DOE/EE-0264

Domestic Water Conservation Technologies

Using less water and energy is an investment in a sustainable future

Executive Summary

Conserving water helps to ensure that this important resource will be available for many generations to come. Conserving water also saves energy—the energy needed to treat, transport, and heat our water. That is why the Energy Policy Act (EPAct) of 1992 (Public Law 102-486) addresses water efficiency as well as energy efficiency on a national scale.

As part of the Federal government's goal to lead the nation by example in improving energy and water efficiency, Executive Order 13123, *Greening the Government through Efficient Energy Management* (1999), directs agencies to reduce their potable water consumption. This order calls on the government to implement all cost-effective water conservation measures in Federal facilities by 2010. The order also required Federal agencies to determine their baseline water use in FY 2000 and report on their usage every two years.

Agencies must also implement at least four of 10 cost-effective Best Management Practices (BMPs) for water conservation at up to 80% of their facilities by 2010. Cost-effective practices include actions the government can take, methods it can use, and products and systems it can purchase and install that have payback periods of 10 years or less, on a life-cycle cost basis. Federal agency representatives developed the BMPs with guidance from staff in the U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP). For a list of these BMPs, please see page 8. And for more information about Federal water conservation, please see FEMP's Web site, www.eren.doe.gov/femp/.

To help set priorities for Federal water conservation activities, in 1997 FEMP conducted a study of water use in Federal facilities. That study indicated that the government consumes more than 50% of its water in just three types of Federal facilities: housing, hospitals, and office buildings. These facilities have enough kitchens, restrooms, and laundry areas to provide facility managers with many opportunities to begin reducing their water and energy use—and utility costs—with cost-effective, water-saving products. Therefore, this *Federal Technology Alert* focuses on water-efficient domestic technologies, products, and appliances. They include water-saving faucets, showerheads, toilets, urinals, washing machines, and dishwashers.

Water- and Energy-Saving Mechanisms

Domestic water conservation technologies can be used effectively in many kinds of residential, institutional, and commercial buildings to help conserve water. They are especially helpful in areas where water use has been restricted because of scarce or dwindling supplies. However, these technologies can be used anywhere in almost any kind of building.

Federal facility managers can begin achieving significant savings by installing technologies and products like faucet aerators, low-flow or sensored faucets, low-flow showerheads, low-flush and composting toilets, and low-flush or waterless urinals wherever possible. Domestic appliances such as water-saving dishwashers and clothes washers can also be cost-effective. All these products are available in models that

Jim Miller, NREL/PIX03282

Water conservation technologies help extend our limited freshwater resources.

Office of Energy Efficiency and Renewable Energy

Federal Technology Alert

A publication series designed to speed the adoption of energy-efficient and renewable technologies in the Federal sector

Prepared by the New Technology Demonstration Program reduce water use without sacrificing performance.

And all these products help to save energy, as well, by reducing the amount of energy needed to process, move, and heat the water. Moreover, domestic appliances often include features that save energy at the point of use. For example, water-efficient dishwashers usually have energy-saving features such as air-drying, rather than heat-drying.

In addition, detecting and fixing water system leaks, and making sure that valves operate at the proper pressure, can add to water savings. Fixing leaks in pipes, fittings, tanks, and fixtures enhances the effectiveness of water-saving products. And pressure-reducing valves can be used to lessen the force and amount of water flows.

Recent drought conditions have made water efficiency a high priority in many parts of the nation. It is not enough, however, to simply install a new water-saving technology or product in a Federal facility. Federal experiences with the technologies show that upgrades and retrofits are most effective when employees and others know how to use a new fixture or appliance properly. Therefore, FEMP recommends that facility managers educate employees about the purposes and proper use of these water-saving technologies.

Potential Applications

Domestic water conservation technologies can be cost-effective in almost any Federal facility or housing complex that includes restrooms, kitchens, or laundry areas that are used regularly. New products are not always needed; retrofits can often bring older domestic products, such as faucets, up to today's efficiency standards. The majority of these technologies are most cost-effective in facilities that obtain their water from a water utility and send wastewater to a sewer utility.

The 1997 study funded by DOE FEMP estimated that the Federal government consumes at least 300-400 million gallons (about 1-1.5 billion liters) of water per day. Because some agencies did not respond to the survey, this is a very conservative estimate. The study estimated the cost of this water to be at least \$229 million-\$250 million per year. The estimated cost is based on an average water / wastewater rate of \$2.08 per 1000 gallons (3785 liters).

The average rate used to estimate costs is fairly low because many military facilities, which consume the bulk of Federal water, pay \$1.29 or less per 1000 gallons for water. The average rate for nonmilitary facilities, however, is \$3.82 per 1000 gallons. So, savings to those facilities could be significant after water-efficient products are installed.

The FEMP study concluded that the government could save up to 40% of all the water it now consumes by implementing conservation measures in the three building categories (housing, hospitals, and office buildings) with the highest apparent conservation potential. And just four agencies could represent as much as 80% of the potential for conservation: the Army, Air Force, Navy, and Veterans Administration (VA).

Field Experiences

Many Federal, state, and local government agencies have been purchasing and using water-efficient technologies for years. And government agencies have tested a number of them in the field. For example, a few years ago, the VA Medical Center in Portland, Oregon, identified about \$75,000 worth of water and wastewater savings, with a discounted payback of three years, in a quick walk-through audit of the facility. The center was a good candidate for a water efficiency project because of its size (1,364,000 ft^2), its age, and the high volume of use of domestic water technologies.

The audit indicated that it would be cost-effective to begin by installing water-efficient toilets, urinals, faucets, and showerheads. Therefore, the VA Medical Center began replacing as many fixtures as possible. Replacing 346 toilets and urinals resulted in an estimated annual savings of \$33,800. Installing the toilets cost about \$104,000; the simple payback period was three years, and the discounted payback, four years. Retrofitting all the faucets with low-flow aerators cost approximately \$8,000. Estimated annual savings were about \$10,000, for a simple payback of 0.7 year and a discounted payback of 1.5 years. Replacing 51 showerheads resulted in estimated annual savings of \$6,500. The installed cost was about \$2,100, the simple payback was 0.3 year, and the discounted payback, one year.

Implementation Barriers

Despite the potential for water, energy, and money savings, certain institutional barriers could reduce or prevent the widespread implementation of water-efficient technologies. Barriers in the Federal sector include these:

- Inadequate information about the amount of water a facility uses
- Low current water costs
- Insufficient knowledge about the cost-effectiveness of water conservation projects
- Lack of funding to carry out projects
- Misconceptions about the use and benefits of water-efficient technologies.

Overcoming these barriers is important, because in some areas, the nation faces a crisis in water supplies. In such areas, water-saving technologies and products can make an important contribution to aggressive conservation efforts.

Conclusion

Water-saving technologies provide important benefits to facilities in severely dry areas, but they are worth considering for Federal facilities everywhere because of their environmental and economic benefits. Even in areas where water resources are not scarce, we are likely to see increases in the use of these and other practical, water-saving technologies in our homes, places of business, and government facilities, because they are cost-effective, they help us save natural resources—and they work.

Domestic Water Conservation Technologies

Using less water and energy is an investment in a sustainable future

Federal Technology Alert

Abstract

The Energy Policy Act (EPAct) of 1992 set new standards for energy and water efficiency. Because the government is required to lead by example in achieving the nation's conservation goals, EPAct directs Federal agencies to install all cost-effective water efficiency measures by 2005 and to purchase products in the upper 25% of those that meet standards for energy and water efficiency.

In support of EPAct, Executive Order 13123, *Greening the Government through Efficient Energy Management*, signed in 1999, directs the Federal government to implement all cost-effective water conservation measures in its facilities by 2010. Cost-effective measures include conservation methods, products, and fully equipped systems that have simple payback periods of 10 years or less. Agencies must report on the measures they are taking and their water usage every two years.

By implementing water conservation measures, the Federal government could save more than 120 million gallons (450 million liters) of water per day, or 40% of the estimated 300 million gallons (about 1.1 billion liters) or more that it now consumes daily, according to one conservative estimate. There is great potential for savings, and it may be greatest in housing, hospitals, office buildings, and other Federal facilities that make extensive use of water-using equipment.

Most of the domestic products being manufactured to new standards for water and energy efficiency are cost-effective to install in Federal facilities now. In other words, they will pay for themselves in water and energy savings in 10 years or less. These products include faucet aerators, low-flow and sensored faucets, low-flow showerheads, low-flush and ultra-low-flush toilets, and ultra-low-flush and waterless urinals.

Along with those fixtures, many water-efficient appliances—such as clothes washers and dishwashers—are cost-effective for new government housing and other facilities that use them. The cost-effectiveness of these products has been demonstrated in numerous studies done by the water utility industry.

Fixing supply system leaks and installing pressure-reducing valves, where appropriate, can also help to conserve water. Because they save water and energy in areas with good conservation potential, and they provide environmental and economic benefits to the nation, these domestic products, technologies, and conservation measures are the focus of this *Federal Technology Alert*.

Jim Miller, NREL/PIX03282

Water conservation technologies help extend our limited freshwater resources.

Contents

About the Technologies

The technologies described in this *Federal Technology Alert* include water-efficient faucets and faucet aerators, low-flow showerheads, low-flush and composting toilets, low-flush and waterless (water-free) urinals, and water-efficient clothes washers and dishwashers. These domestic water-conserving technologies can help to reduce water use at your facility and trim your water utility costs. Table 1 shows the water usage rates for the fixtures and appliances described in this section.

Water-efficient faucets—EPAct set new Federal efficiency standard for faucets manufactured after January 1, 1994. The new standard for kitchen faucets is a maximum flow rate of 2.5 gallons per minute (gpm) [9.5 liters per minute (lpm)] at 80 pounds per square inch (psi) [550 kilopascals (kPa)]. The standard for lavatory faucets is 2–2.2 gpm (7.6–8.3 lpm) or less at 60 psi (414 kPa). EPAct requires that metered, self-closing, and sensor-operated faucets use a maximum of 0.25 gallon (0.9 liter) per cycle.

Faucets and aerators. New faucet products that meet or exceed Federal water efficiency guidelines operate by means of either laminar flow or aeration. In laminar-flow faucets, water flows in clear, parallel streams and is not mixed with air. Thus, laminar-flow faucets usually wet surfaces better than aerating faucets do. Nonaerating, laminar-flow devices that do not pull potentially contaminated air into the water stream are usually required in hospitals. Aerated faucets are suitable for many other applications, especially residential and office building lavatories.

Kitchen faucets usually need to operate at higher flow rates and pressures than lavatory faucets. This is because the washing, rinsing, filling, and sanitizing tasks done in kitchens often require rather forceful flows. Flows between 2 and 2.2 gpm (7.6 and 8.3 lpm) are about the minimum needed for kitchen faucets and aerators. In contrast, flow rates as low as 0.5 gpm (1.9 lpm) may supply

Warren Gretz, NREL/PIX00653

Infrared sink sensors help conserve water in a restroom at the Denver Federal Center.

Table 1. Water-Usage Rates for Domestic Fixtures

Technology	Pre-1990 Usage	Pre-EPAct Usage	EPAct Requirement (1994–1997)	2000 Efficient Models
Faucet	5–7 gpm [a] (18.9-26.5 lpm)	4 gpm (15.1 lpm)	2.5 gpm (9.5 lpm)	0.5 gpm (1.9 lpm)
Showerhead	4.5–8 gpm (17–30.3 lpm)	3.5 gpm (13.2 lpm)	2.5 gpm (9.5 lpm)	1.5 gpm (5.7 lpm)
Tank toilet	4–7 gpf [b] (15.1–26.5 lpf)	3.5 gpf (13.2 lpf)	1.6 gpf (6.1 lpf)	1 gpf (3.8 lpf)
Flushometer toilet	4.5 gpf (17 lpf)	3.5 gpf (13.2 lpf)	1.6 gpf (6.1 lpf)	1 gpf (3.8 lpf)
Urinal	3.5–5 gpf (13.2–18.9 lpf)	1.5 gpf (5.7 lpf)	1 gpf (3.8 lpf)	Waterless urinal
Clothes washer		45–55 gpu [c] (170.3–208.2 lpu)	No requirement, 45 gpu average (170.3 lpu)	25 gpu (94.6 lpu)
Dishwasher		10–5 gpu (37.9–56.8 lpu)	No requirement, 10–15 gpu average (37.9-56.8 lpu)	4.5–6 gpu (17–22.7 lpu)

[a] gpm = gallons per minute; lpm = liters per minute

[b] gpf = gallons per flush; lpf = liters per flush

[c] gpu = gallons per use; lpu = liters per use

enough water for the average user of a lavatory faucet.

Both kitchen and lavatory faucets with flow rates of about 2 gpm (7.6 lpm) should be satisfactory for many applications, according to the Environmental Protection Agency (EPA). And FEMP has recommended that faucets have a flow rate of 2 gpm or less at 60 psi. In contrast, older manually operated faucets usually have flow rates from about 3–5 gpm (11.4–18.9 lpm), though some are as high as 7 gpm (26.5 lpm). Older faucets can often be made more efficient with new aerators, if the faucets are in good condition and have threads at the ends that can accommodate an aerator.

Faucet controls. Mechanical, electronic, and battery-operated controls can be used to turn faucets on or off. They are probably most cost-effective in facilities in which users tend to leave lavatory or kitchen faucets on too long.

Push-spring controls turn the faucet on when the user pushes the mechanism down; the faucet turns off when the push spring bounces back. However, these controls must be properly maintained to be effective. For example, water audits of 25 schools in Georgia uncovered several malfunctioning push-spring faucets containing grit, which was causing them to stay on longer than necessary.

Trickle shut-off valves or fingertip levers can often be added to faucets. They allow the user to shut the water off during a task that does not require a continuous flow and then turn it back on without having to readjust the flow and temperature.

Other controls feature electronic or battery-operated sensors. The electronic type uses an infrared sensor to detect movement within a certain distance; it is wired to an electrical circuit. The battery-powered type uses fiber optics to detect motion. Many models can be customized, and some can be adjusted to turn the faucet on and off only when users' hands are within a certain distance. With many models, an installer or maintenance worker adjusts the amount of time that the faucet stays on. Some older faucets can also be fitted with sensors.

Low-flow showerheads—EPAct mandates that showerheads manufactured after January 1, 1994, have flow rates of 2.5 gpm (9.5 lpm) or less at a maximum pressure of 80 psi (552 kPa). Many showerheads are effective at lower flow rates, however. To choose the best showerheads, facility managers should first determine the water pressure in their buildings. If it is less than 40 psi (275 kPa), a low-flow showerhead will probably not be satisfactory. If the water pressure is greater than 80 psi, however, the flow rate will be greater than the allowed 2.5 gpm.

Older showerheads have an average flow of 3.7 gpm (14 lpm). However, customer satisfaction surveys—such as the one undertaken by SBW Consulting for the Bonneville Power Administration—have shown that well-designed, low-flow showerheads provide showers that are just as satisfactory as those provided by older models with more forceful flows.

Today's 2.5-gpm showerheads are highly efficient, cost-effective, water-conserving devices with good track records. They are relatively inexpensive, and they yield significant water savings, especially in facilities with a high volume of use. To further reduce water use in facilities with public showers, facility operators may also want to consider installing coin-operated timer controls.

Several companies manufacture showerheads with flow rates lower than 2.5 gpm; customers have provided favorable feedback on many of them. Several models have flow rates of 1–1.5 gpm (3.8–5.7 lpm) or less. In at least one model, a venturi effect is built into the design; this creates a strong spray pattern at a high velocity and low flow rate.

Low-flush and composting toilets—EPAct requires that all indoor residential toilets manufactured after January 1, 1994, consume 1.6 gallons per flush (gpf) of water or less [6.1 liters per flush (lpf) or less]. Until January 1, 1997, commercial toilets that consumed about 3.5 gpf (13.2 lpf) were allowable under EPAct. FEMP procurement recommendations for toilets are consistent with the EPAct standard.

When low-flow toilets were first introduced, they were thought to be ineffective because they required more flushes than should be necessary. Most of those low-flow models were modified versions of older 3.5 gpf (13.2 lpf) toilets. Today, many have been redesigned to provide a more effective flow through the unit and a better wash in the bowl. However, some low-quality toilets are still on the market, so FEMP recommends purchasing high-quality models that save time and money in the long run.

