Water Efficiency For Public Water Systems

This document introduces water efficiency for public water systems, identifies measures to improve water efficiency, and provides recommendations on how water systems can get started and continue making water efficiency improvements. This document is intended for small and medium-sized water systems as well as technical assistance providers and state programs that support or regulate these systems.

Introduction

Water efficiency is becoming increasingly important to public water systems in the United States from a resource management and economic perspective. Increasing water efficiency can help a water system simultaneously deal with critical issues such as:

- Decreasing availability and quality of source waters,
- Increasing costs of treating and providing water,
- Aging infrastructure in service beyond its useful life,
- Growing demands for an improved level of service placed on the system by customers,
- Reducing or delaying the need for expensive capital projects, and
- Important environmental sustainability benefits, including reduced energy use and reduced pressure on water resources.

What Is Water Efficiency?

Water efficiency is the long term ethic of saving water resources through the use of water-saving technologies and practices. A related concept is water conservation, which is more narrowly focused on reducing water loss, waste or use. EPA's efforts have evolved from emphasizing only water conservation to the more holistic framework of water efficiency. As the volume of water lost (or wasted) is reduced, water efficiency improves. Likewise, as the volume of water needed to satisfy customer demands is reduced, water efficiency improves.

During periods of drought and extreme summer heat, communities and water systems are very aware of the need to conserve their water supplies. However, an increasing number of communities and water systems are recognizing the value of improving water efficiency in addition to using the short-term tools of conservation and water use restrictions during periods of emergency. Water that is lost unnecessarily or used inefficiently impedes the long-term sustainability of water systems even in parts of the country without chronic water shortages. Many water systems dealing with source water scarcity already recognize that their options are increasingly limited and that improving water efficiency has become a necessity.

How Can a Water System Improve Water Efficiency?

There is no one-size-fits-all approach to improving water efficiency – every water system is different and will need a plan that fits its conditions and needs. The building blocks for most water systems to get started include metering, water audits and implementation of a water loss control program. An annual water audit can be integrated into routine business practice. Some smaller water systems may not need a formal water audit to identify where water losses are occurring and to prioritize projects. Strategies to improve water efficiency should also examine how water is used and lost on both the supply-side and the demand-side. This includes operational uses of water by the system, such as water used during treatment (filter backwash) and water needed to flush distribution lines, as well as end-use by customers for everything from brushing teeth to industrial manufacturing.

The following section presents several commonly-used water efficiency measures. The measures are presented in the two broad categories of water efficiency: supply-side and demand-side.

Supply-Side Measures

On the supply-side, systems can often find significant efficiency gains before their water even reaches the customer. These measures benefit from their invisibility to the customer – customers get identical (and perhaps better) service while the system saves money and has more water to deliver to customers (or can withdraw less water to meet customer demand). On the other hand, if a system chooses to promote its efforts, these measures can offer an added benefit of good public relations that connects supply-side efficiency measures with demand-side efficiency measures.

Measure 1: Water Metering

Metering is the most essential capability that a drinking water system needs to obtain in order to have an understanding of how much water the system uses and loses. Metering allows a system to measure the volume of water flowing into, through and out of the system, as well as the volume of water used by customers.

In a public water system, meters may be installed at the following locations:

- Source/intake
- End of transmission line
- End of treatment train
- Entry points to the distribution system
- Entry points to pressure zones or district metered areas (DMA)
- Zones
- Each customer connection or consecutive system
- Other approved connections, such as hydrants and parks

Further information on types of meter, metering points, and metering programs can be found in *Control and Mitigation of Drinking Water Losses in Distribution Systems,* EPA 816-R-10-019, November 2010, at http://water.epa.gov/type/drink/pws/smallsystems/technical_help.cfm.

Meters need to be calibrated and in good repair to provide accurate data. The size and type of meter selected is based on the flow profile for a given service connection. Age and damage to meters can lead to deterioration and incorrect readings, making it difficult to detect leakage. Using the wrong size or type of meter in an application can also result in a portion of the flow delivered to a service connection not being registered by the meter. Regular inspection and calibration of meters, and replacing them as necessary, is an important part of managing water loss. Meter inspection and maintenance frequency may depend on system specific conditions such as water quality and the results of previous tests.

