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Advanced Irrigation Controls

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1.0 Introduction

The Federal Energy Management Program (FEMP) identified advanced irrigation controls as a water-saving technology that is relevant to the federal sector, is commercially available, and offers significant water-savings potential. This overview provides agencies with key information to deploy innovative products and systems that may otherwise be overlooked. It also helps agencies identify water-efficient technologies for consideration when entering into *energy savings performance contracts* or *utility energy service contracts*.

FEMP used the following considerations when selecting this technology.

- Broad applicability across the federal sector
- Water and cost savings potential
- Market availability
- Produced by multiple manufacturers
- Ease of installation/suitable as a retrofit.

2.0 Technology Description

Advanced irrigation controllers manage irrigation with smart sensing technology that optimizes the irrigation schedule. Generally, two types of commercially available advanced irrigation controllers are used to replace standard timer-based controllers—weather-based controllers and soil moisture-based controllers. Timer-based controllers operate on a fixed schedule and deliver a fixed amount of water. Advanced irrigation controllers optimize the irrigation schedule by applying water based on plant needs. Advanced irrigation controllers can have the ability to suspend irrigation if conditions such as adequate rainfall or soil moisture have been met. Figure 1 provides an overview of both technologies.

2.1 Weather-Based Irrigation Controllers

Weather-based irrigation controllers (WBIC) use weather/climate data and landscape conditions (such as plant type, soil type, and slope) to determine the amount of irrigation to provide to the plants. To do this, the climate and landscape are used to calculate evapotranspiration (ET), which is the amount of water that evaporates from the soil surface and transpires from the plants. ET is essentially the water demand that must be met for the plants to stay healthy. The actual amount of provided irrigation also depends on the weather conditions at the current moment. For example, short term weather conditions such as high winds and cloud cover may not be reflected in the ET depending on the calculation method, but these factors can affect the amount of watering done if a sensor is available. Similarly, conditions such as rain may delay the next watering cycle. Weather data can be obtained from a nearby weather station (signal-based controller) or from locally measured data (onsite sensor-based controller). Both types of WBICs can be stand-alone devices or devices that can be added to an existing timer-based system.

2.2 Soil Moisture-Based Irrigation Controllers

Soil moisture-based irrigation controllers, also known as soil moisture sensors (SMSs), use direct measurements of soil moisture to adjust the irrigation schedule. If the soil is dry, the scheduled irrigation will occur as usual or the controller will provide additional watering if there is no scheduled irrigation. If the soil is adequately moist, the scheduled irrigation will be prevented or delayed. Demand initiated controllers can modify the schedule while bypass controllers can only allow or prevent the scheduled events. These controllers have two important components: a sensor and an interface. The sensor is in contact with the soil and takes moisture measurements while the interface communicates the results to the controller. These controllers can be stand-alone devices or devices that can be added to an existing timer-based system. Sometimes, SMSs are available as an add-on to WBICs.