The three general types of toilets are tank-style, flushometer, and composting.

- Tank toilets are the type that most people have in their apartments or homes. Most tank models use stored water and water pressure to flush waste. Some tank toilets also use another flushing mechanism, such as a vacuum.
- Flushometer-style toilets are those found in most commercial office buildings. They contain a bowl and a flush valve that allows a metered amount of water to enter the toilet under pressure and flush the waste. These toilets are flushed either manually or automatically by means of a sensor.
- Composting toilets have no flush valves or handles and use little or no water, allowing waste to fall into a cavity where it is composted. They make use of aerobic bacteria to break down wastes into by-products that can be used as fertilizer for trees and shrubs.

Tank toilets. There are four basic types of tank toilets: gravity-flush, pressure-assisted, pump-assisted, and vacuum-assisted. Gravity-flush and pressure-assisted toilets are the two most common types.

- Gravity-flush toilets are the standard for residential use. They use the weight and pressure of water stored in the tank to wash the bowl and remove waste. These models require a water pressure of only 10–15 psi (68.8–103.1 kPa) to operate properly. They are usually the cheapest toilets to buy, install, and maintain, starting at about $75. However, they can be less effective at removing wastes than pressure-assisted models.
- Pressure-assisted toilets use compressed air to increase the force of the flush. The pressure in a facility's water line compresses the air. Releasing the valve forces pressurized water into the bowl with a force up to 500 times greater than that of a conventional gravity-flush toilet. These toilets require a minimum water pressure of 25 psi (171.9 kPa) to operate well. Generally, they remove wastes more effectively than other types, but they are also noisier and more expensive. At $200–$700, they cost approximately as much as efficient flushometer toilets.
- Pump-assisted toilets are a kind of hybrid, somewhere between gravity-flush and pressure-assisted. Rather than using the pressure in a facility's water lines, these toilets have a pump to increase the force of the flush. Drawbacks include the electric power required to run the pump and higher costs (up to $1,000). It can also be difficult to find replacement parts.
- Vacuum-assisted toilets use a vacuum chamber inside the toilet tank to pull wastes from the bowl. They are easy to install and maintain. These specialty toilets work well in niche applications and are often installed in boats and planes. They can use as little as 1 pint (about half a liter) of water. However, they are noisier and more complicated than most other models. Some are very expensive, but one model was listed in the May 1998 *Consumer Reports* at around $225.

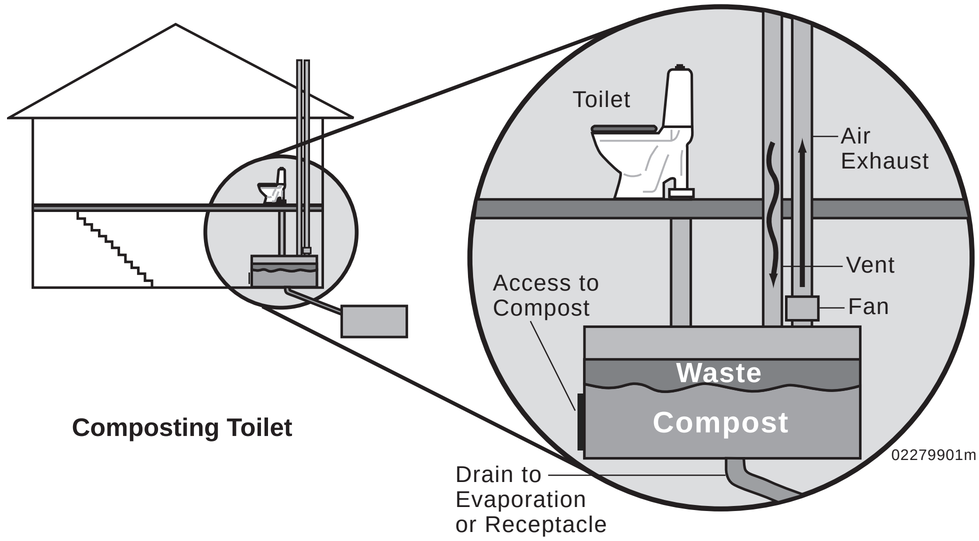
The best ultra-low-flush tank toilets are very effective while using as little as 0.5–0.8 gpf (1.9–3 liters). Ultra-low-flush metal toilets can often be used in hospitals and prisons. Some models consume only a pint of water (about half a liter) per flush. A consultant or contractor can advise you about their suitability for your facilities.

Flushometer toilets. EPAct states that all new flushometer toilets must consume 1.6 gallons (6.1 liters) per flush or less. Low-flush models require that the flush valve and the toilet bowl match, so both must be replaced. These toilets operate best at pressures between 25 and 40 psi (171.9–275 kPa). The average cost of flushometer models is about $450.

Composting toilets. These use little or no water and are not connected to traditional plumbing systems. They can be very effective in remote or hard-to-plumb facilities. They consist of one or more conventional-looking toilets connected to a composting unit underneath (for example, on the floor below or in a crawl space or basement). Residential-style toilets can process waste from up to seven people; commercial models can accommodate from seven to 50 people. Long popular in Europe, composting toilets are now available in several designs from a variety of U.S. manufacturers and suppliers.

These toilet systems convert wastes to compost by means of an aerobic decomposition process carried out by micro- and macro-organisms. Decomposition is accelerated by air, heat, and periodic mixing of the compost; in some models, this is an automated process requiring electricity. Air is drawn through the system to help control odors. Disease-causing pathogens are destroyed by thermophilic (high-temperature) bacteria that break down the pathogens within a few days if the composting chamber reaches a certain temperature. According to the *Humanure Book, E. coli*, cholera, *salmonella*, hookworms, roundworms, and many other pathogens will be killed within 20 hours at around 140°F (60°C) or within 24 hours at 122°F (50°C).

These systems can produce both liquid and solid high-nutrient fertilizers. Wastes can then be used to fertilize trees, shrubs, and lawns and thus offset the cost of artificial fertilizers. Composting toilets also reduce the pollution associated with runoff of artificial fertilizers. At current utility rates, however, composting toilets are usually not a cost-effective way to save water at facilities connected to commercial water and wastewater systems. Check local codes and installation requirements in your area before purchasing these systems.



Composting toilets use little water and can be effective in remote or hard-to-plumb facilities.

Warren Gretz, NREL/PIX00656

Ultra-low-flush urinals, like these used at the Denver Federal Center, are one of many water-saving fixtures that can be purchased by Federal agencies.

Low-flush and waterless urinals—Older urinals use 1.5–3.5 gpf (5.7–13.2 lpf) of water or more. New urinals, to comply with EPAct guidelines, must consume no more than 1 gpf (3.8 lpf). A waterless or water-free urinal requires no water at all, except for occasional cleaning. Waterless urinals manufactured in the United States use a 95% biodegradable, immiscible fluid through which heavier liquid waste passes. This fluid, which is kept in a special, U-shaped drain insert, controls odors by forming a barrier on top of the waste that traps vapors.

Note that the term *waterless* refers here to a fixture that does not require water for flushing, rather than to a specific product. Urinals that do not require flush water are currently manufactured by at least two U.S. companies; please see the list of service companies and equipment manufacturers in this publication.

In part to test the performance of this technology, hundreds of units have been installed in more than 40 different government facilities and public buildings, to date. Most of the feedback on the technology's water efficiency and ease of maintenance has been favorable. In facilities in which the number of users is expected to increase, waterless urinals will not require additional water-supply plumbing, and they add a negligible load to the waste system.

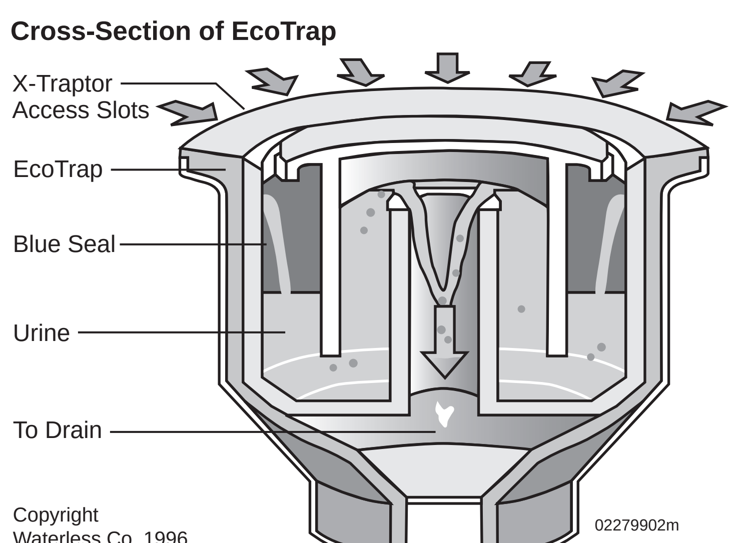
Water-efficient clothes washers—Many new washing machines use much less water than older models do. They have either a horizontal-axis tub or drum or a conventional, vertical-axis drum. The drums in horizontal-axis clothes washers rotate the way the drums in clothes dryers do, allowing clothes to tumble through a relatively shallow pool of water. Large-capacity, horizontal-axis washers are often used in commercial laundries; they are available in smaller sizes for residential use, as well. Highly efficient versions of vertical-axis washers, especially for residential use, are also available.

Federal facilities with large laundries can often use commercial-size horizontal-axis washers. Manufactured for many years in Europe, residential-size horizontal-axis washers are now being made by several U.S. companies, and they are widely available. In 1995, EPRI and a group of utilities used DOE test procedures to compare six horizontal-axis models with one vertical-axis model. The horizontal-axis machines consumed an average of 25% less water than the vertical-axis machine did. The horizontal-axis washers also used about 45% less energy and left less moisture in the clothes, which reduces drying time. However, today's new vertical-axis machines are performing better in terms of water and energy savings.

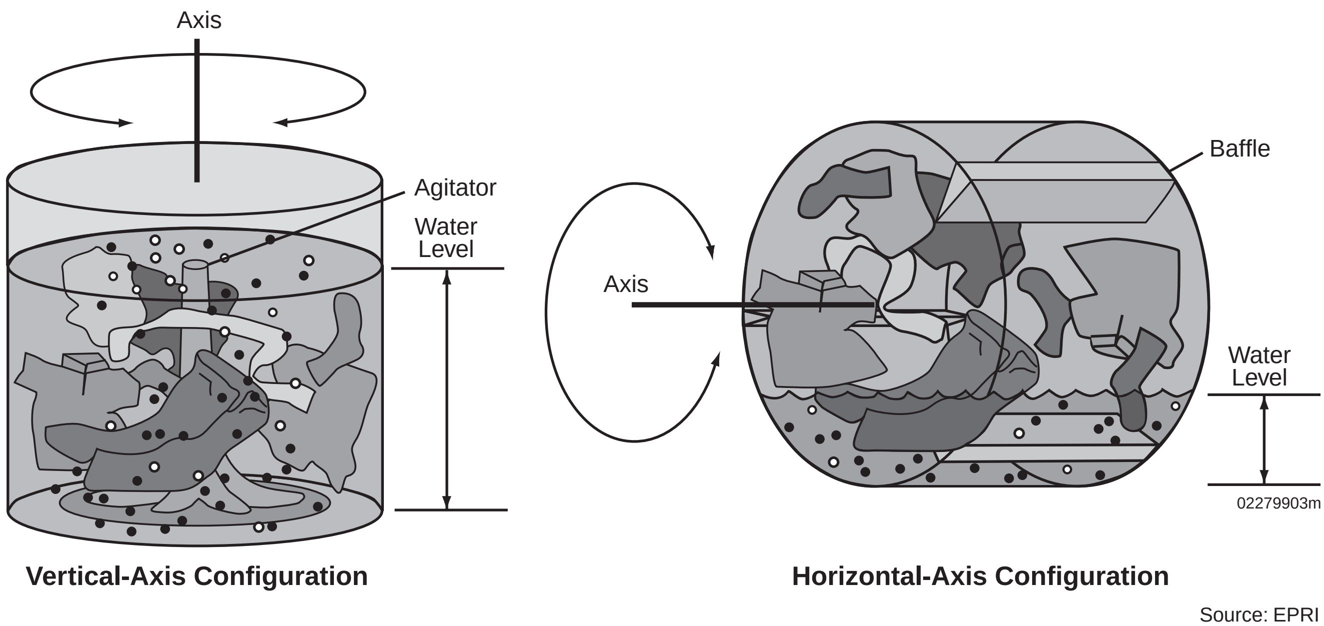
Horizontal-axis washers usually cost more than other types. But paybacks from water and energy savings make them cost-competitive, especially where energy costs are high and local utilities offer rebates. If you use older, vertical-axis machines one or more times a day, it is usually cost-effective to replace them with horizontal-axis machines or highly efficient vertical-axis models.

There are many different models of water-efficient domestic washing machines to choose from. DOE and EPA's ENERGY STAR® Web site has information on several different models. The site also includes a calculator to determine water and energy savings (www.energystar.gov/products/clothes washers/index.html). The calculator can help you quickly determine the payback associated with each machine.

Water-efficient dishwashers—Old, inefficient automatic dishwashers can often be replacedwith water- and energy-efficient models. Newer models use less water, and less energy to heat water, than older models do. Several models have boosters to heat water to



Water-saving estimates for flushless urinals range from 10,000–45,000 gallons per unit each year.



Horizontal-axis washing machines use 25% less water than vertical-axis machines, according to a 1995 EPRI report.

140°F (60°C) or more. So, if you do not have special needs for very hot water elsewhere in your building, these dishwashers could allow you to lower the maximum temperature setting on your main water heater.

Older residential-size dishwashers use between 9 and 15 gallons (34.1–56.8 liters) of water per cycle. The average is about 10 gallons (37.9 liters) per load. Newer water-saving dishwashers use between 4.5 and 9 gallons of water (17–34 liters), according to *Consumer Reports* (December 2000). It is usually cost-effective to replace a residential dishwasher if your current model uses 13 or more gallons (49 liters) per load and you run at least one load per day. Whether you have large-capacity models or residential-size machines, operating them fully loaded will maximize water and energy savings.

Fixing domestic system leaks—DOE has estimated that as much as 15%–25% of the water that goes through any system could be lost because of leaks and breaks in valves, faucets, pipes, and other equipment. To reduce water waste with any technology, all pipes and fixtures in a facility must be properly maintained and free of leaks.

Small leaks can quickly add up to a lot of wasted water. For example, a toilet leaking only four tablespoons of water per minute will waste 30 gallons (about 114 liters) of water per day, which adds up to 10,920 gallons (41,337 liters) per year at a cost of about $60 or more. If your facility had 50 toilets with similar "small" leaks, you could be paying about $3,000 per year or more for water that is never used.

Be sure to check fixtures regularly for leaky pipes, seals, valves, and other components. Dye tablet testing is a simple, inexpensive way to detect otherwise imperceptible leaks from the toilet tank to the bowl. Another way is to check two readings on a water meter. First, select a time when you know that the building's occupants will not be using water fixtures for a while. Next, read the meter and record the reading. Then, check the meter again one hour later. If the reading has increased, there is probably a leak somewhere in the system.

You can also compare water-use data if you have records from past years. A detailed water audit of your facility can provide recent data, and you can compare the new data with past annual totals to determine if a significant amount is unaccounted for. If you still cannot account for a large amount of water after correcting for data collection and analysis errors, your facility probably has hidden leaks. Contact a plumbing contractor or other expert for help in finding and fixing them.

Using pressure-reducing valves—Consider installing a pressure-reducing valve when your water line pressure is higher than 80 psi (552 kPa). Reducing or stabilizing the pressure helps to reduce leaks and flow rates from faucets, hoses, showerheads, and other equipment. Reducing the water pressure from 80 to about 65 psi (448 kPa) will reduce the flow by only about 10%. Reducing the pressure from 80 to about 50 psi (345 kPa) can reduce water usage approximately 25% in most small commercial-type buildings.

Before installing pressure-reducing valves, however, you may want to determine if several areas of your building need water at high pressure (for example, for thorough cleaning or rinsing tasks). If only one area needs high-pressure water, other areas might still be able to accommodate lower pressures.

You can usually install a pressure-reducing valve for about $75–$100. The exact installed cost depends on the size of the water line, the size of the facility, the need for a meter box, and so on. For example, including a meter box can increase the cost to $250–$275. Consult a licensed plumber or other expert about requirements for pressure-reducing valves in your building.