Technological advances have yielded much more powerful tools for water systems to monitor water use and loss than the traditional manual-read meters. Automated meter reading (AMR) allows water systems to measure water use per connection remotely and in real time, which not only allows for more accurate and frequent billing (itself a measure to improve water efficiency) but also is an important tool for detecting changes that might indicate significant water loss. This technology offers the added benefit of optimizing the volume of water billings issued by the water system.

Measure 2: Water Audits

Systems can use metering and other monitoring data to establish a baseline understanding of how much water the system uses and loses. This is typically accomplished with a water audit. The water audit is an assessment of the distribution, metering, and accounting operations of the water utility and uses accounting principles to determine how much water is being lost and where. Many federal and state agencies offer information to help systems plan for a water audit and, in some cases, to pay for a comprehensive water audit. For more information on conducting a water audit, see EPA's *Control and Mitigation of Drinking Water Losses in Distribution Systems* guidance document. This document is available at http://water.epa.gov/type/drink/pws/smallsystems/technical_help.cfm.

Through water audits and ongoing water accounting, systems can learn how much water is being lost or wasted in the system from source-to-tap and pinpoint problem areas so that operation improvements and maintenance can be properly prioritized and targeted to maximize water efficiency. Further, as they implement water efficiency projects and operational changes, systems can use their baseline water audit to evaluate the effectiveness of the changes and to measure the increases in water efficiency.

Measure 3: Water Loss Control

Every public water system relies either directly or indirectly on withdrawing water from a ground water source (typically a well) or a surface water source (typically a lake, reservoir or river). Not all of this water reaches a beneficial end use. Some of this water is lost along the source-to-tap pathway. Zero loss is not considered realistic given the number of pipes, valves, connections, tanks, treatment devices, meters and fixtures associated with even the least complicated public water system. A key part of any effort to improve water efficiency, therefore, is to identify sources of water loss throughout the system and to implement measures to reduce this waste.

Real water losses (leakage) in the distribution system require more water to be pumped and treated, which requires additional energy and chemical usage, resulting in wasted resources and excess pumping capacity. Apparent water losses due to customer metering inaccuracies, unauthorized consumption and billing errors can result in lost revenue. A well implemented water loss control program can reduce water and revenue loss and can also protect public health by reducing the threat of sanitary defects such as backflow or infiltration that may allow microbial or other contaminants to enter the finished water. A water loss control program should be flexible and tailored to the specific needs and characteristics of a public water system. There are three major components to an effective program:

1. Water Audit
2. Intervention
3. Evaluation

EPA has published a guidance document on water loss control, *Control and Mitigation of Drinking Water Losses in Distribution Systems*, EPA 816-R-10-019, November 2010, available at http://water.epa.gov/type/drink/pws/smallsystems/technical_help.cfm that provides detailed information on how systems can account for their water and establish a leak detection and repair strategy. The central focus of such a strategy is to identify “non–revenue water.” Non–revenue water is water that is not producing revenue and generally not producing value to customers. Systems without a comprehensive water loss control program still have opportunities to reduce lost water by addressing leaking pipes and storage, replacing inaccurate and malfunctioning meters, and eliminating unauthorized use. Many systems know about some of the leaks in their distribution system, which is an easy way to get started. Technological advances in metering, such as automated sensors and telemetry, can help systems gain a more complete and sophisticated picture of water loss, which might help systems prioritize leak repairs.

Measure 4: Pressure Management

Managing water pressure is another way that systems can improve water efficiency and manage water losses. Pressure differences may occur across a system for many reasons; the simplest reason is variance in elevation differential between water sources and end users. Reducing excess pressure can:

- Reduce the volume of leaks and decrease flow through open taps or faucets.
- Limit future losses by reducing stresses on pipes and joints, limiting the risk of new leaks.