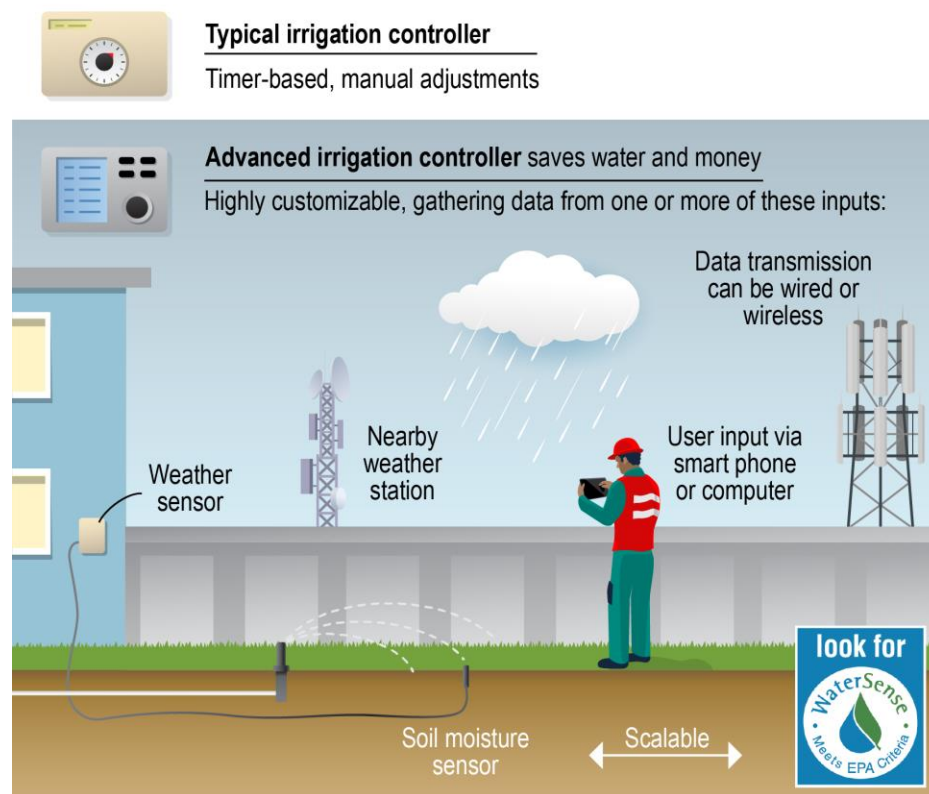


Figure 1. Advanced Irrigation Control Options

3.0 WaterSense Labeled Irrigation Control Technology

The Environmental Protection Agency (EPA) WaterSense Program labels advanced WBIC and SMS products that meet performance requirements that ensure the controller meets the irrigation needs of plants while minimizing overwatering.

3.1 WBIC Requirements: WBICs with the WaterSense Label

WBICs with the WaterSense label have been tested using the American National Standards Institute (ANSI)/American Society of Agricultural and Biological Engineers (ASABE) Standard

S627: Weather-Based Landscape Irrigation Control Systems, which makes sure the product meets the minimum performance in the following areas:

- *Irrigation Adequacy:* Evaluates the controller's ability to meet the necessary water requirements of the plants or landscape (based on the specific ET rate). WaterSense labeled controllers must score at least an 80% adequacy per irrigation zone to meet the performance threshold. Research indicates no significant difference between 80% and 100% irrigation regarding the appearance of turfgrass.
- *Irrigation Excess:* Evaluates the controller's ability to avoid excess watering. WaterSense labeled controllers must score 10% or less irrigation excess per zone and 5% or less irrigation excess as an average across six irrigation zones to meet the performance threshold (if a controller has less than six zones, it must be programmed together with additional controllers to reach six zones). This approach allows variation in controller scheduling while still preventing overwatering.

3.2 SMS Requirements: SMSs with the WaterSense Label

SMSs with the WaterSense label have been tested using ANSI/ASABE Standard S633, Testing Protocol for Landscape Irrigation Soil Moisture-Based Control Technologies, which makes sure the product meets the minimum performance in the following areas:

- *Function:* Determines whether the SMS can enable or disable irrigation at a variety of moisture levels. This makes sure the SMS will work properly regardless of landscape conditions.
- *Precision:* Measures whether the SMS can consistently enable or disable an irrigation event at a pre-set moisture threshold.
- *Soil Moisture Response:* Determines whether the SMS can adequately sense a change in soil moisture when moisture levels change.
- *Freezing Functionality:* Evaluates whether the SMS properly functions after its sensor mechanism is frozen and thawed.