Application Domain

EPAct requires every Federal agency to have all possible cost-effective water- and energy-saving technologies and products installed in government-owned facilities by January 1, 2005. This means that a substantial percentage of the 500,000 buildings that the Federal government owns or leases will require at least some new or retrofitted water-efficient fixtures, appliances, or other equipment. A technology or product is considered cost-effective if it has a discounted payback period of 10 years or less.

Executive Order 13123 requires Federal agencies to determine their baseline water use and to meet a new water conservation goal. Under the guidelines, agencies had to determine their FY 2000 water usage in million gallons per year and report that number to FEMP that fiscal year. The report must then be updated every two years. The conservation goals also require agencies to implement at least four Best Management Practices, or BMPs, for water efficiency in up to 80% of their facilities by 2010. FEMP developed the BMPs to help facilities identify the best ways to use water more efficiently. The managers of each government-owned facility can decide which four of the 10 BMPs are the most cost-effective for them, and they can set priorities for purchases and installations. The BMPs are as follows:

BMP #1 — Public Information and Education Programs

BMP #2 — Distribution System Audits, Leak Detection & Repair

BMP #3 — Water Efficient Landscape

BMP #4 — Toilets and Urinals

BMP #5 — Faucets and Showerheads

BMP #6 — Boiler/Steam Systems

BMP #7 — Single-Pass Cooling Systems

BMP #8 — Cooling Tower Systems

BMP #9 — Miscellaneous High Water-Using Processes

BMP #10 — Water Reuse and Recycling

For more information on the water baseline guidance and the Federal water efficiency goal, see FEMP's Web site (www.eren.doe.gov/femp/resources.waterguide.html).

Your agency could begin meeting Federal water efficiency goals by concentrating on categories of buildings with the highest potential for savings. A 1997 study conducted by Lombardo Associates for FEMP indicated that as much as 40% of the water the government consumes could be saved by implementing water conservation measures in three building categories: housing, hospitals, and office buildings. These categories could represent about 78% of the total Federal potential for water conservation. Additional categories examined in the study were industrial, prisons, R&D, schools, services, and "other."

This section describes some of the most cost-effective technologies for Federal applications. And Appendix A lists some of the best low-water-use options for a variety of facilities.

Faucets, aerators, and controls—Most kinds of water-efficient faucets are cost-effective in Federal buildings. In fact, low-flow faucets are required in new Federal construction. Faucet aerators are so inexpensive—and save so much water and money—that they are cost-effective in nearly all applications. In large facilities with frequently used faucets—such as public lavatories in large hospitals or office buildings—faucet controls are often cost-effective, as well.

Low-flow faucet aerators can be especially cost-effective in restrooms and kitchen areas in government housing, hospitals, and office buildings. Although ultra-low-flow aerators [0.5 gpm (1.9 lpm)] are often cost-effective in restrooms, they are not as suitable in most kitchens and janitor closets, because a more forceful flow is usually needed for the washing, rinsing, and sanitizing tasks done in those areas. In public restrooms, vandal-resistant aerators that must be removed with a special tool can discourage theft.

Metered and sensor-operated faucets powered by batteries or low-voltage AC are often used in new airports and other high-traffic public restrooms. Also known as "duration" faucets, metered faucets are less susceptible to vandalism than many other types. In hospitals and food preparation areas, sensored faucets can also improve hygiene by eliminating the transfer of germs to and from faucet controls. Metered and sensor-operated faucets appear to be most cost-effective in large restrooms and kitchens in which a significant amount of water is wasted when faucets are operated manually. But these types of faucets are not yet cost-effective for most residential applications.

Showerheads— Low-flow showerheads can save so much water that they are cost-effective in almost every situation. And they are especially appropriate for use in military housing and barracks, VA hospitals, recreation areas and centers, and prisons. There are many different models to choose from; please see the list of manufacturers in this publication.

Toilets—Many low-flush and ultra-low-flush toilets are already in use in a wide variety of Federal facilities. But there is still enormous potential to retrofit or replace older technologies with water-saving products.

Composting toilets are usually cost-effective only in remote sites, such as many Federal parks and recreation areas, that are not connected to utility-operated water and sewer lines. In new construction, composting toilets may be preferable to a septic system because they often have lower life-cycle costs. They appear to operate best where temperatures are at least 60°F (15.6°C), but some are effective in cooler areas at high altitudes. Space heating helps to increase their applicability.

Urinals—Waterless urinals have already been installed in more than 40 Federal facilities. They are particularly cost-effective in areas of high usage such as barracks, large office buildings with many male occupants, and men's restrooms in large or popular national parks and recreation areas.

Appliances—Water-efficient appliances such as clothes washers and dishwashers are cost-effective in most Federal housing. They are also economical in many large facilities—such as hospitals, large schools, and prisons—that have their own kitchens and laundries.

Water- and Energy-Saving Mechanisms

Some information follows about the water- and energy-saving mechanisms of these technologies and associated savings. Exact water and energy savings for each technology vary, and depend on factors such as the number of users and the frequency of use.

Water-Saving Mechanisms

Water-saving mechanisms, as well as the amount of water that can be saved with each product, can vary widely even within one technology category.

Aerators, faucets, and showerheads—Low-flow aerators save water simply by reducing the flow from the faucet while mixing water with air. Many low-flow faucets are designed to maintain a flow at the standard 2.5 gpm (9.5 lpm) rate, and some operate at even lower rates. And many low-flow showerheads can control flows to around 2 gpm (7.6 lpm) or less. With each technology, actual water savings depend on the amount of use. But each one will reduce total water usage, and thus water costs, unless the number of users increases to offset savings, or people begin to use them much more frequently.

Toilets and urinals—Water-saving toilets and urinals are efficient because they either (1) reduce the amount of water available per flush, (2) use compressed air to increase the force of the flush, (3) refine the design of the fixture so more waste is washed away per flush, or (4) are completely redesigned, for example, as a composting toilet or waterless urinal. The fourth option can virtually eliminate the need for water to operate the fixture, though some water is usually required to clean it.

According to the Rocky Mountain Institute, replacing an older conventional toilet that uses 3–5 gpf (11.4–18.9 lpf) with a low-flush model can reduce residential water use per capita by 8–22 gallons (30–83 liters) per day, depending on the number of uses. Estimates for savings obtainable with waterless urinals range from about 10,000–45,000 gallons (37,854 –170,344 liters) of water per unit each year.

Appliances—One of the most effective water-saving mechanisms in clothes washers is a horizontal-axis tub or drum. These kinds of machines can clean as many clothes as comparable vertical-axis or "agitator" washers, but with less water. Manufacturers' estimates of the water savings obtainable with horizontal-axis washing machines range from one-third to one-half the water and energy used by conventional, vertical-axis machines. One manufacturer states that 18 gallons (68.1 liters) of water per load can be saved with its extra-large-capacity, horizontal-axis household machine. Some newer, more water-efficient vertical-axis models may save as much water per load as some horizontal-axis machines, however.

Newer dishwashers designed for efficiency use advanced technologies to operate with less water than older models do. For example, many models include modified spray arms and pumps that reduce the total amount of water used per load. Some models employ special sensors to gauge the amount of food left on dishes and adjust the amount of water accordingly. And some adjust the amount of water according to the size of the load.

Energy-Saving Mechanisms

Reducing water consumption saves energy, either directly on site at the point of use or off site at water treatment and distribution points. For example, using less hot water at a lavatory sink reduces the amount of energy needed to process the water at a treatment plant, pump it from a storage tank, and heat it in our homes. Off-site energy savings are real savings. But they can be counted in Federal life-cycle cost calculations only when a facility treats and distributes its water on site.

This section provides some of the energy-saving mechanisms associated with these technologies. See FEMP, DOE, and EPA product efficiency and ENERGY STAR® ratings for details

U.S. Department of Energy/PIX02252

Federal agencies can save water and costs by installing faucet aerators and sensored faucets, among other products.

(www.eren.doe.gov/femp; www.epa.gov).

Faucets and showerheads—FEMP reports that a water-efficient faucet that reduces the flow rate to about 2 gpm (about 7.6 lpm) can save up to 2.5 gallons (9.5 liters) of hot water per person per day, assuming that at least one-fourth to one-half of the total amount used is heated. This translates to an on-site energy savings of 0.07 kilowatt-hour (kWh) per person per day. Similar on-site energy savings can be obtained with low-flow showerheads (approximately 0.85 kWh per person per day) and efficient washing machines and dishwashers (about 0.2 kWh each). These are estimates; actual savings depend on the type of water heater used (gas or electric), its efficiency, the frequency of use of the fixtures, and other variables.

Toilets and urinals—Using water-efficient toilets and urinals reduces the amount of energy needed to treat and pump the cold water they consume. These savings can be counted in a life-cycle cost analysis if the facility pumps and treats water at the site. The amount of energy needed for pumping can be considerable. Estimates of the energy consumed in water treatment and distribution range from 1.5 kWh per 1,000 gallons (3,785 liters) to as much as 9 kWh per 1,000 gallons.

Appliances—Horizontal-axis washers save energy chiefly by using less hot water per load. And some new vertical-axis machines have been modified to use as much as 18 gallons (68.1 liters) less water per load than older agitator washers use, according to some estimates. Newer, energy-saving dishwashers often employ such features as more efficient motors, better insulation, and improved drying cycles (such as air-drying or overnight-drying) to save energy. A new ENERGY STAR®-rated appliance displays a tag showing where its energy use falls on a scale from least to most use for that particular kind of appliance. Appliances must meet efficiency standards higher than the minimum to qualify for an ENERGY STAR® rating.

Graham Knight, KnightScenes, Inc./PIX06847

Water conservation upgrades and retrofits are most effective when users are educated about the technologies.

Other Benefits

Conserving both water and energy with water-efficient technologies is extremely beneficial to the environment. In the early 1990s, only about two-thirds of the freshwater used every year was being treated and returned to our rivers and streams. As the population increases, so will the depletion rate of our freshwater resources, unless we begin using more rigorous water conservation and management practices. Every gallon we conserve adds to the reserves of available freshwater, reducing the likelihood of dangerously depleting our reservoirs, lakes, rivers, and streams during times of dry weather or severe drought.

Saving energy by conserving water also helps to protect the environment from further damage caused by the excessive use of fossil fuels. Studies indicate that energy production and use are the chief causes of environmental damage. And burning fossil fuels is still the chief method of producing electricity to heat, treat, and pump water. In the United States, fossil-fuel power plants produce about 50% of the nation's total air pollution, and gasoline-powered vehicles cause another 20%. The air pollution caused by conventional energy production and use is also said to be a major cause of lung-related illnesses. Thus, reducing energy use has health benefits, as well.

These benefits can be achieved with the help of Federal water efficiency programs. The most successful programs will combine the use of water-efficient equipment with long-term water resource planning, effective system operation and maintenance, and education programs for employees and other users about conservation products and practices. Communicating information to users about the quantity, cost, and impacts of water use can go a long way toward enlisting people in a successful water-efficiency campaign that will reap considerable rewards.

Federal-Sector Potential

This *Federal Technology Alert* is one of a series of publications describing energy- and water-conserving technologies that have significant potential for application in the Federal sector.

Technology Screening Process

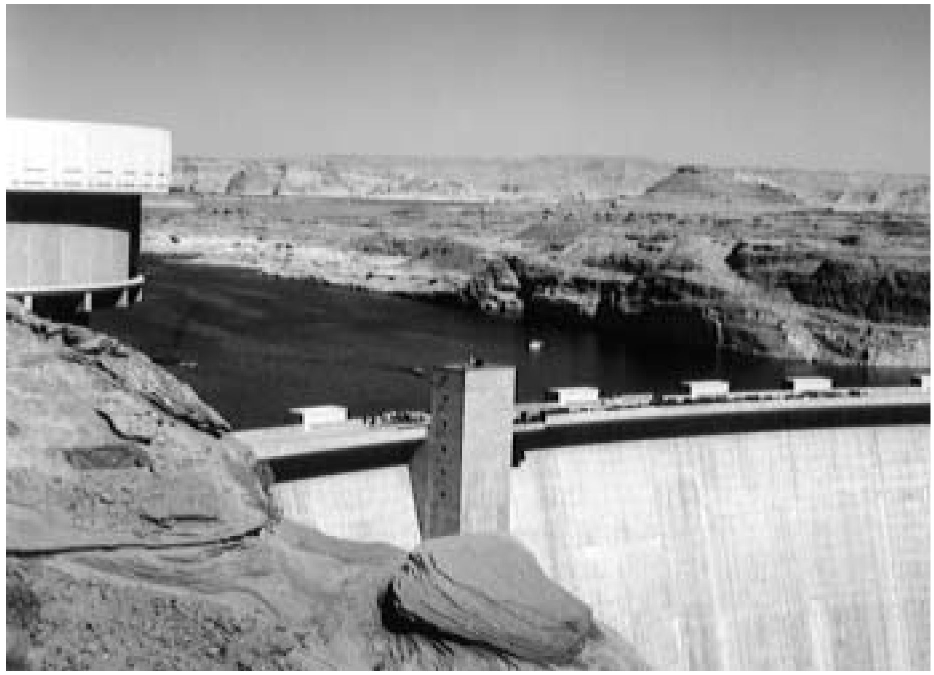
Federal facility managers have tested and evaluated many water-conservation technologies over the past several years, and many have shared their experiences in reports and papers. The technologies are also described in numerous reports published by DOE, EPA, the General Services Administration (GSA), the Rocky Mountain Institute, the American Water Works Association, and other organizations specializing in energy- and water-efficient equipment. Through evaluations, case studies, and reports, FEMP's New Technology Demonstration Program also provides information about conservation to Federal facility managers to help them meet national efficiency goals.

Estimated Market Potential

Federal facilities include more than 500,000 owned or leased buildings and more than 420,000 military housing units. Nearly all of them can use some of the cost-effective water conservation techniques and technologies described here. So, there is a very large market for these technologies in the Federal sector.

Data from the 1997 Lombardo Associates study for FEMP indicate that the Federal government consumes at least 300–400 million gallons (about 1.1–1.5 billion liters) of water per day. Because only some agencies responded to surveys, the actual figure is probably at least 450 million gallons (1.7 billion liters) or more. This water costs at least $229 million–$250 million per year, but probably much more. The study estimates that the potential for water conservation in the Federal government is at least 121 million gallons (458 million liters) per day, or about 40% of current usage. The conservation potential appears to be greatest in hospitals, housing, and office buildings, as noted earlier; those types of facilities could represent about 78% of the total potential.

The actual potential for water savings in Federal facilities could be even greater. The GSA estimated that an average of 300,000–500,000 gallons (1–1.9 million liters) of water are consumed every month in a typical GSA regional facility *alone*. A typical facility has about 188,000 square feet (17,465 square meters) of space occupied by about 450 people. To put this estimate in perspective, note that the GSA manages more than 285 million square feet (more than 26 million square meters) of building space—and this is only about 10% of the space occupied by all Federal agencies.



Larry Gordon/PIX04211

Water-efficient technologies at the Carl Hayden Visitors Center at Glen Canyon Dam in Arizona included low-flow toilets and urinals, flushless urinals, and sensored sinks.

Estimates indicate that Federal water consumption represents only about 0.5% of total U.S. domestic water use and about 3% of total commercial use. Nevertheless, trimming water usage can help to reduce the cost of government and conserve our resources.

Laboratory Perspective

Most water-saving technologies, such as low-flow faucets and toilets manufactured since 1994, are so well established that few additional technical demonstrations are needed. Newer technologies, such as waterless urinals, are being demonstrated, tested, and monitored for their conservation potential and cost-effectiveness in Federal facilities.

Not every technology or retrofit is appropriate for every facility, however. FEMP case studies and the references in this publication indicate Federal agencies' experience to date. Please see the list of contacts in this publication, or contact FEMP for additional guidance and information (800-363-3732).

Implementation Barriers

Certain institutional barriers to conservation may be reducing or preventing wider implementation of water-efficient technologies. Some barriers in the Federal sector, and suggestions for overcoming them, follow.

- Inadequate information about the amount of water a facility uses
- Low current water costs
- Insufficient knowledge about the cost-effectiveness of water conservation projects
- Lack of funding to carry out projects
- Misconceptions about the proper use and benefits of water-efficient technologies installed at a site.