To identify potential areas within a system for pressure reduction, hydraulic models and field studies may be needed. Maintaining adequate pressure is critical to maintaining adequate fire flow, protecting against backflow and intrusion, and maintaining water quality. All pressure reductions should be consistent with any applicable state or local regulations. In some cases, fire suppression systems or hot water heating systems on customer premises may have to be upgraded to continue to function if water pressure is lowered, especially if these systems have been damaged by corrosion or other wear.[i]

Improved pressure control often requires the installation of new equipment. Two common options are 1) pressure reducing values that can be installed in either water mains or directly into buildings, and 2) flow restrictors. Utilities may also wish to offer individualized consultation with large-volume users to offer additional pressure management advice.

Measure 5: Water Use In Treatment Processes

Utilities' treatment processes consume water. In particular, backwashing of sand filters must be done frequently and requires large volumes. In optimizing backwash practices, utilities should consider ways to minimize water use while maintaining effective cleaning of the filters. This may involve fine tuning the frequency and duration of backwashing. Overly frequent backwashing may consume water unnecessarily, although not backwashing frequently enough hinders performance. Monitoring head loss or the turbidity of the effluent from the filter may provide more flexibility than a fixed schedule. Water use may also be reduced by altering the backwash rate. The use of an air scour system can drop the rate from 15 gpm/ft^2 to 8 gpm/ft^2.[ii] A simultaneous air/water backwash system has also been shown to reduce water rates while providing sufficient cleaning.[iii]

Demand-Side Measures

Although water systems can implement water efficiency improvements on the supply-side of the equation, the long-term factor driving water use is customer demand. The measures that water systems can use to shape customer demand fall along a spectrum from voluntary approaches to mandatory conditions of water service and include:

- Education
- Water use audits
- Rebate and Incentive programs
- Water recycling and reuse (on-site reuse of process water, use of treated wastewater for non-potable reuse, or indirect potable reuse)
- Water pricing
- Water use regulations

Measure 6: Education

Information and education measures can indirectly result in water savings by encouraging customers to change inefficient water use habits and to support the water system's conservation planning goals. Water bills can identify volume of usage, rates and charges to help customers understand their water usage. Systems can also include inserts in bills with tips for home water consumption. School programs can provide information on water conservation practices to students and their families. Additional information and resources are available from EPA's WaterSense Program at http://www.epa.gov/watersense/.

Communicating the value of the water the system supplies is an important element of educating customers. Systems can explain that the public water supply is not free because of the testing and treatment needed to ensure its safety as well as the need to maintain infrastructure to deliver the water to every building throughout the community (the consumer is often unaware of the pipe network because it is out of sight). In terms of service, water systems can emphasize that they provide safe water 24 hours a day and personnel are expected to be available even during emergencies and severe storms that often knock-out other utility service, such as electricity and phone. The system's team of highly trained professionals and certified operators provide the best assurance that water is there when people need it at home, at their business, or for fighting fires. Customers that understand the number of samples and tests, the miles of pipe, the impending capital needs, the number of staff and the volume of water treated may be more receptive to water efficiency efforts and to future rate increases when necessary.

Measure 7: Water Use Audits

Some water systems have found success in offering free water audits to their large volume users, both residential and commercial. The auditor can identify ways the customers can reduce their water footprints, saving money for the customers and improving the system's overall water efficiency. Systems might find customers more willing to undergo an audit prior to an increase in water rates.

Measure 8: Rebate and Incentive Programs

Rebates and incentives can be used to encourage homeowners, businesses and institutions to replace less water efficient appliances and fixtures, as well as to install water efficient technologies. Utilities can design incentive rebate programs that are targeted to the nonresidential and residential sectors, and to indoor and outdoor uses. A program to accelerate replacements or retrofits can yield substantial water savings for the system and cost savings for the customer. Also, demonstrations and pilot programs can be used to introduce and promote new water efficient technologies.

EPA's WaterSense Program has developed water efficiency standards for many common appliances and fixtures including water efficient toilets, shower heads and faucets. Water systems can encourage customers to invest in these water-conserving devices. Federal, state and local incentives can be combined to promote WaterSense technologies. Energy utilities might also be willing to participate in order to lower the peak electrical demand from the water system during extended periods of high temperature.