3.3 Key Capability Requirements

All WaterSense labeled WBICs and SMSs must have the following supplemental capabilities which were developed through feedback and discussions with WaterSense stakeholders and are in addition to the ANSI/ASABE S627 and S633 standards:

- *System Memory:* The controller must be able to retain its programmed settings even when power is lost, and no backup battery is available. This type of data storage is known as non-volatile memory.
- *Zone Control:* The controller must have zone-by-zone control for landscapes that have multiple areas with various watering requirements that need to be managed separately.
- *Error Alerts:* The controller must be able to notify the user if it is not operating in smart mode (automatically adjusting irrigation based on sensor/signal input).
- *Sensor Connections:* The controller must be able to connect to a rainfall device or SMSs (in the case of WBICs). These can be important components of an efficient irrigation system in many climate regions and multiple states have mandated their inclusion by law. EPA

provides contacts for [irrigation professionals](#) with information about installation and mandates.

- *Compliance With Utility Restrictions:* The controller must be able to accommodate watering restrictions. With the existence of utility-imposed watering restrictions, it is important that WBICs and SMSs are capable of watering efficiently while complying with these restrictions.
- *Water Budget Mode:* The controller must include a percent adjust (aka “water budget”) feature. This feature allows users to adjust the amount of water applied to the landscape without changing the detailed settings in the controller’s program. A potential use of this feature is called “deficit watering,” in which the landscape does not receive the full ET requirement and is essentially underwatered in favor of conserving water for other uses.
- *Loss of Real-Time Data:* The controller must be able to revert to a conservative watering schedule if the product loses its real-time data input from the sensors. Historical weather data or the percent adjust (water budget) feature can be used.
- *Automatic Return to Smart Mode:* The controller must be capable of automatically returning to smart mode if switched to manual mode. Often, controllers are turned to manual mode for troubleshooting or other reasons and inadvertently not returned to smart mode. This requirement makes sure the controller will automatically return to smart mode within a specified time period as designated by the manufacturer.

4.0 Considerations for Selecting the Right Advanced Irrigation Controller

The following considerations are important when determining the appropriate advanced irrigation controller:

- *Size of Landscape:* Understanding the size and boundaries of the landscape is a good first step toward selecting or designing an appropriate system. The size of the landscape factors into many of the considerations discussed below. Large landscapes could require multiple controllers with multiple zones, each with multiple sensors. Small landscapes could require different measurements or features than larger landscapes.
- *WBICs Weather Data:* The location and accuracy of weather data is vital to the effectiveness of an WBIC. Commonly, Wi-Fi enabled controllers connect to local weather stations for data; thus, the quality of data from the weather station can impact the performance of the controller. Some manufacturers offer their own weather data service, which could require a subscription. If climate varies drastically over time or within a small area (such as in microclimates), an on-site sensor may be a more precise option for weather data. The possible sources of weather data for the specific application and the associated costs should be considered.
- *SMSs Sensor Connections:* The connectivity requirements (wired, wireless, multiple sensors, etc.) of the irrigation system when selecting a SMSs should be considered. In the case of on-site measurements, the sensor must be connected to the controller. Commonly, this is done with a wired connection. For some applications, wireless communication can be used. In larger landscapes, multiple sensors may have to connect to the same controller.
- *Performance:* The accuracy of the irrigation system needed to meet the landscape requirements should be considered. The accuracy and effectiveness of a controller can vary depending on the model. While products with the WaterSense label provide adequate

irrigation without excess water use, performance standards are met if the controller functions within a given range. Actual performance of labeled controllers depends on a wide range of factors. Irrigation managers should expect to fine tune their system to the specific site conditions to optimize performance.