Inadequate information about water use—Water management needs to begin with actual data on current water use, or an audit of your facility's usage. It can be more difficult to obtain water-use data in leased facilities than in facilities owned by an agency, depending on how a facility's water bill is paid. Metering is just one good way to obtain this information. Small, portable meters can also help you determine the cost-effectiveness of individual technologies and processes. You can also request a water-use audit or engineering estimate from an expert in government or the private sector.

Low current water costs—In some areas of the country, water utility rates are currently low (for example, less than $2/kgal). In those areas, monitoring water use, conservation, and resource management planning are often not priorities. To determine actual costs, however, all costs associated with water use should be included in your economic analysis. These can include the cost of treatment, pumping, energy for heating and processing, chemicals, and even environmental permits. Once you know your facility's total water costs, you can benchmark them against those of similar facilities and begin setting conservation goals.

Insufficient knowledge about cost-effectiveness—Many people might not realize that a water conservation project can be one of the most cost-effective expenditures they can make. This is true in part because water conservation measures usually have a significant energy-saving component. When water, sewer, energy and other costs are included, many water efficiency projects typically have a discounted payback period of three years or less. Bundling a water project with a cost-effective energy efficiency project, such as an efficient new cooling system, can also improve the economics of a project.

Lack of funding—Another barrier to implementation is the lack of funds for projects. However, a variety of funding mechanisms are available in addition to direct Federal appropriations. These include energy savings performance contracts, shared savings, utility incentive programs, and utility energy services contracts. Contact FEMP to learn more about financing options that can include funding for water projects. FEMP's Financing Team provides policy guidance and technical and contracting assistance with private-sector funding for Federal energy efficiency, renewable energy, and water conservation projects.

Misconceptions about the technologies—Upgrades and retrofits can be more acceptable to both managers and employees when they know what a new technology is, what it does, and how to use it properly. See FEMP's Web site (www.eren.doe.gov/femp) for information you can use to discuss water-efficient technologies and products with employees.

Application

The criteria for applying domestic water-efficient technologies in a particular facility depend on many factors, especially the age and water efficiency of current fixtures and appliances. Other factors include current plumbing configurations, plumbing codes, and local laws and regulations (for example, composting toilets are not legal in all areas). Another major consideration is the cost-effectiveness of the retrofit or technology—whether the technology will pay for itself through water and energy savings (discounted payback) in 10 years or less.

Application Screening

Before considering new water-efficient products and technologies, begin by estimating the amount of water you are consuming now, using actual billing data or as part of a preliminary survey. If project funds are limited, you might want to compare the amount of water consumed by each major type of fixture, appliance, or system in your facility to find out which ones would provide the lowest life-cycle cost or the greatest net present value after a retrofit or replacement. Appendix B shows three examples of methods you can use to evaluate costs and savings associated with domestic water-using fixtures and appliances.

FEMP's experiences show that a facility's operating costs can be reduced as a result of adopting cost-effective water conservation measures and practices. Lower operating costs result from reducing costs in some or all of the following categories—water, pretreatment, sewer, energy, chemicals, contracts, equipment, and labor. Operating-cost reductions can also help to offset increases in capacity charges and limits, drought surcharges, and utility rates.

Where to Apply the Technologies

After calculating life-cycle costs (including the cost of operation and maintenance) of potential water efficiency improvements in your facility, you can choose improvements, retrofits, and new technologies with more confidence. These choices will also help you bring your facilities into compliance with Federal and local regulations and guidelines for water management. Then, you can request a professional water audit of part or all of your facility.

Areas and systems to include in these audits will vary, depending on your needs. In commercial, residential, and institutional facilities, audits should include restrooms, shower areas, kitchens, cleaning areas, janitor closets, and laundries. Although this *Federal Technology Alert* focuses on domestic water technologies, audits can cover all categories of water use at a facility. These include irrigated landscape; heating, ventilation, and air-conditioning systems; single-pass cooling systems; distribution systems; and other high-water-using processes.

Comprehensive audits require a systems approach in which all water-consuming areas of the facility are analyzed and all available auditing tools are used. Begin by gathering data on your facility's water usage and associated costs. Find out your facility's plumbing configuration, since that will affect the selection of appropriate retrofits and new products; a blueprint is helpful. Consult with a local water utility or water board for advice or assistance with the audit, if necessary. Or contact your DOE Regional Office FEMP representative (see the list of contacts in this publication) for information about SAVEnergy Program audits and water-survey software. It is also a good idea to conduct a leak-detection survey.

What to Avoid

Although most of the technologies and products described here can be used widely and cost-effectively, they should be evaluated according to their appropriateness for a particular facility (see Appendix A). Some general caveats are given below; see the list of references for publications with more specific information.

Don't rely solely on manufacturers' claims—Be sure to balance manufacturers' claims about water savings against the results of independent tests, field experiences, and product reviews (for example, in trade journals or consumer-oriented publications). Check catalogues and reports prepared by government agencies and nonprofit conservation groups that include data on water efficiency and lists of manufacturers. Government and nonprofit groups cannot provide warranties or endorse products, but some conduct tests, make comparisons, and provide ratings. Check product warranties to see if water efficiency claims are backed up by a guarantee, and look for ENERGY STAR®-rated appliances. FEMP has prepared case studies and fact sheets with agencies that are already using various technologies with good results (see FEMP's Web site).

With many low-flow products, user satisfaction can depend heavily on subjective factors such as aesthetics or "feel," which may not be evident in the manufacturers' claims. You may want to field-test new products in your facility to determine which ones are most suitable and meet your requirements before purchasing them in any quantity.

Don't rely solely on the estimated savings in case studies—The savings reported in case studies can help you choose new water-saving technologies. However, because individual experiences and usage patterns vary, you will want to weigh various water-management options against your own usage patterns, needs, and budget constraints. Actual water and energy savings associated with each technology vary from region to region and from one facility to another. Therefore, the data reported here are only estimates of a range of possible savings.

Don't base decisions on another facility's needs—Consider your facility's specific needs for water quality and other important factors. Some technologies are effective only at certain water pressures and temperatures. Seek expert advice to determine what is most appropriate for your facility. FEMP can answer many of your questions about water-management technologies.

Don't forget to check local codes, rules, and regulations—Just as conservation needs and savings vary from one location to another, so do local laws, codes, and standards applying to retrofits and new technologies. Local plumbing codes and regulations could be strict in some areas. So, it is a good idea to involve local utilities and water boards in decisions whenever there is any question about regulations governing a water-conserving technology.

Don't neglect to educate employees and other users—As noted, educating users is very important in implementing water conservation technologies and methods successfully. Refer to BMP #1, Public Information and Education Programs, on the FEMP Web site for more information and ideas about how to educate users (www.eren.doe.gov/femp/resources/waterguide.html).

Equipment Installation, Integration, and Maintenance

You will need to evaluate many of these technologies according to whether they fit in with your current plumbing configuration. This section provides guidance on integrating new technologies with current equipment as well as installing, maintaining, and using new equipment.

Equipment Installation

It is important to know the water pressure of a building or other facility before installing flow-reducing retrofits. And there are some special considerations to keep in mind when installing low-flush toilets or toilet retrofit devices.

Aerators and showerheads—Check the water pressure in your facility before installing aerators and showerheads. The water pressure should be at least 40–60 psi (276–414 kPa). In buildings with extremely low water pressure, flow rates might become so low with these fixtures that users might try to bypass or modify a fixture to achieve a more satisfactory flow. In buildings with extremely high water pressure, the resulting high flow rate can accelerate the deterioration of a fixture as well as reduce savings.

Toilets—Ask building managers, plumbers, or other professionals for recommendations. You can also ask to see the manufacturer's performance testing data and guarantees. Look for toilets with a 2-in. (50.8 mm) glazed trapway, which makes the fixture less likely to plug up. Make sure that the water pressure on each floor is adequate for the type of toilet you select; low-consumption toilets can make waste line or venting problems worse. Solving current problems now may increase project costs, but it will also help you avoid expensive repairs later. So, check shut-off valves, drain line slopes, waste lines, and venting before installation. Be sure that plumbing contractors include all necessary repair costs in their bids, as well as the cost of replacing flooring and wall coverings in a restroom and disposing of old toilets.

Toilet retrofits—Sometimes a retrofit can make an older toilet more efficient. With gravity-flush models, placing displacement devices in the tank, such as plastic bottles filled with water or pebbles, could save as much as 1 gallon (3.8 liters) per flush. Toilet dams can keep a certain amount of water from entering the flush cycle. And some toilets can be retrofit with early closure devices or dual-flush adapters that save from 0.5–2 gpf (about 1.9–7.6 lpf). Retrofit devices are more likely to work on toilets that consume a large amount of water per flush [5 gallons (18.9 liters) or more]. You can ask local plumbers and water utility conservation staff about retrofit devices. Or you could test a device on a few sample toilets in your facility.

The Rocky Mountain Institute has stated, however, that some toilet retrofit devices have damaged plumbing and performed poorly in the past. Retrofit devices can also be removed easily, eliminating water and cost savings. Because most toilets are designed to work with a certain amount of water, modifying that amount might cause operational problems.

Integration

You can install most of the products and appliances described here almost anywhere a fixture or appliance is already being used. Utilities, plumbing contractors, permitters, local water boards, zoning authorities, and others may have to be involved, as well, depending on the complexity and size of a particular installation.

It is important to ensure that even simple water-management technologies are integrated correctly into your plumbing and HVAC systems. The water temperature, pressure, piping, installation height, and other factors must be correct for new fixtures and appliances. Make sure, too, that controls are adjusted properly.

In older facilities, sewer and drain lines can become fouled or constricted from many years of use. Older technologies usually keep enough water flowing through a drain line to move waste material. However, the quantity of water used with low-flow technologies can be substantially less, and in older facilities, this could increase clogs and backups. To prevent them, you could snake or clean out older sewer and drain lines before installing low-flush toilets to make sure there is sufficient line capacity for waste removal.

Most of the technologies can be integrated successfully with various kinds of piping. There is some anecdotal evidence that the undiluted urine in waterless urinals can have a negative effect on copper piping, although at least one manufacturer disagrees with this.

Maintenance

Even the simplest water-efficient technologies need some maintenance. And some need more than others. Check to see that parts are readily available for all new water-using equipment. And make sure that maintenance staff receive training in the care of new technologies.


Graham Knight, KnightScenes, Inc./PIX06840

Workers make fixtures more water-efficient at the Carl Hayden Visitors Center.

Faucets—Faucet filters need to be unclogged, cleaned, and replaced periodically, and fixtures and pipes need to be checked regularly for leaks or damage. Many leaky faucets can be fixed simply by replacing the washer at the spout. This low-cost, high-savings measure should be part of a maintenance program. A leak of 0.09 gpm (0.34 lpm), if not fixed for a year, would add approximately $160 to your water costs, assuming that the water rate is about $3.34 per 1000 gallons or $2.50 per hundred cubic feet (CCF). An installed cost of $15-$20 for a new washer would have a payback of 1–2 months. If wastewater and energy savings were taken into consideration, the payback would be considerably less than a month.

Leaks can also develop in faucet handles, in part because the washer inside the handle mechanism wears out over time. One manufacturer, Sloan, has replaced the washer with a diaphragm that has a long, leak-resistant life. In addition, Chicago and Zurn have developed ceramic cartridges that can be used to retrofit many of their faucet models. The cartridges have an installed cost of approximately $30-$50. This is a very cost-effective measure, assuming water costs of about $2.50/CCF. However, not all faucets can be retrofitted with ceramic cartridges; you will need to determine the make and model to choose the correct cartridge. An experienced plumber or other specialist can provide assistance.

Toilets—Large amounts of water can be lost when toilet flappers or diaphragms leak. Some leaks can be detected by simply listening, but some are not noticeable. In such cases, you can place dye tablets in the tank, if there is one, when you know the toilet will not be used. If there is dye in the toilet bowl when you return about half an hour later, there is a leak. It is a good idea for maintenance staff to conduct a dye tablet test on tank toilets every year.

You can also check Web sites such as the one maintained by Water Management, Inc. (www.toiletology.com/index.shtml) for valuable tips on how to maintain and repair the tank toilets in your facilities or in staff housing. For example, flappers in tank toilets deteriorate when maintenance crews use chlorine-based bowl cleaners but not when nontoxic products are used. Also, replacing flappers with ones not designed for the toilet can cause the flush volume to increase.

Waterless urinals—Urinals that don't require flush water need much less maintenance than other kinds, primarily because they lack moving parts. Maintenance for one model involves replacing a few ounces of trap liquid on a regular basis and replacing the trap one to six times a year, depending on usage. The unit should also be cleaned periodically by pouring hot water in it. Pouring soft drinks and other liquids into these units can compromise their effectiveness, however, so these units are not always suitable for large, public buildings.

Appliances—New water- and energy-saving appliances should be cleaned and maintained according to the manufacturer's instructions.

Warranties, Standards, and Codes

Warranties should be available for most of these technologies. Product warranties will probably not guarantee the amount of water savings possible with each product, although manufacturers of most fixtures and appliances usually indicate the water consumption rates that consumers can expect.

For reasons of public health, there are many laws, rules, and codes governing the installation and use of water management systems at the municipal, state, and national level. Goleta, California, was one of the first U.S. cities to establish modern water conservation standards when it specified consumption rates for toilets, urinals, and faucets in 1983. Since then, many other communities and states have followed suit. EPAct has established standards for fixtures manufactured in 1994 and beyond, and it required that manufacturers mark flow or consumption rates indelibly on their fixtures.

Local plumbing codes must also be followed. In some places, plumbing codes discourage the use of composting toilets or regulations prohibit them. Local utilities or water boards can provide specific information.

Costs

The costs of water-efficient technologies vary widely. Costs depend on the size, quality, and complexity of the product or system, among other factors. They can range from about a dollar for a simple faucet aerator to several thousand dollars for special fixtures and appliances.

Regional variations in prices and installation costs can be significant, even for specific products. For this reason, consider your needs for product quality, durability, and performance when evaluating each technology and requesting bids for multiple installations. Table 2 lists the retail cost ranges associated with some of the major technologies described in this report. It is important to note that aesthetics, and not quality differences, are often the cause of these large ranges in cost. For example, a color toilet often costs much more than a white one, though the basic design and materials are the same.

Purchasing products in bulk orders can also reduce the cost per product. The costs listed here do not necessarily reflect the discounts you could obtain through high-volume purchases.

Savings also vary widely among and within technologies. The water and cost savings provided by sensored faucets, for example, depend on good estimates of the amount of time, and the number of times per day, that a faucet is on. Assuming that a faucet runs 20 minutes longer than necessary every day at a rate of 2 gpm, then 14,600 gallons, or 19.5 CCF, of water would be wasted per year. At a rate of $3.34 per 1000 gallons (3785 liters), this wasted water would cost $48.75. The payback period would thus be about 10 years on the basis of the value of the water saved.

Fitting an older faucet with a sensor would cost about $150-$200 for materials and another $100 or so for installation. Assuming the same water costs as those in the example above, this retrofit could have a payback of 5.6 years on the basis of water cost savings. Nevertheless, it is worth considering for facilities in which a considerable amount of water is wasted. In general, sensor-controlled faucets appear to be most cost-effective in facilities where they are used continually every day, such as in airport lavatories.

See also Appendix B for three analyses of the savings and costs associated with replacing some domestic water-efficient technologies.

Procurement

FEMP provides procurement information for faucets, showerheads, toilets, and urinals in the Product Efficiency Recommendations series. These are guides for Federal purchasers that recommend efficient levels for commonly purchased energy- and water-using products. FEMP recommends levels that roughly represent the top 25% of the market, in terms of energy and water efficiency, for all similar products (e.g., 2.2 gpm for showerheads). The top 25% is the threshold targeted in E.O. 13123 and Federal Acquisition Regulations (FAR) section 23.704.

Each recommendation, in addition to delineating the recommended level of efficiency, identifies a Federal supply source (at GSA or the Defense Logistics Agency), provides "Buyer Tips" for selection and use of the product, demonstrates a cost-effective example, and includes a list of additional sources of information. The recommendations are available through FEMP's *Buying Energy-Efficient Products* binder, which can be ordered free by calling 800-363-3732. You can also access this information online (www.eren.doe.gov/femp/procurement).