Measure 9: Water Reuse and Recycling

Water reuse and recycling can reduce production demands on the utility. Such programs are particularly suited for:

- Industrial settings. Water utilities can work with non-residential customers to identify potential areas for reuse or recycling. Some industries can substantially reduce water demand through water reuse (or multiple use) in manufacturing processes. Recycled wastewater can be used for some industrial and agricultural purposes.
- Large-volume irrigation applications. Reuse and recycling can be encouraged for large volume irrigation.
- Selective residential applications. In some areas, recycled water can be used in residential applications. Water systems will need to check with local plumbing codes and ordinances for possible conditions and restrictions.

Measure 10: Water Pricing

One of the most fundamental tools water systems can use to improve water efficiency is to ensure that customers receive a cost signal by putting a volume price on the water used. Costing and pricing convey the true value of water and water delivery services to customers. Using cost-of-service accounting, user charges are established and metered rates are used so that the customer's water bill corresponds to their usage. New automated, remote metering technology makes it easier for water systems to send out more frequent bills (such as monthly rather than annual or biannual bills), which helps customers better understand their personal water usage and potentially give then more control over future water usage. Moving to more frequent billing can also soften the 'sticker shock' that customers may experience when rates are raised.

A cost analysis may be useful to understand what types of usage drive system costs. In this analysis, systems consider whether their current rate structures promote water usage (declining block rates) or conservation (increasing block rates) and what the effects might be of introducing a new rate structure on revenues. More advanced pricing methods generally allocate costs by customer class (e.g. industrial or residential) and/or type of water use. Advanced pricing might also consider seasonal variations or other methods for pricing indoor and outdoor usage based on differing contributions to system peaks.

Measure 11: Water-use Regulations

Some water systems use water-use regulations for managing water demand during droughts or other water-supply emergencies. They may also be used for promoting conservation during non-emergency situations. A few examples of water-use regulations are:

- Restrictions on non-essential uses, such as lawn watering, car washing and washing sidewalks and driveways
- Restrictions on commercial car washes, nurseries, hotels and restaurants.
- Restrictions on once-through cooling
- Restrictions on non-recirculating car washes, laundries and decorative fountains
- Standards for water-using fixtures and appliances
- Standards on new developments' landscaping, drainage and irrigation practices

State Role

States can play a significant supporting role in helping water systems understand the need for water efficiency, design a program that will work for their situation and reach out to customers to promote the program. Most state tools are voluntary, although some states have enacted regulations that require water efficiency activities and more than half of the states have established water loss standards that range from 7.5 percent to 20 percent. Examples of state tools include requirements for water systems to have a water conservation or water efficiency plan and programs to recognize and reward water systems that voluntarily implement a water efficiency program as part of good management.

States can use **Drinking Water State Revolving Fund** (DWSRF) set-aside resources to educate certified operators, system staff, and community boards about the importance of water efficiency. These set-asides can pay for water audits, leak detection efforts, designing new rates and funding rebate/incentive programs. States can also promote water efficiency directly to the public statewide and provide outreach and education materials to water systems to use in educating their customers.

Another powerful way states can apply their DWSRF program is to create incentives for systems to implement water efficiency measures. Some states give systems applying for a DWSRF loan bonus points for water efficiency efforts, while other states make a water efficiency plan a condition of receiving assistance.

States can incorporate a review of water efficiency as part of their regular sanitary surveys and during engineering plan review processes for initial water system design or modifications.

