost of providing additional consumer information, please see the California IOU C&S Team Report "Air Filter Testing, Listing, and Labeling" dated July 29, 2013. That report estimated the incremental labeling cost at $0.02 per unit on a national basis. While the cost of providing consumer information for controllers may be higher on a per unit basis than air filters, for instance due to less sales volumes and economies of scale, the CASE Team assumes that it will be minor.

Equation 2. Product Energy Use Calculation

$$Active\ Mode\ Energy\ Use\ (kWh) = \text{active mode controller electricity use} + \text{solenoid electricity use}$$

Annual energy consumption of an irrigation controller is primarily driven by its standby power consumption; a typical irrigation controller is connected to the grid continuously throughout the year and spends about 97 percent of the time in standby mode (i.e. not activating a solenoid) (Foster-Porter et al. 2006).

Solenoid valve operation is another source of energy use related to landscape irrigation controllers. Solenoids typically use about 14 watts per solenoid in active mode (Rain Bird 2015c, 78).

8. Standards Implementation Issues

8.1 Consumer Education

Consumer and contractor education can help facilitate savings from qualifying products (Haley 2007). The information needed to properly install and configure landscape irrigation controllers should be included with all products sold in California, which would also help educate homeowners who self-install retrofit controllers.

For instance, rain shut-off devices could be packaged with clear instructions for proper siting and use, such as avoiding installation within the spray path of sprinklers, under tree canopies, or under gutters (Meeks 2012). Rain shut-off devices utilizing an expanding disk should also contain instructions and a recommended maintenance interval. Utility and local government education and outreach can also help encourage proper maintenance of these devices.

DWR added requirements for landscape irrigation controller configuration to the MWELO (23 CCR Division 2 Section 492.12) as recommended in comments submitted by the CASE Team on July 26, 2015. The revised MWELO requires configuration of irrigation controllers with irrigation application rate, soil types, plant factors, slope, exposure, and any other factors necessary for accurate programming. This new requirement will provide greater assurance that irrigation controllers for new landscapes are properly configured. Increased installer education and training due to compliance with the MWELO for new landscapes should also provide benefits for the installation of retrofit equipment.

8.2 Stakeholder Outreach and Positions

Numerous stakeholders have vetted a recommendation that the Energy Commission adopt Title 20 Standards for landscape irrigation controllers. For instance, the Independent Technical Panel (ITP) convened by the Department of Water Resources has included a recommendation in its "Report to the Legislature on Landscape Water Use Efficiency" (April 2016) that recommends the adoption of California landscape irrigation controller appliance efficiency standards in two phases. The first phase would require that traditional landscape irrigation controllers are packaged with a rain shut-off sensor and that they have a standby power consumption limit. The second phase would require that weather-based and soil moisture-based controllers comply with existing and upcoming WaterSense specifications and that Title 20 compliant controllers meet these requirements (ITP 2016). The proposal does not include specific code language. The membership of the ITP is shown below in Table 3.

Table 3. Independent Technical Panel Members

Name	Representation	Organization
Peter Estournes	Business	Gardenworks, Inc., Santa Rosa
Penny Falcon, P.E.	Retailer	Los Angeles Department of Water and Power
David W. Fujino, Ph.D.	Academia	UC Davis, CA Center for Urban Horticulture
William Granger	Retail Water Provider	City of Sacramento
Lisa Maddaus, P.E.	At large	Maddaus Water Management
Edward R. Osann	Environmental	Natural Resources Defense Council
Jeff Stephenson	Wholesaler	San Diego County Water Authority

The CASE Team conducted stakeholder outreach to inform the analyses in this document. The CASE Team held several discussions with the IA (a manufacturer trade association) regarding IA's test methods and other research. The CASE Team also contacted product development and customer support staff for major equipment manufacturers including Hunter, Rain Bird, and Toro to request product technology and market data and review of the proposed rain sensor test protocol. In addition, the CASE Team interviewed several smaller manufacturers, including several with WaterSense certified products that rely on off-site data collection to optimize irrigation scheduling.

These interviews informed this document, including technical details of the potential test method for rain shut-off devices. The CASE Team also found that manufacturers have made significant investments in water efficient products and several staff expressed support for statewide standards for water efficient controllers.

In addition, the CASE Team interviewed WaterSense staff and coordinated with DWR staff. The CASE Team also reached out to the Metropolitan Water District of Southern California and interviewed staff at Fresno State University's Center for Irrigation Technology (CIT).

8.3 Compliance Issues

Compliance with standards for weather-based controllers will be facilitated by the current WaterSense Specification (Version 1.0). Products that have been tested to meet the current WaterSense Specification could meet a potential Title 20 standard, and vice versa. Any manufacturer with products that have not been tested can do so through a well-established testing process. Thus, the CASE Team anticipates that for water efficiency measures, the compliance process will be relatively straightforward for manufacturers and retailers.

The CASE Team notes that fewer rain shut-off device products have been tested, at least based on the limited number of product test results reported in the literature and on the IA's website. The time required for additional testing is reasonable, as noted in Section 5 of this response, and there are a limited number of models that are common in the marketplace. Additional manufacturer outreach may be appropriate to ensure that all manufacturers are aware any rain shut-off specification or test method. When the soil moisture sensor test method is finalized, outreach could be required to make manufacturers aware of the method so they can begin testing their products. However, fewer manufacturers make a soil moisture-based controller product so less coordination is anticipated.

For potential energy efficiency standards, manufacturers will need lead time to complete manufacturing and product changes. The CASE Team recommends that the Energy Commission set a compliance date of twelve months to allow manufacturers to comply with the changes.

8.4 Other State Standards

Potential Title 20 standards are consistent with the goals of other existing standards (e.g., CALGreen, MWELO) in several ways and can help improve compliance with those standards. In terms of the MWELO, some landscapes are installed without permits, and thus, are not in compliance with the MWELO. For instance, backyards of production single family homes are often sold without landscaped backyards and may be landscaped later without a permit. In addition, current MWELO implementation is inconsistent across jurisdictions though increased local jurisdiction reporting required under the revised MWELO (effective December 1, 2015) is expected to improve implementation rates (DWR 2015b). Title 20 standards would provide a backstop for any landscapes that do not comply with the MWELO since Title 20 regulates products sold in California (i.e., new and replacement units).

Title 20 standards would also be consistent with CALGreen and MWELO requirements that mandate weather-based controllers. A wide variety of models are certified by WaterSense and available for sale in California to meet the needs of consumers for different applications.

The rain shut-off device option is also compatible with the MWELO, though not as a standalone option. Developers complying with MWELO Appendix D must install a rain shut-off device, and Title 20 standards would provide further assurance that the units achieve the intended benefits. Developers complying with the standard MWELO compliance option could choose to add a rain shut-off device to a weather-based system to achieve even greater water savings.

9. Potential Environmental Impacts

Several other environmental benefits are expected from this measure. First, as noted earlier, water conservation will lead to several significant environmental benefits. Secondly, reductions in excess irrigation will reduce run-off that can contain sediment, pesticides, and fertilizers thus reducing discharges of these pollutants to receiving water bodies. In addition, the measure may improve plant health by reducing over-irrigation.

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