Utility Incentives and Support

Both water and energy utilities sponsor incentive programs for water efficiency. Before undertaking a water efficiency project, contact your water utility to determine if they have a program that's right for you. It is important to contact them before you start a project, because many utilities will not provide rebates after products are installed. States in which comprehensive water and energy efficiency programs have been conducted include California, Connecticut, Texas, and Washington.

In Southern California, a number of retail water providers have funded conservation projects. Financial incentives have included a specific rebate per low-flow fixture installed in commercial projects (e.g., $75 per low-flush toilet). For large water-using processes, the utilities have provided a rebate per unit of water conserved over a specified period. For example, Metropolitan Water District has provided a rebate of $154 per acre-foot for five years if a project is expected to save at least 10 acre-feet per year. (One acre-foot equals about 326,000 gallons.) In addition to financial incentives, local water utilities may also provide training in conservation methods and technologies, such as efficient landscaping and cooling tower operation, as well as technical assistance with projects.

Connecticut has required that utilities promote conservation by providing retrofit kits. A few years ago, Northeast Utilities and three water utilities joined forces to provide customers with kits that included showerheads, faucet aerators, toilet dams, compact fluorescent lamps, and wraps for water heaters and pipes.

In Texas, the Water Commission's decision to conduct a statewide retrofit program prompted the city of Austin's Water Department to begin commercial, industrial, and institutional conservation activities. The city has provided rebates of up to $40,000 for new domestic products such as efficient toilets, clothes washers, and irrigation systems, depending on the size of the installation. There is also a rebate for large systems, such as single-pass cooling equipment and water reuse or recycling systems. Qualifying projects had to reduce water use by at least 500 gallons (about 1893 liters) per day.

In Washington State, a conservation-oriented collaboration was formed in 1992 by the Seattle Water Department, Seattle City Light, Puget Sound Power & Light, Washington Natural Gas, and Metro, the regional sewer authority, to help deliver almost 800,000 retrofit kits in the Seattle area. The kits included low-flow showerheads, faucet aerators, and wraps for water heaters.

Table 2. Cost Ranges for Domestic Water Conservation Technologies

Technology	Estimated Installed Cost Range [a]	Approximate Average Installed Price [b]
Low-flow sensored faucets	$100–$1,300	$330
Low-flow showerheads	$15–$75	$31
Pressure-reducing valve		$100
Horizontal-axis clothes washer, residential size	$600–$1,000	$850
Water-efficient dishwasher, residential size [c]	$200–$1,600	$700
Low-flush tank toilets	$150–$1,000	$240
Low-flush flushometer toilets	$300–$800	$450
Low-flow urinals	$300–$800	$450
Waterless urinals [d]	$600–$800	

[a] Cost ranges provided by the Rocky Mountain Institute, *Consumer Reports*, FEMP, and WaterWiser, the Water Efficiency Clearinghouse (a program of the American Water Works Association, operated in cooperation with the Bureau of Reclamation).

[b] Most average installed prices are based on *Seattle Public Utilities, Water Conservation Potential Assessment*, Draft Summary Report, December 4, 1997.

[c] *Consumer Reports*, December 2000.

[d] Data obtained from the Waterless Company's quotations for the GSA price list, 1996; includes fluid traps and seal.

In addition to joint programs like these, other utilities in many states, cities, and communities have supported water conservation with education and incentive programs. Some water utilities provide rebates and other incentives to those who reduce consumption in areas where rapid growth strains local water supplies. FEMP is working with local utilities in its Water Utility Partnership program to establish partnerships and facilitate communication among Federal agencies, utilities, and service companies. For more information on the program and other utility partnerships, see FEMP's Web site.

Technology Performance

The true test of a new technology usually takes place in the field rather than in the lab. This section reports on some users' experiences with the water-conservation technologies described in this report.

Field Experiences

High-efficiency, low-flow showerheads—A number of utilities, such as Boise Water Corporation, have proactively installed water-efficient showerheads for their residential customers. The Rocky Mountain Institute has calculated that retrofitting one household with water-efficient showerheads and faucet flow controls (averaging 1.6 showerheads and 2 faucet flow controls per household) saves about 5,600–15,000 gallons (21,198–56,781 liters) of water each year, and cuts utility bills by $25–$170 per year.

In one program, the Seattle Water Department followed up with users in 93 multifamily housing units that installed low-flow showerheads to check on the resulting savings. They found that the new fixtures saved an average of 4.5 gallons (17 liters) per day.

Sensored faucets and ultra-low-flush toilets and urinals—According to field studies, sensored faucets and low-flush toilets and urinals can reduce indoor residential water use by about 35%. And some results have been much better. For example, new toilets installed in a

Sara Farrar, NREL/PIX06463

The City of Austin's water utility encouraged residential customers to conserve water by conducting water audits, replacing old fixtures, and providing educational materials.

project sponsored by Seattle Public Utilities used approximately 60% less water than older models.

FEMP and other groups sponsored a retrofit project in which several different water-efficient fixtures were installed in restrooms in a high-rise office building in the Denver Federal Center. These included ultra-low-flush toilets that consume 0.5 gpf (1.9 lpf), and sensored lavatory faucets that control the amount of hot water used in hand washing. Water consumption was monitored before and after the retrofits were installed in several restrooms.

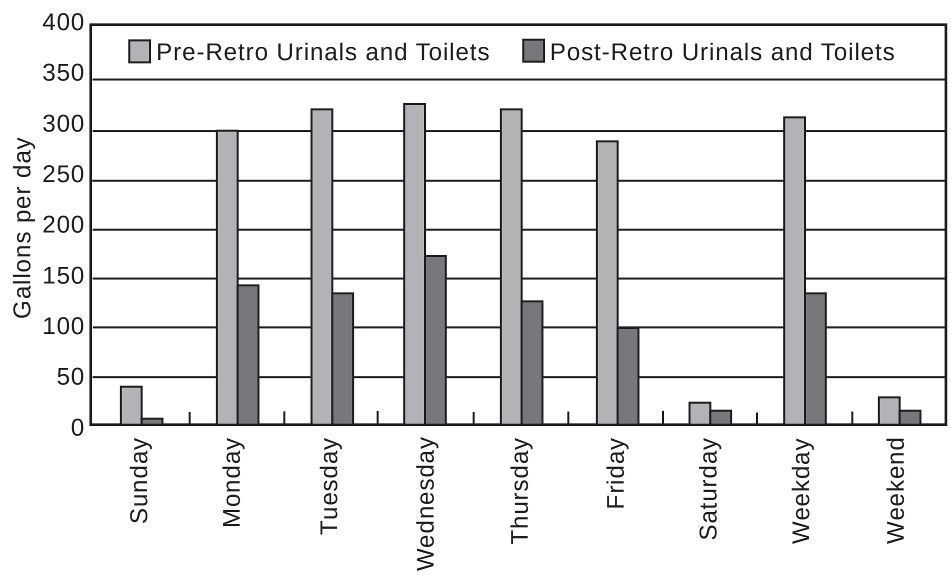
Water-use monitoring showed that usage quickly dropped by about 50% in the three men's restrooms and about 35% in one women's restroom, according to Richard Bronowski, assistant buildings manager. He said that most users seem to like the fixtures. However, because it takes only 3-5 seconds for the faucet system to reset, some people were using faucets more than once, which reduced water savings. An information campaign may have helped to show people how to use water-conserving fixtures more efficiently.

Field studies have also shown that low-flush toilets reduce indoor residential water use by at least 35%. In fact, toilets installed in a project sponsored by Seattle Public Utilities used about 60% less water than older models.

In many surveys, consumers have said that low-flush toilets are very acceptable or satisfactory. A recent *Consumer Reports* article evaluated 13 residential low-flush toilets, and all received an overall score of "good" or better. Potomac Resources, Inc., recently completed a study of low-flush toilets in the United States and found that most users were satisfied with newer models. For example, 83% of residents polled in San Diego, California, 95% of those in Austin, Texas, and 87% of those in Denver, Colorado, found the low-flush toilets to be as good as, or better than, their old toilets. Most surveys have shown an acceptance or satisfaction rate exceeding 80%.

Waterless urinals—Hundreds of waterless urinals have been tested in recent years in more than 40 Federal facilities; many of these facilities are either in national parks or in Department of Defense (DoD) installations. In 1996, DoD staff conducted a survey to determine the level of satisfaction in about a dozen installations. Joseph Dooley of the Secretary of Defense Energy and Engineering Department reported that the overall response to these fixtures has been quite favorable.

Actual water savings vary at each installation because of differences in the types of urinals replaced and the amount of water used. But in general, waterless urinals appear to save an average of 1.5–3 gallons (about 5.7–11.4 liters) of water per use in comparison to rates for conventional urinals, Dooley said. Savings in maintenance costs vary as well. Although these urinals must be



Average water use for toilets and urinals in the men's room at the Denver Federal Center changed from 310 gallons per day to 125 gallons per day, a reduction of 60%.

cleaned and the fluid trap replaced regularly, Kirtland Air Force Base staff reported that the units showed little wear and tear or effects of vandalism after a period of time. This might be in part because the units lack flush mechanisms or valves that have to be repaired or replaced.

Dooley also said that some personnel hesitated to use the unfamiliar new fixtures at first. Posting informational notices solved that problem. Here are some of the lessons that the staff learned from their experiences with the urinals:

- Be sure the drain is clear before installing the fixture; snake it out, if you need to.
- Make sure that both the urinal and trap are properly installed.
- Train custodians to clean the urinals regularly and completely.
- Expect that it will take a little time for personnel to be comfortable using these urinals.

Some waterless urinals were removed a few years ago from the Denver Federal Center water efficiency project because they were not working out well. The cause could have been an installation problem or a building ventilation problem. The urinals were later shipped to the National Park Service's Glen Canyon Dam Visitors Center, where they have been satisfactory. Rusty Gattis of the Glen Canyon Dam Visitors Center reported that, after about a year of use, there were no major problems with three waterless urinals installed there.

Case Study

Portland VA Hospital

A few years ago, the Veterans Administration Hospital in Portland, Oregon, appeared to be a very good candidate for a water efficiency project. It is a large (1,364,000 ft2) facility, and it had a wide range of aging water-related fixtures and equipment. The equipment experienced a high volume of use, as well. The facility consumed 64.6 million gallons (244.5 million liters) of water from August 1995 through July 1996. To determine which equipment would be cost-effective to retrofit or replace, the DOE FEMP SAVEnergy Program conducted a water audit.

In the audit, data on water use rates and times of use were collected for toilets, urinals, faucets, single-pass water-cooled equipment (vacuum pumps and air compressors), cooling towers, boilers, the irrigation system, sterilizers, dishwashers, the laundry, and other water-using equipment. Usage rates were compared with rates for newer, commonly available equipment. The auditors determined how much water the new equipment would save in performing the same tasks as the old equipment, and the cost to install it. Cost estimates were based on their experiences with similar projects and on estimates from contractors. New equipment was recommended that had a discounted payback of 10 years or less. The recommendations for domestic water-using equipment are presented here.

Toilets and urinals in the hospital were found to use 3.5–5 gallons (13.2–18.9 liters) of water per flush. The auditors measured flush volumes in representative toilets by plugging the toilet drain with a plunger, flushing the toilet, marking the level to which the toilet filled, draining the toilet, plugging it again, and filling it to the marked line using a bucket with volume measurements. Because low-flush toilets use 1.6 gallons (6.1 liters) per flush and urinals use about 1 gallon (3.8 liters), a significant amount of water could be saved by replacing most toilets and urinals with water-efficient models. Savings resulting from replacing 346 toilets and urinals were estimated at $33,800. The estimated cost of installing the toilets was $104,000, for a simple payback of 3 years and a discounted payback of 4 years.

Most of the faucets in the facility used 5–6 gpm (18.9–22.7 lpm) of water, a much greater flow than is needed in a restroom. So, the auditors recommended installing faucet aerators with flow rates of 2.5 gpm (9.5 lpm) on all patient room and restroom faucets that did not have them. The estimated cost of retrofitting the faucets with low-flow aerators was approximately $8,000. Estimated savings were about $10,000, for a simple payback of 0.7 year and a discounted payback of about 1.5 years. Since the audit was conducted, a number of high-quality, 0.5 gpm (1.9 lpm) aerators have become available that save even more water, energy, and money.

Most of the facility's showers used 5–6 gpm (18.9–22.7 lpm) of water. This was also much more than necessary. The flow rate of faucets and showerheads was measured using a timer and a plastic bag with volume measurements. The auditors recommended replacing most of the old showerheads with low-flow models having a flow rate of 2.5 gpm (9.5 lpm). Replacing 51 showerheads would save an estimated $6,500; the installed cost was estimated at $2,100. The estimated simple payback was 0.3 year, and the discounted payback, 1 year.

The Technologies in Perspective

Technology Development

The efficiency of most domestic water conservation technologies is improving constantly. Some products—such as composting toilets, waterless urinals, and horizontal-axis washers—are relative newcomers to mass U.S. markets, though they have been purchased here in limited quantities for several years. All these technologies can help to conserve water unless they are installed or used incorrectly. Nearly all are available in models that meet local and national standards for water and energy efficiency.

Technology Outlook

We can expect these and other water-related technologies to make a much greater contribution to conservation efforts in the future, as water management begins to have greater priority in our nation. Water rates will probably continue to climb as prices come closer to reflecting the real value of water, and

Warren Gretz NREL/PIX060654

Infrared sensors help to save water at the Denver Federal Center.

users will continue to find ways to use water more efficiently.

According to a recent article in *Energy User News*, water utilities will spend $138 billion in the next 20 years to upgrade their infrastructures. Subsidies for water-wasting behavior are likely to be reduced as a growing population places greater demands on a limited resource. Idaho, Maryland, New Mexico, Oregon, Virginia, Washington, and several other states are already experiencing conflicts over who has access to limited water resources.

New legal and political protection for aquatic wildlife could further limit sources of water and increase prices. For example, endangered species protection efforts for salmon in Washington and Oregon are expected to have major impacts on how water is used in those states.

Regarding specific water conservation technologies, it seems clear that ultra-low-flow showerheads will be used more frequently. Many models consume 1–1.5 gpm (3.8–5.7 lpm) or less. And some have one plastic orifice that does not usually clog even with hard water. So, these products are becoming more attractive to consumers every year.

Some new dishwashers adjust the amount of water according to the size and food content of the load, as mentioned earlier. Ultrasonic dishwashers save both water and energy, and are finding buyers among U.S. consumers. Ultrasonic clothes washers are likely to be widely available soon; they save a considerable amount of water, energy, and detergent. And enzymatic dishwasher detergents are available now that digest protein, starch, and fat; they clean dishes better with less water (especially less hot water) than other kinds.

In addition, more rainwater collection systems are likely to be used for domestic purposes. In most areas, the pure, naturally distilled water that falls on roofs is carried off to storm drains and treated, at a high cost to consumers. Saving and using this rainwater for domestic use requires appropriately sized, nontoxic collection and storage systems, periodic water quality testing, and, in some cases, some water treatment.

In many areas, it is cheaper to build a rainwater collection system than to drill a well. In Hawaii, Australia, Bermuda, Hong Kong, and several other areas, rainwater collection is already a common practice. A rainwater collection system can be more sustainable over the long term than a well, which draws down the water table and creates a number of new problems. In the recently built King Street Center in Seattle, rainwater is captured and reused for flushing toilets; this saves 1.4 million gallons (5.3 million liters) of water per year. The King Street system allows more river water to be available to native species such as salmon.

The number of graywater systems should also increase. Graywater systems collect bath, shower, restroom sink, washing machine, and wet-bar sink water and reuse it, usually for irrigating landscapes and flushing toilets. In one example, using graywater to flush toilets at an office park in Essex County, New Jersey, has cut potable water use there by an impressive 62%. Hundreds of projects already reclaim wastewater to irrigate golf courses and other large lawn areas. States like California have passed laws allowing the use of graywater systems that meet certain health standards.

Composting toilets will probably be purchased more often, as well. Many people realize how wasteful it is to use valuable drinking water to dilute and flush toilet waste, especially when the waste could be composted and used as high-quality fertilizer. In one example, a Swedish composting system separates the liquid and solid waste, collecting both for use as fertilizer. Codes and laws governing rainwater collection, graywater, and composting toilets vary from state to state, so be sure to check them when considering a system for your facility.