Here are some examples of how states encourage or require public water systems to improve their water efficiency:

- **Florida** has created a voluntary certification program for residential and commercial developments that encourage water efficiency through the use of efficient appliances, fixtures, and landscaping. In addition, the state uses DWSRF set-asides to provide water audits and leak detection services to small systems.
- **Washington** has a comprehensive water efficiency program based on its Water Efficiency Rule requiring metering, data collection, distribution system leakage of 10 percent or less and other requirements.
- **Colorado** requires water systems that provide over 2,000 acre feet of water per year to have a water efficiency plan in place to receive DWSRF funding. In addition, smaller systems can get bonus points for implementing water efficiency plans. The state has made grant money available to water systems to develop a water efficiency plan, implement the plan and provide public outreach and education.
- **Kansas** requires DWSRF applicants to implement a water efficiency plan that has been approved by the state.
- **Pennsylvania** has funded a leak detection program for small systems using a DWSRF set-aside; the program has saved over 1.4 billion gallons to date.
- **Nebraska** systems must either have metered all connections or the project must include meter installation to receive a DWSRF loan.
- **Nevada** uses DWSRF set-asides to fund technical assistance efforts to water systems to prepare comprehensive water conservation programs.
- **Texas** requires comprehensive regional water conservation plans of most drinking water systems.

Integrated Resource Management

Water efficiency can be accomplished by instituting operating practices such as automation methods and strategic use of storage, as well as source water protection strategies and land-use management methods aimed at conserving water. Water efficiency can be accomplished jointly with the conservation of other resources, such as energy and treatment chemicals. In addition, water and wastewater utilities can jointly plan and implement conservation programs to realize savings and share in the benefits.

Integrative practices can also be accomplished on the demand side. Water and energy utilities can conduct comprehensive end-use audits and jointly promote conservation practices by end-users. Large-volume users can work with utilities to make adjustments to processes that reduce water and energy usage and wastewater flows, while saving other resources. Utilities that provide wholesale water can work with wholesale customers to design a water efficiency program that will be mutually beneficial.

Case Studies

Metropolitan Georgia North Water Planning District (MGNWPD)

In 2003, the Metropolitan Georgia North Water Planning District (MGNWPD) adopted a water supply and water conservation management plan that focused heavily on promoting water efficiency from both producers and users to ensure a safe and sufficient supply of water to more than 6 million people in and around the Atlanta area. The creation of the regional MGNWPD, two years earlier, was driven by concerns raised by rapid population growth (> 1 million people between 2000-2008), by uncertainty over the potential impacts of climate change on a primarily surface water regional water supply, and by the need to coordinate efficiency and conservation initiatives among the more than 50 public and private water entities supplying the region.

MGNWPD developed the plan by examining the 30-year outlook for supply-side and demand-side trends. They evaluated potential water conservation and efficiency measures based on the maturity of the technologies, service area applicability, and the likelihood of consumer acceptance. Measures that were adopted include tiered water conservation rates, fixture retrofits, legislation to mandate irrigation rain sensors, residential and commercial water audits and sub-metering for multi-family buildings. A public education component was included to improve public participation. Progress has been made in achieving plan objectives, including a 20 percent reduction in water demand. Since the adoption of the plan, the average daily water use within the district has decreased from 168 gallons per day(baseline) to 151 gallons per day(2008).

The severe regional 2007-2008 drought, caused by the driest weather in 75 years, stressed drinking water supplies and underscored the timeliness of conservation and efficiency measures to the greater Atlanta area.[iv]

Gallitzin Water Authority (GWA), Pennsylvania

Water efficiency and conservation measures taken by the Gallitzin Water Authority (GWA) in Cambria County, Pennsylvania, highlight the significant energy, materials and other savings that can be realized through improved water efficiency. This is the case even when the systems involved are small (the GWA serves approximately 2,000 people through roughly 1,000 connections).

In the early 1990s, the system was experiencing high operating costs, low pressure, and extreme water loss; more than 309,929 gallons per day (70 percent) was estimated to be lost through leakage. To solve these problems, in 1994 GWA instituted a water efficiency plan. As part of the plan, GWA created production and distribution records and mapped system leaks, eventually isolating 95 percent of the leaks. Once the leaks were identified, a leak repair and corrosion control program was developed and implemented.