- *Controller Interface*: The desired control interface and desired functions should be considered when selecting an irrigation system. Many advanced controllers have software applications adapted for mobile phones. This software can allow for monitoring or control of an irrigation system from a remote location. Similarly, web or computer-based software is available for many controllers. Deficit watering, remote control of the irrigation program, and live monitoring are all possible features.
- *Cloud Connection*: Some irrigation controllers store and communicate using cloud data, allowing for increased connectivity between controllers. This means that a network connection may be required. Some controllers have Wi-Fi modules available as an add-on. The advantages of cloud connection include the ability to communicate with other controllers in a large landscape and real-time data measurement and storage.
- *Cost*: Carefully choosing the appropriate features for a controller can avoid unnecessary costs for unneeded features. The cost of a controller is highly dependent on the number of zones it can irrigate. Therefore, the number of zones required for the current landscape should be determined before selecting the appropriate controller. Selecting a controller with extra capacity could allow for adding future zones, but keep in mind this will increase the cost. Add-ons such as on-site soil moisture or weather sensors also can significantly affect the price. Software such as weather data services and maintenance add cost and should also be considered carefully.
- *Other Measurements*: Flow sensors/meters can monitor water flow rate and can be used to measure water use and detect unscheduled irrigation events or unusual water patterns such as leaks. Similarly, pressure sensors can monitor system pressures to detect line and sprinkler head leaks. For applications requiring quick and accurate fault detections, these supplemental devices could be helpful.
- *Building Automation System (BAS) Interconnection*: Building operators can potentially collect and interpret water data or control irrigation via the BAS platform. This allows for increased monitoring and control of the building's water resources.
- *Installation and Programming*: Installation varies depending on the size of the system and the number of controllers/sensors/add-ons. Manufacturers provide installation instructions along with each model of controller, but irrigation professionals certified by a WaterSense labeled program can provide more information and assistance.

5.0 Proven Savings Potential

There have been numerous studies performed by independent third parties to investigate the potential water savings associated with commercially available WBICs and SMSs controllers. Studies reviewed show a range of 15%–40% reduction in water use. The amount of water savings depends on many factors including climate, plant types, control programming, sensor types, and system size. These studies show that advanced irrigation controls demonstrate proven savings and are expected to provide even more benefits as the state-of-the-art technology advances. Specific findings of several research studies are briefly discussed in the following sections.

General Services Administration BAS Enabled WBIC Study³: Pacific Northwest National Laboratory assessed the performance of a unique smart irrigation system that connects to a BAS in Battle Creek, Michigan. The unique BAS system was estimated at 66% water savings, showing the future potential of this currently advancing technology.

Lawrence Berkeley National Laboratory Data Analysis⁵: A study by Lawrence Berkeley National Laboratory performed a literature review and estimated the savings achievable from advanced irrigation controllers. In the United States, average outdoor water use is 58,000 gallons per year per household, and of the 13.5 million single-family homes with automatic irrigation systems, a vast majority use an inefficient timer-based system. Based on 47 different references, advanced irrigation controllers could achieve water savings of 38% for SMSs and 15% for WBICs.

American Society of Agricultural and Biological Engineers Data Analysis¹: The American Society of Agricultural and Biological Engineers performed a literature review and found that the amount of savings from an advanced irrigation controller varies widely depending on climate, plant type, and the amount of human interaction with the technology (such as updating watering schedules and properly programming the controller). Controlled research studies found an average 50% water savings, but case studies on home and commercial landscapes found an average 30% water savings.

University of Florida Advanced Irrigation Control Study⁴: A study from University of Florida found that advanced irrigation controllers need to be set up and used properly to demonstrate the significant documented water savings. Both weather and soil-based systems may need fine tuning after installation to realize the potential savings in the range of 40%–70% rather than the realized savings of 10% typical of large pilot projects.

EPA WaterSense Commercial WBIC Study²: A WaterSense case study of a WBIC in the 372,000-square-foot Granite Park office complex in Dallas, Texas, found that 12.5 million gallons of water were saved in the first year (a 40% reduction). The water reduction resulted in a \$47,000 savings within the year, with a simple payback period of 1.5 years.

6.0 Additional Resources

For more information about advanced irrigation controls, see:

- WaterSense Labeled Irrigation Controllers: Find information on WaterSense labeled WBICs and SMSs: <https://www.epa.gov/watersense/watersense-labeled-controllers>
- Irrigation Association Smart Watering Application Technologies (SWAT): Find information on WBICs, SMSs, and efficient irrigation: <https://www.irrigation.org/SWAT>

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