To help conserve the considerable amount of water that is wasted because of leaky fixtures and pipes, automated leak-detecting equipment is also becoming available. This equipment activates an alarm when a leak occurs.

Because of their many environmental and economic benefits, water-saving technologies are worth considering for Federal facilities everywhere. Even in areas where water resources are not scarce, we are likely to see increases in the use of these and other practical, water-saving technologies in our homes, places of business, and government facilities because they are cost-effective, they help us conserve our natural resources, and they work.

Water Efficiency Service Companies and Equipment Manufacturers

Note that the water efficiency products and services companies listed here were identified at the time this document was published. The list does not purport to be complete, to indicate the right to practice the technologies, or to reflect future market conditions.

Water-Saving Toilets, Urinals, and Flush Valves

American Standard, Inc.
1 Centennial Avenue
Piscataway, NJ 08855
800-223-0068

Briggs Industries
4350 W. Cypress St., Suite 800
Tampa, FL 33607
800-888-4458

Crane Plumbing
1235 Hartrey Ave.
Evanston, IL 60202-1056
847-864-9777; 800-955-0316

Eljer PlumbingWare, Inc.
14801 Quorum Dr.
Dallas, TX 75254
800-423-5537

Falcon Waterfree Technologies, LLC
10900 Wilshire Blvd., 15th Floor
Los Angeles, CA 90024
310-209-7250

Gerber Plumbing Fixtures Corp.
4600 W. Touhy
Chicago, IL 60646
847-675-6570

Geberit Mfg., Inc.
1100 Boone Dr., P.O. Box 2008
Michigan City, IN 46360-8008
219-879-4466

Jade Mountain
P.O. Box 4616
Boulder, CO 80306
800-442-1972

Kohler Co.
444 Highland Dr.
Kohler, WI 53044
920-457-4441; 800-4KOHLER

Mansfield Plumbing Products
150 First St.
Perrysville, OH 44864
419-938-5211

Microphor, Inc.
P.O. Box 1460
Willits, CA 95490
707-459-5563; 800-358-8280

Niagara Conservation Corp.
45 Horse Hill Rd.
Cedar Knolls, NJ 07927
800-831-8383

P-Knows, Inc.
2233 South Choctaw
Baton Rouge, LA 70815
888-275-2291

Peerless Pottery, Inc.
P.O. Box 145
Rockport, IN 47635-0145
800-457-5785

Sloan Valve Company
10500 Seymour Avenue
Franklin Park, Ill. 60131-1268
847-671-4300
www.sloanvalve.com

Titon Industries Inc
P O Box 566858
Atlanta, GA 31156
770-399-5252

Toto Kiki USA, Inc
1155 Southern Rd.
Morrow, GA 30260-2917
770-282-8686

U.S. Brass
P.O. Box 37
Plano, TX 75074
800-USBRASS

Waterless Co.
1549 Idlewood Rd.
Glendale, CA 91202
800-969-6364

Water-Saving Showerheads, Faucets, and Related Products

American Standard, Inc.
1 Centennial Ave.
Piscataway, NJ 08855
800-223-0068

AM Conservation Group, Inc.
R.D. 3, Box 920, Rt. 517
Hackettstown, NJ 07840
908-852-6464

Beacon Valve Co.
P.O. Box 540478
Waltham, MA 02454
800-325-2032

Bradley Corp.
9101 Fountain Blvd.
Menomonee Falls, WI 53051
414-251-6000

Briggs Industries
4350 W. Cypress St., Suite 800
Tampa, FL 33607
800-627-4447

Chatham Brass Co., Inc.
5 Olsen Ave.
Edison, NJ 08820-2498
732-494-7101

Chicago Faucet Co.
2100 S. Clearwater Dr.
Des Plaines, IL 60018-5999
847-803-5000

Chronomite Laboratories Inc.
1420 W. 240th St
Harbor City, CA 90710-1307
310-534-2300

Coyne & Delany Co.
P.O. Box 411
Charlottesville, VA 22902
434-296-0166

Eljer PlumbingWare, Inc.
14801 Quorum Dr.
Dallas, TX 75254
800-423-5537

Gerber Plumbing Fixtures Corp.
4600 W. Touhy Ave.
Chicago, IL 60646
847-675-6570

Interbath
665 N. Baldwin Park Blvd.
City of Industry, CA 91746-1502
800-423-9485

Kohler Co.
444 Highland Dr.
Kohler, WI 53044
920-457-4441; 800-4KOHLER

Melard Mfg. Corp.
153 Linden St.
Passaic, NJ 07055
800-635-2731

Moen Inc.
25300 Al Moen Dr.
North Olmsted, OH 44070-8022
216-962-2000; 800-321-8809

Niagara Conservation Corp.
45 Horse Hill Rd.
Cedar Knolls, NJ 07927
800-831-8383

Resources Conservation Inc.
P.O. Box 71
Greenwich, CT 06836
203-964-0600; 800-243-2862

Sloan Valve Co.
10500 Seymour Ave.
Franklin Park, IL 60131
847-671-4300

Symmons Industries Inc.
31 Brooks Dr.
Braintree, MA 02184
800-SYMMONS

Teledyne Water Pik
1730 E. Prospect St.
Fort Collins, CO 80553
970-484-1352

Ultraflo Valves & Controls
#8 Trautman Ind. Dr.
Ste. Genevieve, MO 63670
800-950-1762

U.S. Brass
P.O. Box 37
Plano, TX 75074
800-USBRASS

Composting Toilets

Advanced Composting Systems
195 Meadows Rd.
Whitefish, MT 59937
406-862-3854

Biolet Interamericas
550 North Sam Houston
PO Box 592
San Benito, TX 78586
888-5-BIOLET

Biolet USA
45 Newbury St.
Boston, MA 02116
800-5-BIOLET

Clivus Multrum
104 Mt Auburn St, 5th floor
Cambridge MA 02138-5051
1-800-4CLIVUS

Composting Toilet Systems, Inc.
PO Box 1928
Newport, WA 99156
888-786-4538

Ecotech Composting Toilets
152 Commonwealth Ave.
Concord, MA 01742
978-369-3951

ECOS-Water Conservation Systems
152 Commonwealth Ave.
Concord, MA 01742
508-369-3951

Equaris Corp.
1740 Magnolia Lane N.
Plymouth, MN 55441
763-383-5136

Jade Mountain Inc.
PO Box 4616
Boulder, CO 80306
800-442-1972

Lehman's Hardware and Appliances
One Lehman Circle
PO Box 41
Kidron, OH 44636
330-857-5757

Mountain Lion Trading Co.
2404 N. Columbus St.
Spokane, WA 99207
509-487-0765

Real Goods Trading Co.
555 Leslie St.
Ukiah, CA 95482
707-468-9292

Sancor Industries Ltd, USA
6391 Walmore Rd.
Niagara Falls, NY 14304
800-387-5126

Soiltech
607 E. Canal St.
Newcomerstown, OH 43832
800-296-6026

Sun-Mar Corp.
600 Main St.
Tonawanda, NY 14150
800-461-2461

Clothes Washers and Dishwashers

See the EPA ENERGY STAR® Web site for water- and energy-efficient models: www.energystar.gov

See also the Web sites and numbers below for more information; many efficient appliances can be ordered from local appliance distributors.

Frigidaire
www.frigidaire.com; 800-Frigidaire

General Electric
www.ge.com

Maytag
www.maytag.com; 800-688-9900

Staber
www.staber.com; 800-848-6200

Whirlpool
www.whirlpool.com; 800-253-1301

Water-Efficient Commercial Laundry Systems

Florida Water Solutions
2936 S. Semoran Blvd.
Suite 108
Orlando, Fl 32822
407-249-5668

Pellerin Milnor Corp.
P.O. Box 400
Kenner, LA 70063
504-467-9591, Ext. 222

Wascomat of America
461 Doughty Blvd.
Inwood, NY 11096-1344
516-371-4400

Other Water Conservation Products

Acorn Engineering Company
(Drinking fountains)
15125 E. Proctor Ave.
City of Industry, CA 91744-0527
800-488-8999

Jade Mountain
(Demand water heaters)
P.O. Box 4616
Boulder, CO 80306
800-442-1972

Keltech, Inc.
(Tankless water heaters)
9285 N. 32nd, P.O. Box 405
Richland, MI 49083-0405
800-999-4320

Wolter Systems, Inc.
(Instantaneous water heaters)
1100 Harrison Ave.
Cincinnati, OH 45214-1805
513-651-2666

Metropolitan Water Saving Inc.
(Water-saving devices)
4701 Sangamore Rd.
Bethesda, MD 20816-2579
301-229-1980

Whole Energy & Hardware, Inc.
(Water conservation equipment and supplies)
1620 Audubon Rd.
Chaska, MN 55318
800-544-2986

Audits and Retrofits

American Water & Energy Savers
4431 N. Dixie Highway
Boca Raton, FL 33431
800-950-9058

Amy Vickers & Associates, Inc.
800 Main St., Suite 4
Amherst, MA 01002-2402
413-253-1520

Atlas Enterprises of America, Inc.
8143 Richmond Hwy.
Alexandria, VA 22309
703-780-1101

Ayres Associates
8875 Hidden River Pkwy.
Tampa, FL 33637
813-978-8688

Battenkill Group
90 Main St.
Charlestown, MA 02129
617-241-0077

BRACO Resource Services
155 NE 100th St.
Seattle, WA 98125
206-729-6034

California Water Conservation Co.
7277 Hayvenhurst Ave., Suite B-5
Van Nuys, CA 91406
818-787-5588

Consumers Applied Technologies
5858 S. Semoran Blvd.
Orlando, FL 32822
800-362-9964

CTSI Corporation
2722 Walnut Ave.
Tustin, CA 92780
800-660-8028

Diversified Conservation Inc.
22-24 W. Main St.
Freehold, NJ 07728
800-4-0-WASTE

ERI Services, Inc.
8380 Old York Rd.
Elkins Pk., PA 19027
215-887-7100

The Fuller Group (Aqua Saver)
3461 Summerford Ct.
Marietta, GA 30062
770-565-8539

H20 Matrix
2 Oliver St.
Boston, MA 02109
617-574-1180

Heath Consultants
9030 Monroe Road
Houston, TX 77061-5229
713-844-1300

Honeywell DMC Services, Inc.
299 Washington St.
Woburn, MA 01801
781-933-9558

John Olaf Nelson Water Resources Management
1833 Castle Drive
Petaluma, CA 94594
707-778-8620

Koeller and Company
5962 Sandra Drive
Yorba Linda, CA 92886-5337
714-777-2744

Lombardo Associates
49 Edge Hill Rd.
Newton, MA 02167
617-964-2924

Margiloff & Associates
6221 Royalview St.
Duarte, CA 91010-1346
626-303-1266

Metropolitan Resource Management
516 Fifth Ave., Suite 1500
New York, NY 10036
1-888-542-7586

MSA Professional Services
1230 South Blvd.
Baraboo, WI 53913
608-356-2771

National Exemption Services, Inc.
10810 72nd St. North, Suite 207
Largo, FL 33777
800-780-8848

Sloan Hydronomic Systems, Inc. (East)
44 Granite St.
Medway, MA 02053
800-671-6973

Utility Services Associates
10013 Martin Luther King Jr. Way So.
Seattle, WA 98178
800-621-9292

Volt VIEWtech
3430 E. Miraloma Ave.
Anaheim, CA 92806
800-355-VIEW

WaterTech International, Inc.
200 High St., 6th Floor
Boston, MA 02110
617-592-8224

Water Loss Systems, Inc.
26409 Aiken Dr.
Clarksburg, MD 20871
800-330-8905

Water Management, Inc.
117 Claremont Ave
Alexandria, VA 22304
703-370-9133

Water Savers, Inc.
9672 Via Excelencia
San Diego, CA 92126
800-459-2837

Wellspring Water Management
6333 Greenwich Dr. #140
San Diego, CA 92122
858-824-0900

Who Is Using the Technologies

This list provides a sampling of the many Federal agencies that are using water-efficient technologies.

Bureau of Reclamation
U.S. Department of the Interior
Glen Canyon Dam, Arizona
Contact: Larry Gordon
Phone: 801-524-3657

Department of Energy
Sandia National Laboratories
Albuquerque, New Mexico
Contact: Darell Rogers
Phone: 505-844-5842

U.S. Air Force
Air Force Civil Engineering Support Agency
Contact: Michael Clawson
Tyndall AFB, Florida
Phone: 850-283-6362

U.S. Navy
Navy Facilities Engineering Service Ctr.
Port Hueneme, California
Contact: Dan Magro
Phone: 805-982-3529

For More Information

American Water Works Association
6666 W. Quincy Ave.
Denver, CO 80235
303-794-7711
www.awwa.org

California Energy Commission (CEC)
916-654-4287
See the "Consumer Tips" Web pages:
www.consumerenergycenter.org/flex/index.html

Rocky Mountain Institute Water Program
1739 Snowmass Creek Road
Snowmass, CO 81654-9199
970-927-3851
www.rmi.org

U.S. Department of Energy
Federal Energy Management Program (FEMP)
Help Line: 1-800-363-3732
www.eren.doe.gov/femp
FEMP Water Efficiency Program:
202-646-5218

WaterWiser, the Water Efficiency Clearinghouse
(A program of the American Water Works Association operated in cooperation with the U.S Bureau of Reclamation)
6666 W. Quincy Ave.
Denver, CO 80235
800-926-7337
www.waterwiser.org

Third-Party Information and Guide Books

Air Force Civil Engineering Support Agency
Information for Air Force bases that other agencies can use:
www.afcesa.af.mil/Directorate/CES/Civil/Water/Water.htm
(See especially the *Water Conservation Guidebook*)

General Services Administration
www.gsa.gov
(See especially *Water Management: A Comprehensive Approach for Facility Managers*)

Navy Facilities Engineering Service Center
Information for Navy bases that other agencies can use:
energy.navy.mil/key-areas/WaterWeb.html
(See especially the *Water Conservation Military Handbook*, MIL-HDBK-1165)

New Mexico Office of the State Engineer
Phone: 800-water-nm
(See especially *A Water Conservation Guide for Commercial, Institutional and Industrial Users*)

References

"A new spin on clothes washers." (July 1998). *Consumer Reports*, pp. 50-53.

Arnold, Marilyn L.; Gray, Don. (1993). *Water Efficiency in Federal Facilities and Programs*. Prepared by the Environmental and Energy Study Institute under grant no. X-816389-01-0 for the U.S. Environmental Protection Agency. Washington, DC: Environmental and Energy Study Institute.

City of San Jose, Environmental Services Department. (n.d.) *Water Conservation Guide for Cooling Towers*. San Jose, CA; phone 408-277-5533.

"Clean enough for you?" (March 2000). *Consumer Reports*, pp. 47-50

Dieckmann, J.; Murphy, W. (December 1995). *Laboratory Testing of Clothes Washers*. Report No. TR-105098. Prepared by Arthur D. Little, Inc., for the Electric Power Research Institute. Palo Alto, CA: EPRI.

"Dishing it out." (March 1999). *Consumer Reports*, pp. 50-53.

Dooley, Joseph W. (1996). *Waterless Urinals*. Report to the Office of the Deputy Under Secretary of Defense, Energy and Engineering, 400 ArmyNavy Drive, Suite 206, Arlington, VA 22202.

Dyballa, Cynthia; Connelly, Christopher. (1993). "Electric and Water Utilities: Building Cooperation and Saving." *Proceedings of the ACEEE 1992 Summer Study on Energy Efficiency in Buildings*. Washington, D.C.: American Council for an Energy-Efficient Economy, pp. 5-51–5-61.

Edgemon, Sandi D.; Gregg, Tony T.; Baechler, Michael C. (1998). "ENERGY STAR®, Partnerships Clothes Washer Volume Purchase: Partnering with the City of Austin." Conference paper. Richland, WA: Pacific Northwest National Laboratory.

Electric Power Research Institute. (1995). *Horizontal-Axis Residential Washing Machine*. EPRI Technical Brief no. RP3872. Palo Alto, CA: EPRI, December.

Gelinas, C. Gary; Brant, Benjamin. (November 1995). "A Systems Approach to Saving Water and Energy." Presented at the 18th World Energy Engineering Congress, Atlanta, GA.

How to Buy a Water-Saving Faucet. (February 1997). Washington, DC: U.S. Department of Energy, Federal Energy Management Program.