The results of the water efficiency program have been impressive; four years after the start of the program GWA had logged a 59 percent decrease in water production and an 87 percent decrease in non-revenue water. This has resulted in an annual $20,000 savings in energy costs and an annual $5,000 savings in chemical costs. It has also extended the life of the system's equipment.[v]

Resources

- The **Drinking Water State Revolving Fund** (DWSRF) can provide low-interest loans for a variety of energy efficiency and water efficiency projects. States are encouraged to continue to use their DWSRF capitalization grant to fund green drinking water projects to address green infrastructure, water and energy efficiency improvements and other environmentally innovative activities. In FY2010 and FY2011, states were required to use a minimum of 20 percent of their capitalization grant for green projects (also known as the Green Project Reserve or GPR). For the FY2012 capitalization grant, designating green projects is at the discretion of the state. Examples of fundable green projects include energy audits, equipment upgrades, leak detection equipment, water meter installation and installation of water efficient devices. Other improvements, which in FY2010 and FY2011 required the development of a business case to be designated for GPR, include retrofit or replacement of pumps and motors with high efficiency motors, replacement or rehabilitation of distribution lines or installing Supervisory Control and Data Acquisition (SCADA) systems. These improvements may also still be eligible for funding even if they are not designated for GPR.

Drinking water systems should contact their state DWSRF programs to find out more about the state's priorities and funding options.

Eligible water efficiency projects may include the following:

- Installing and retrofitting water efficient devices such as plumbing fixtures and appliances
- Installing water meters on previously unmetered connections and replacing broken or malfunctioning meters
- Adding Automated Meter Reading capabilities or leak detection equipment to existing meters
- Conducting water audits, leak detection studies and water use efficiency baseline studies*
- Developing conservation plans*
- Recycling and water reuse projects
- Retrofitting or replacement of existing landscape irrigation systems with more efficient systems that include moisture and rain sensing controllers
- Projects that result from a water efficiency related assessment
- Distribution system leak detection equipment
- Automatic flushing systems
- Pressure reducing valves
- Internal plant water reuse (such as backwash water recycling)
- Distribution pipe replacement or rehab**
- Storage tank replacement or rehab**
- New water efficient landscape irrigation system**

** that are reasonably expected to result in a capital project or in reduction in demand to alleviate the need for additional capital investment*
*** requires approved business case*

Reducing water loss and improving water efficiency do not have to be daunting tasks. Beginning with the basic ideas and principles outlined in this fact sheet, water systems can limit their water losses and improve their water efficiency. Additional resources available to assist water systems in promoting water efficiency, both at your facilities and with your customers, include:

- The Alliance for Water Efficiency. http://www.allianceforwaterefficiency.org
- American Water Works Association. http://www.awwa.org/waterwiser/
- US EPA WaterSense Program. http://www.epa.gov/watersense/
  Water Efficiency: The Journal for Water Resource Management. http://www.waterefficiency.net/
- The Association of Metropolitan Water Agencies. http://www.amwa.net/cs/water_efficiency/information

Additional ideas for water saving measures come from Australia and the United Kingdom:

- The savewater!® Alliance (Australia). http://www.savewater.com.au/
- Waterwise (a not-for-profit, non-governmental organization) in the UK focused on decreasing water consumption). http://www.waterwise.org.uk/

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[i] Sydney Water. 2006. Water Pressure Management Program: Improving the reliability of our water supply. http://aim.prepared-fp7.eu/viewer/doc.aspx?id=48

[ii] Satterfield, A., 2005. Filter Backwashing. Tech Brief, Vol. 5, Issue 3. National Environmental Services Center.

[iii] Amirtharajah et al., 1991. Optimum Backwash of dual Media Filters and GAC Filter-Adsorbers with Air Scour. American Water Works Association Research Foundation Report.

[iv] Metropolitan Georgia North Water Planning District (MGNWPD). 2011. Water Supply and Water Conservation Management Plan. http://www.northgeorgiawater.com/plans/water-resources-plans

[v] Maryland Department of the Environment. 2003. Developing and implementing a water conservation Plan: Guidance for Maryland Public Water Systems on Best Management Practices for Improving Water Conservation and Water Use Efficiency, page D-2. http://www.mde.state.md.us/assets/document/water_cons/wcp_guidance2003.pdf