How to Buy a Water-Saving Replacement Toilet. (February 1997). Washington, DC: U.S. Department of Energy, Federal Energy Management Program.

How to Buy a Water-Saving Replacement Urinal. (February 1997). Washington, DC: U.S. Department of Energy, Federal Energy Management Program.

How to Buy a Water-Saving Showerhead. (February 1997). Washington, DC: U.S. Department of Energy, Federal Energy Management Program.

"In Search of a Better Toilet: How Well Do Low Flush Models Work? And Do They Save Water?" (May 1998). *Consumer Reports*, Volume 63, No. 5; p. 44.

Jenkins, Joseph. (1999). *The Humanure Handbook*. Second edition. Grove City, PA: Jenkins Publishing.

Jones, Andrew P. (1993). *High-Efficiency Showerheads and Faucets*. Water Efficiency Technology Report #2. Snowmass, CO: Rocky Mountain Institute.

Kesselring, John; Gillman, Richard. (1997). "Horizontal-Axis Washing Machines." *EPRI Journal*, January/February, pp. 38–41.

Laird, Colin. (1991). *Water-Efficient Technologies. A Catalog for the Residential/ Light Commercial Sector*. 2nd edition. Snowmass, CO: Rocky Mountain Institute.

Laurie, Michael (1996). *Commercial Water Auditing Workshop*, Seattle, Wa. BRACO Resource Services.

Lombardo Associates. (June 1997). Draft. *Federal Facilities Water Use and Water/Energy Conservation Potential. Task 1 Report: Water Use Estimates*. Prepared under contract no. AAR-7-17778-01. Golden, CO: National Renewable Energy Laboratory.

Osann, Edward; Young, John. (April 1998). *Saving Water, Saving Dollars: Efficient Plumbing Products and the Protection of America's Waters*. Washington, DC: Potomac Resources, Inc. Available from the American Council for an Energy Efficient Economy, 202-429-0063.

Pacific Northwest National Laboratory. (1995). *Ozone Treatment for Cooling Towers. Federal Technology Alert* . Prepared for the Federal Energy Management Program by PNNL. Online: www.pnl.gov/fta/6_ozone.htm.

Postel, Sandra. (April 1997). "Dividing the Waters." *Technology Review*, pp. 54–62.

U.S. General Services Administration. (n.d.) *Water Management: A Comprehensive Approach for Facility Managers*. Prepared by U.S. GSA, Office of Real Property Management and Safety, and Enviro-Management & Research, Inc., 1015 18th St., N.W., Washington, DC 20036, phone 202-293-5300.

Appendixes

Appendix A: Guidelines for Domestic Water Technology Applications in New Federal Construction and Retrofits

Technology	Best choice for new construction with water and sewer lines	Best choice for new construction with water and sewer lines; very likely that users will waste water	Best choice for new construction at remote sites without water and sewer lines	Best choice for retrofits at sites with water and sewer lines	Best choice for retrofits at sites with water and sewer lines; very likely that users will waste water	Best choice for retrofits at remote sites without water and sewer lines
Faucet	Restrooms: 0.5 gpm[a] (1.9 lpm); Kitchens: 2.5 gpm (9.5 lpm)	Restrooms: 0.5 gpm (1.9 lpm); faucet with a timer; Kitchens: 2.5 gpm (9.5 lpm)	Restrooms: 0.5 gpm (1.9 lpm); Kitchens: 2.5 gpm (9.5 lpm); Consider graywater system for waste-water disposal	Restrooms: 0.5 gpm (1.9 lpm); Kitchens: 2.5 gpm (9.5 lpm)	Restrooms: 0.5 gpm (1.9 lpm) faucet with a timer; Kitchens: 2.5 gpm (9.5 lpm)	Restrooms: 0.5 gpm (1.9 lpm); Kitchens: 2.5 gpm (9.5 lpm)
Showerhead	1.5 gpm (5.7 lpm)	1.5 gpm (5.7 lpm)	1.5 gpm (5.7 lpm)	1.5 gpm (5.7 lpm)	1.5 gpm (5.7 lpm)	1.5 gpm (5.7 lpm)
Tank toilet	1.6 gpf[b] (6.1 lpf) pressure-assisted model	1.6 gpf (6.1 lpf) pressure-assisted model	Consider compost toilet or 1.6 gpf (6.1 lpf) pressure-assisted model	1.6 gpf (6.1 lpf) pressure-assisted model	1.6 gpf (6.1 lpf) pressure-assisted model	1.6 gpf (6.1 lpf) pressure-assisted model
Flushometer toilet	1.6 gpf (6.1 lpf)	1.6 gpf (6.1 lpf)	Consider compost toilet or 1.6 gpf (6.1 lpf)	1.6 gpf (6.1 lpf)	1.6 gpf (6.1 lpf)	1.6 gpf (6.1 lpf)
Urinal	1 gpf (3.8 lpf) or waterless	1 gpf (3.8 lpf) or waterless	1 gpf (3.8 lpf) or waterless	1 gpf (3.8 lpf) or waterless	1 gpf (3.8 lpf) or waterless	1 gpf (3.8 lpf) or waterless
Clothes washer	25 gpu[c] (94.6 lpu) or less	25 gpu (94.6 lpu) or less	25 gpu (94.6 lpu) or less consider graywater system for wastewater disposal	25 gpu (94.6 lpu) or less	25 gpu (94.6 lpu) or less	25 gpu (94.6 lpu) or less
Dishwasher	5 gpu (18.9 lpu)	5 gpu (18.9 lpu) or less	5 gpu (18.9 lpu) consider graywater system for wastewater disposal	5 gpu (18.9 lpu) or less	5 gpu (18.9 lpu) or less	5 gpu (18.9 lpu) or less

[a] gpm = gallons per minute; lpm = liters per minute

[b] gpf = gallons per flush; lpf = liters per flush

[c] gpu = gallons per use; lpu = liters per use

Appendix B: Estimating Water Use and Savings Associated with Domestic Fixtures and Appliances

This appendix includes three examples of analyses of water, energy, and cost savings associated with installing water-efficient technologies to demonstrate their cost-effectiveness. Example 1 analyzes the savings and costs associated with replacing toilets and urinals and installing faucet aerators. The water rates and occupancy levels used in the example are average rates for GSA facilities. Example 2 analyzes the savings and costs associated with replacing two dishwashers with different usage patterns. Example 3 analyzes the savings and costs associated with replacing a showerhead and installing faucet aerators.

Example 1: Toilets, Urinals, and Faucet Aerators

This example presents savings, simple paybacks, and discounted paybacks obtainable with a total of 30 water-saving fixtures installed as retrofits in six restrooms.

	Annual Energy Use (kWh/yr)	**Annual Water Use** (gallons)
Existing fixtures	10,502	1,125,000
Proposed retrofits	2,100	450,000

	Average Water Use Before Retrofits (gallons)
Males (average use per worker per workday)	
1 toilet use (at 3.5 gal. per flush)	3.5
2 urinal uses (at 2 gal. per flush)	4
3 lavatory uses (at 2.5 gal. per min., 0.17 min. per use)	1.3
Total	8.8
Females (average use per worker per workday)	
3 toilet uses (at 3.5 gal. per flush)	10.5
3 lavatory uses (at 2.5 gal. per min., 0.17 min. per use)	1.3
Total	11.8

Average water use per person per 8-hr workday before retrofits: 10 gallons

	Average Water Use After Retrofits (gallons)
Males (average use per worker per workday)	
1 toilet use (at 1.6 gal. per flush)	1.6
2 urinal uses (at 1 gal. per flush)	2
3 lavatory uses (at 0.5 gal. per min., 0.17 min. per use)	0.3
Total	3.9
Females (average use per worker per workday)	
3 toilet uses (at 1.6 gal. per flush)	4.8
3 lavatory uses (at 0.5 gal. per min., 0.17 min. per use)	0.3
Total	5.1

Average water use per person per 8-hr workday after retrofits: 4.5 gallons
Daily water savings after retrofits: 5.8 gallons
Annual water savings: 675,000 gallons
Annual cost savings (at $3.88 per 1000 gallons): $2,619
Annual energy savings: 8,237 kWh/yr (Using 250 workdays for 450 people; 112,500 gal./yr; 30% hot water, 8.33 lb/gal., water temp. increase, 100°; 3,413 Btu/energy unit; 100% electric water heater efficiency)
Annual water cost savings: $2,619
Annual energy cost savings: $577
Total annual savings: $3,196
Total installation cost: $8,268 (Assuming 6 restrooms and total of 15 toilets and 3 urinals at $450 each, 12 sinks at $14 each)
Simple payback (using $8,268 installed cost, $3,196 savings/yr): 2.6 years
Life-cycle-cost discounted payback: 1 year

Example 2: Dishwashers

This example presents savings, simple paybacks, and discounted paybacks for water-saving dishwashers with different usage rates.

Assumptions: Water/wastewater rate of $3.88 per 1000 gallons
Electric rate of $0.07 per kWh

Energy and Water Use for Existing Dishwashers

	Energy Use	Water Use
First dishwasher (1 use per day)	547 kWh/yr	13 gal./use; 5000 gal./yr
Second dishwasher (2.5 uses per day)	1824 kWh/yr	13 gal./use; 12,500 gal./yr

Energy and Water Use for Proposed Dishwashers

	Energy Use	Water Use
First dishwasher (1 use per day)	173 kWh/yr	5 gal./use; 2080 gal./yr
Second dishwasher (2.5 uses per day)	701 kWh/yr	5 gal./use; 5200 gal./yr

	First Dishwasher (1 use per day)	Second Dishwasher (2.5 uses per day)
Water saved per use (gal.)	8	8
Water saved daily (gal.)	8	20
Percent hot water	75	75
Hot water saved daily (gal.)	6	6
Pounds/gal.	8.33	8.33
Water temp. increase (deg.)	70	70
Btu/energy unit	3413	3413
Water heater efficiency	1	1
Daily energy savings (kWh)	1.03	2.56
Annual water savings (gal.)	2920	7300
Annual water cost savings	$11	$28
Annual energy savings (kWh)	374	935
Annual energy cost savings	$26	$65
Installed cost	$600	$600
Simple payback (years)	16	6
Life-cycle-cost discounted payback (years)*	1	1

*Life-cycle-cost savings are so good in comparison to the simple paybacks because this example assumes that water and wastewater rates will increase 5% per year for the life of the measures.

Example 3: Showerhead and Aerator

This example shows the savings obtainable with a water-saving showerhead and faucet aerator, as well as their simple paybacks and discounted paybacks.

	Energy Use (kWh/yr)	Water Use (gallons)
Existing fixtures (one of each fixture)	4,706	32,960 per year (3.5 per use)
Proposed retrofits (one of each fixture)	3,361	23,543 per year (2.5 per use)

	Showerhead	Aerator
Number of people per household	4.3	4.3
Average showers per day per person	1	
Average handwashings per day per person		6
Average time per shower (min.)	6	
Average time per handwashing (min.)		0.17
Water savings per min. (gal.)	1	1
Water savings per year (gal.)	9,417	1,601
Installed cost	$31	$14

Totals for both fixtures*:

Installed costs: $45
Annual water savings (gal.): 11,018
Annual energy savings (kWh): 1,345
Annual water cost savings (at $3.88 per 1,000 gal.): $43
Annual energy cost savings (at $0.07/kWh): $94.12
Simple payback: 0.3 yr
Discounted payback: 1 yr

*Using 50% hot water, 8.33 lb/gal., water temp. increase, 100°; 3,413 Btu/energy unit; 100% water heater efficiency.

Appendix C: Comparative Economic Analyses for Selected Water Conservation Technologies

Toilets

NIST BLCC 5.0-01: Comparative Analysis
Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

Base Case: Toilet
Alternative: Low-Flow Toilet

General Information

Project Name:	Toilet / Low-Flow Toilet
Project Location:	Colorado
Analysis Type:	Federal Analysis, Agency-Funded Project
Analyst:	NREL
Base Date of Study:	April 1, 2001
Service Date:	April 1, 2001
Study Period:	20 years 0 months (April 1, 2001 through March 31, 2021)
Discount Rate:	3.3%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$0	$339	-$339
Future Costs:			
Energy Consumption Costs	$0	$0	$0
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$902	$361	$541
Recurring and Non-Recurring OM&R Costs	$926	$926	$0
Capital Replacements	$0	$0	$0
Residual Value at End of Study Period	$0	$0	$0
	------------	------------	------------
Subtotal (for Future Cost Items)	$1,828	$1,287	$541
	------------	------------	------------
Total PV Life-Cycle Cost	$1,828	$1,626	$202

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	$541
- Increased Total Investment	$339

Net Savings	$202

Savings-to-Investment Ratio (SIR)
SIR = 1.60

Adjusted Internal Rate of Return
AIRR = 5.75%

Payback Period
Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year	10
Discounted Payback occurs in year	11

Urinals

NIST BLCC 5.0-01: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

Base Case: Urinal
Alternative: Low-Flow Urinal

General Information

Project Name:	Urinal / Low-Flow Urinal / Flushless Urinal
Project Location:	Colorado
Analysis Type:	Federal Analysis, Agency-Funded Project
Analyst:	NREL
Base Date of Study:	April 1, 2001
Service Date:	April 1, 2001
Study Period:	20 years 0 months (April 1, 2001 through March 31, 2021)
Discount Rate:	3.3%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$0	$318	-$318
Future Costs:			
Energy Consumption Costs	$0	$0	$0
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$1,353	$451	$902
Recurring and Non-Recurring OM&R Costs	$926	$926	$0
Capital Replacements	$0	$0	$0
Residual Value at End of Study Period	$0	$0	$0
	------------	------------	------------
Subtotal (for Future Cost Items)	$2,279	$1,377	$902
	------------	------------	------------
Total PV Life-Cycle Cost	$2,279	$1,695	$584

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	$902
- Increased Total Investment	$318

Net Savings	$584

Savings-to-Investment Ratio (SIR)

SIR = 2.84

Adjusted Internal Rate of Return

AIRR = 8.83%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year	6
Discounted Payback occurs in year	6

Flushless Urinals

NIST BLCC 5.0-01: Comparative Analysis
Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

Base Case: Urinal
Alternative: Flushless Urinal

General Information

File Name:	c:\program files\blcc5\projects\DFCUrinals.xml
Run Date:	Wed Jan 30 14:08:07 MST 2002
Project Name:	Urinal / Low-Flow Urinal / Flushless Urinal
Project Location:	Colorado
Analysis Type:	Federal Analysis, Agency-Funded Project
Analyst:	NREL
Base Date of Study:	April 1, 2001
Service Date:	April 1, 2001
Study Period:	20 years 0 months (April 1, 2001 through March 31, 2021)
Discount Rate:	3.3%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$0	$495	-$495
Future Costs:			
Energy Consumption Costs	$0	$0	$0
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$1,353	$0	$1,353
Recurring and Non-Recurring OM&R Costs	$926	$478	$449
Capital Replacements	$0	$0	$0
Residual Value at End of Study Period	$0	$0	$0
	------------	------------	------------
Subtotal (for Future Cost Items)	$2,279	$478	$1,801
	------------	------------	------------
Total PV Life-Cycle Cost	$2,279	$973	$1,306

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	$1,801
- Increased Total Investment	$495

Net Savings	$1,306

Savings-to-Investment Ratio (SIR)

SIR = 3.64

Adjusted Internal Rate of Return

AIRR = 10.19%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year	4
Discounted Payback occurs in year	5

Sensored Faucets

NIST BLCC 5.0-01: Comparative Analysis
Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

Base Case: Sink
Alternative: Low-Flow Sink

General Information

File Name:	c:\program files\blcc5\projects\DFCSinks.xml
Run Date:	Wed Jan 30 14:13:01 MST 2002
Project Name:	Sink / Low-Flow Sink
Project Location:	Colorado
Analysis Type:	Federal Analysis, Agency-Funded Project
Analyst:	NREL
Base Date of Study:	April 1, 2001
Service Date:	April 1, 2001
Study Period:	20 years 0 months (April 1, 2001 through March 31, 2021)
Discount Rate:	3.3%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$0	$339	-$339
Future Costs:			
Energy Consumption Costs	$390	$65	$3250
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$677	$113	$564
Recurring and Non-Recurring OM&R Costs	$926	$926	$0
Capital Replacements	$0	$0	$0
Residual Value at End of Study Period	$0	$0	$0
	------------	------------	------------
Subtotal (for Future Cost Items)	$1,993	$1,104	$889
	------------	------------	------------
Total PV Life-Cycle Cost	$1,993	$1,443	$550

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	$889
- Increased Total Investment	$339

Net Savings	$550

Savings-to-Investment Ratio (SIR)

SIR = 2.62

Adjusted Internal Rate of Return

AIRR = 8.40%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year	6
Discounted Payback occurs in year	7

Energy Savings Summary

Energy Savings Summary (in MBtu)

Energy Type	Average Base Case	Annual Alternative	Consumption Savings	Life-Cycle Savings
Natural Gas	7.7 Mbtu	1.3 Mbtu	6.5 Mbtu	129.2 MBtu

Emissions Reduction Summary

Energy Type	Average Base Case	Annual Alternative	Emissions Reduction	Life-Cycle Reduction
Natural Gas				
CO_2	409.38 kg	68.14 kg	341.24 kg	6,823.84 kg
SO_2	3.30 kg	0.55 kg	2.75 kg	55.07 kg
NO_x	0.48 kg	0.08 kg	0.40 kg	8.04 kg
Total:				
CO_2	409.38 kg	68.14 kg	341.24 kg	6,823.84 kg
SO_2	3.30 kg	0.55 kg	2.75 kg	55.07 kg
NO_x	0.48 kg	0.08 kg	0.40 kg	8.04 kg

Assumptions

Basic Assumptions:

1. 28 male users; daily fixture use increases if women users assumed.
2. 1 toilet flush/man/day; 2 urinal flushes/man/day; 2 hand washes/man/day
3. Water and wastewater costs are based on Denver Federal Center rate schedule:
Cost of water = $1.24 per 1000 gallons
Cost of wastewater = $0.90 per 1000 gallons
4. For sink water use:
50% of the water used is heated hot water
Each wash lasts 30 seconds
Natural gas water heating assumed
5. Natural gas costs $3.66/MBtu
6. Results are for a 20-year life cycle
7. 20-year lifetime assumed for all fixtures.

Toilet / Low-Flow Toilet

	Toilet	**L.F. Toilet**
Capital Cost:	$0	$289
Set-up Cost:	$0	$50
Annual Recurring Costs:	$64	$64
Water Use:	4 gpf (29,120 gal/yr)	1.6 gpf (11,650 gal/yr)

Other:
Assumes one valve/yr in maintenance, approximately $64.

Urinal / Low-Flow Urinal / Flushless Urinal

	Urinal	**L.F. Urinal**	**Flushless Urinal**
Capital Cost:	$0	$268	$495
Set-up Cost:	$0	$50	included in capital cost
Annual Recurring Costs:	$64	$64	$33
Water Use:	3 gpf (43,680 gal/yr)	1 gpf (14,560 gal/yr)	12 gal/yr (for cleaning)

Other:
Flushless urinals require about 1 gallon of hot water per month for cleaning.

Sink / Low-Flow Sink

	Sink	**L.F. Sink**
Capital Cost:	$0	$289
Set-up Cost:	$0	$50
Annual Recurring Costs:	$64	$64
Water Use:	0.5 gpm (3,640 gal/yr)	3 gpm (21,840 gal/yr)
Energy Use (Heat):	1.29 MBtu/yr	7.75 MBtu/yr

Other:
L.F. sink replaces three ordinary sinks and includes sensored faucets and durable basin as one unit; comparison is for three 3-gpm stand-alone sinks to one Bradley Express unit.

Appendix D: Estimating Savings with WATERGY

The WATERGY program is a spreadsheet model for estimating the savings that can result from using water conservation measures. It makes use of assumptions about the water-energy relationship to analyze potential water savings and associated energy savings in a facility. Users incorporate two kinds of data as input into the spreadsheet: (1) utility data, which include energy and water costs and consumption for the most recent 12-month period, and (2) facility data, which include the number and kind of water-consuming or water-moving devices and consumption rates or flow rates.

The program calculates annual direct water, direct energy, and indirect energy savings, as well as the total cost and payback periods for a number of conservation methods, including the following:

- Toilets consuming 1.6 gpf (6 lpf) or less; urinals consuming 1 gpf (about 4 lpf) or less
- Automatic faucets; faucet aerators; low-flow showerheads
- Efficient dishwashers and washing machines
- Boiler blowdown optimization
- Landscape irrigation optimization.

Most of the assumptions that WATERGY uses for energy and water calculations can be grouped into the following categories:

- The heating values of fuels
- The efficiencies of energy- and water-consuming devices or processes [for example, the number of kilowatt-hours consumed per gallon for electric hot water heaters, or the number of kilowatt-hours consumed per 1,000 gallons (3785 liters) of treated wastewater]
- Time-of-use estimates for fixtures (for example, the number of minutes per use of infrared sensor faucets) and percentage of hot water use in machines or fixtures (for example, the percentage of water usage that is hot water for a typical faucet).

WATERGY also makes simple assumptions about capital and labor costs of equipment and fixture replacements. The user can modify all the assumptions that WATERGY applies. To obtain a copy of the program, contact the FEMP Help Desk, 1-800-363-3732.

Appendix E: Guidelines for Conducting a Water Audit

Choosing a Facility for a Water Audit

The first step in completing a water efficiency project is to complete a water audit of a facility that you think will likely have cost-effective water savings opportunities. Here are a few guidelines to follow when you, as a facility manager, want to choose a building to receive a water audit. Select a facility that has older water-using equipment with a high volume of use. Graph water bills for two years and analyze usage trends. When water use increases, is there a good reason, such as a higher occupancy rate or increases in irrigation in summer? Or is there a hard-to-explain spike in water use? Buildings with inexplicable water use patterns are good candidates for a water audit.

Preparing for a Water Audit

If you do not have capabilities in house to conduct your water audit, you can contact the FEMP SAVEnergy Program about audit services for Federal agencies. Your local water utility may also offer free or low-cost audits. If you want to conduct the audit yourself, please see the guidelines below. To ensure the success of a water audit, here are some steps to take before beginning:

- Obtain two years of water and wastewater usage records, names and phone numbers of staff who know how your facility is operated and used, and information about experienced consultants to assist you, if necessary.
- Contact appropriate facility staff and ask them to accompany you on the audit.
- Obtain lists of all water-using equipment and where it is located, the operating schedule of the facility, a schedule of outdoor water use and irrigation, and records of water use for all equipment.

Where to Focus the Audit

If you have time and the budget, it is best to walk through the whole facility, measuring the water use flows and usage rates of all water using equipment. At the end of the audit, you can total the water use from all the equipment you measured and analyzed and compare it to the water usage from 12 months of billing records. The two numbers should be within 10% of each other. If the numbers vary by more than 10%, there are several possibilities; you have under-or-over estimated water-usage, you missed some water using equipment, you are not being billed accurately for your water use or there is a leak. In facilities that are at least 6 years old that have not had major water efficiency projects, this complete audit approach is worth the effort; use the checklist in Appendix H to guide you in looking for savings opportunities.

If you do not have the time or budget for a full water audit, focus on areas that are the most likely to provide opportunities for cost-effective savings. Your water audit efforts should focus on (1) equipment having a high volume of use and (2) equipment that presents the best prospects for savings.

In regard to volume of use, studies show that toilets, urinals, and faucets are associated with 40% or more of the water consumed in most buildings. So, restrooms are a good place to look for opportunities. If the facility was built after 1997, it probably already has low-flush toilets and urinals and low-flow faucets. However, even if the faucets are new, there might be opportunities to save more water and energy by installing aerators with flows of 0.5 gpm.

Second, equipment that provides good opportunities for cost-effective savings is usually associated with high-energy-using processes, such as doing laundry. For example, you may use a number of residential-size washing machines several times a day. If they are old, inefficient machines, they represent a good savings opportunity. If they are new, water-saving, horizontal-axis models, there is not much opportunity for saving except in ensuring that machines are run only with full loads.

Water Audit Analysis

After you have collected information on your facility's water-using equipment, flow rates, usage, schedules, and so on, you can determine which equipment is cost-effective to retrofit or replace. Before you begin the analysis, talk to the finance staff in your agency to determine the type of payback or rate of return required to obtain funding. Contact your local water utility about any grant, loan, or rebate programs that could help pay for the cost of installing the equipment. Obtain a copy of the Federal life-cycle cost analysis software, BLCC5. You can download it for free from the Web (www.eren.doe.gov/femp/techassist/softwaretools/softwaretools.html).

You can use spreadsheet calculations to determine savings opportunities. The calculations in Appendix B of this document are good examples of an appropriate analysis. DOE's WATERGY tool can assist you in the analysis process. You may download it free from the Web: (www.eren.doe.gov/femp/techassist/softwaretools/softwaretools.html).

Obtain a source for estimated installed costs for your project. This Federal Technology Alert and the WATERGY tool can provide some estimated costs. For actual costs, contact people in your agency that have recently implemented water efficiency projects. Local plumbers and other contractors can give you estimated per-item installed costs, although they may want to visit a facility before giving a cost estimate. Actual costs can differ from estimated costs for a variety of reasons, including unexpected plumbing replacement costs, the expensive of retrofitting some existing equipment, and discoveries of hidden leaks.

Appendix F: Commercial Self-Audit Checklist

If your facility contains one or more of the following types of equipment, there may be some very good opportunities for water, energy, and money savings. If you need help in reviewing your equipment for opportunities, contact your local water utility, a consultant, or FEMP to request or schedule a water audit.

Items in *italic type* below are either low-cost measures or operation and maintenance measures you can take to reduce water and wastewater costs.

Items in regular type are capital expenditure measures that cost more to implement but can save considerable amounts of water and energy.

Toilets

❑ *For Flushometer toilets, check flush valve diaphragms for leaks and replace diaphragms every few years, if necessary.*

❑ *For tank toilets, check flappers for leaks and, if necessary, replace flappers every few years.*

❑ Replace toilets using 3.5 gallons (13.2 liters) or more per flush with toilets using 1.6 gallons (6.1 liters) per flush.

Urinals

❑ *Check flush valve diaphragms and, if necessary, replace them every few years.*

❑ Replace urinals using 2 gallons (7.6 iters) or more per flush with urinals using 1 gallon (3.8 liters) or less per flush.

Restroom Faucets

❑ *Install 0.5 gallon-per-minute (about 2-liter-per-minute) aerators on restroom faucets that have flows of 1 gallon (about 4 liters) per minute or greater.*

Showers

❑ *Install showerheads with flows of 2.5 gallons (9.5 liters) per minute or less on showers with flows greater than 3 gallons (11.4 liters) per minute.*

Garbage Disposal

❑ *Eliminate the use of commercial kitchen garbage disposals and replace them with composting of food waste.*

Leak Repair

❑ *Look at water bills to find sudden, inexplicable increases in water use, and look for obvious or suspected leaks; repair leaks.*

Residential-Size Laundry

❑ Replace vertical-axis machines that are used regularly with horizontal-axis machines.

About FEMP's New Technology Demonstration Program

The Energy Policy Act of 1992, and subsequent Executive Orders, mandate that energy consumption in Federal buildings be reduced by 35% from 1985 levels by the year 2010. To achieve this goal, the U.S. Department of Energy's Federal Energy Management Program (FEMP) is sponsoring a series of programs to reduce energy consumption at Federal installations nationwide. One of these programs, the New Technology Demonstration Program (NTDP), is tasked to accelerate the introduction of energy-efficient and renewable technologies into the Federal sector and to improve the rate of technology transfer.

As part of this effort FEMP is sponsoring a series of publications that are designed to disseminate information on new and emerging technologies. New Technology Demonstration Program publications comprise four separate series:

Federal Technology Alerts—longer summary reports that provide details on energy-efficient, water-conserving, and renewable-energy technologies that have been selected for further study for possible implementation in the Federal sector. Additional information on Federal Technology Alerts (FTAs) is provided in the next column.

Technology Installation Reviews—concise reports describing a new technology and providing case study results, typically from another demonstration program or pilot project.

Technology Focuses—brief information on new, energy-efficient, environmentally friendly technologies of potential interest to the Federal sector.

Other Publications—the program also issues other publications on energy-saving technologies with potential use in the Federal sector.

More on Federal Technology Alerts

Federal Technology Alerts, our signature reports, provide summary information on candidate energy-saving technologies developed and manufactured in the United States. The technologies featured in the FTAs have already entered the market and have some experience but are not in general use in the Federal sector.

The goal of the FTAs is to improve the rate of technology transfer of new energy-saving technologies within the Federal sector and to provide the right people in the field with accurate, up-to-date information on the new technologies so that they can make educated judgments on whether the technologies are suitable for their Federal sites.

The information in the FTAs typically includes a description of the candidate technology; the results of its screening tests; a description of its performance, applications and field experience to date; a list of manufacturers; and important contact information. Attached appendixes provide supplemental information and example worksheets on the technology.

FEMP sponsors publication of the FTAs to facilitate information-sharing between manufacturers and government staff. While the technology featured promises significant Federal-sector savings, the FTAs do not constitute FEMP's endorsement of a particular product, as FEMP has not independently verified performance data provided by manufacturers. Nor do the FTAs attempt to chart market activity vis-a-vis the technology featured. Readers should note the publication date on the back cover, and consider the FTAs as an accurate picture of the technology and its performance at the time of publication. Product innovations and the entrance of new manufacturers or suppliers should be anticipated since the date of publication. FEMP encourages interested Federal energy and facility managers to contact the manufacturers and other Federal sites directly, and to use the worksheets in the FTAs to aid in their purchasing decisions.

Federal Energy Management Program

The Federal Government is the largest energy consumer in the nation. Annually, in its 500,000 buildings and 8,000 locations worldwide, it uses nearly two quadrillion Btu (quads) of energy, costing over $8 billion. This represents 2.5% of all primary energy consumption in the United States. The Federal Energy Management Program was established in 1974 to provide direction, guidance, and assistance to Federal agencies in planning and implementing energy management programs that will improve the energy efficiency and fuel flexibility of the Federal infrastructure.

Over the years, several Federal laws and Executive Orders have shaped FEMP's mission. These include the Energy Policy and Conservation Act of 1975; the National Energy Conservation and Policy Act of 1978; the Federal Energy Management Improvement Act of 1988; the National Energy Policy Act of 1992 (EPACT); Executive Order 13123, signed in 1999; and, most recently, Executive Order 13221, signed in 2001, and the Presidential Directive of May 3, 2001.

FEMP is currently involved in a wide range of energy-assessment activities, including conducting New Technology Demonstrations, to hasten the penetration of energy-efficient technologies into the Federal marketplace.

Log on to FEMP's New Technology Demonstration Program Web site

www.eren.doe.gov/femp/prodtech/newtechdemo.html

You will find links to

- An overview of the New Technology Demonstration Program
- Information on the program's technology demonstrations
- Downloadable versions of program publications in Adobe Portable Document Format (pdf)
- A list of new technology projects under way
- Electronic access to the program's regular mailing list for new products when they become available
- How Federal agencies may submit requests for the program to assess new and emerging technologies

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 10% postconsumer waste

For More Information

FEMP Help Desk
(800) 363-3732
International callers please use
(703) 287-8391
Web site: www.eren.doe.gov/femp

General Contacts

Ted Collins
New Technology Demonstration Program Manager
Federal Energy Management Program
U.S. Department of Energy
1000 Independence Ave., S.W., EE-92
Washington, DC 20585
Phone: (202) 586-8017
Fax: (202) 586-3000
theodore.collins@ee.doe.gov

Steven A. Parker
Pacific Northwest National Laboratory
P.O. Box 999, MSIN: K5-08
Richland, WA 99352
Phone: (509) 375-6366
Fax: (509) 375-3614
steven.parker@pnl.gov

Technical Contacts

Ab Ream
Federal Energy Management Program
U.S. Department of Energy
1000 Independence Ave., S.W., EE-92
Washington, DC 20585
Phone: (202) 586-7230
Fax: (202) 586-3000
ab.ream@ee.doe.gov

Stephanie Tanner
National Renewable Energy Laboratory
Washington Office
901 D Street, S.W., Suite 930
Washington, DC 20024-2157
Phone: (202) 646-5218
Fax: (202) 646-7780
stephanie_tanner@nrel.gov

Produced for the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, by the National Renewable Energy Laboratory

DOE/EE-0264
October 2002