HIDDEN COSTS: WASTED WATER

Saving water can have a huge impact on the expense of operating multifamily buildings—especially when the water bills and the heating and hot water bills are in the same ballpark.

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Recent SWA audits of multifamily buildings have revealed that on an annual basis, in some instances, a building's water bill exceeds the heat-plus-hot-water bill.

In addition to being energy hogs, multifamily buildings—especially older ones—can be water hogs. The only way to be certain if a multifamily building is a hog or not is to perform an audit. So along with looking at lights, HVAC, and the myriad of other components that go into buildings' energy use, Steven Winter Associates (SWA), where we work, makes sure to give the water uses their due on site visits. Recent SWA audits of multifamily buildings have revealed that on an annual basis, in some instances, a building's water bill exceeds the heat-plus-hot-water bill.

SWA's Multifamily Buildings staff has performed energy audits on buildings all over the country. Some audits are subsidized by utilities, state programs, or statewide surcharges on utility bills, but many are contracted directly with managers and owners of multifamily buildings that have been hit with large increases in energy and water costs.

Savings Potential

Most of the audits that our team has completed in the last two years have been in the New York, Washington, DC, and Philadelphia metropolitan areas, in complexes with more than 100 units. A quick look at some of the bills explains why water consumption has attracted our attention. A multifamily building complex outside of Philadelphia, built in the early 1970s, had common-area electric costs of $31,000, gas expenses of $376,000, and water and sewer costs of $362,000—both water and gas were master-metered for the entire complex. The water bills almost equaled the gas bills!

As is the case with many estimates for savings that are based on consumption, when estimating the possible savings for the Philadelphia buildings, SWA used various national averages for the number of toilet flushes and length and flow rate of showers in order to come up with a range of possible savings ("Water Savings Calculations"). At a cost of $172,000 (573 apartments at $300 each) for installing low-flow showerheads and toilets, and assuming a 10 year improvement lifetime, we calculated yearly savings of $2,480 for gas and $34,000–$100,000 for water. This yields a simple payback of 1.5–4 years, a return on investment of 25%–63%, and a savings to investment ratio of 2.5–6.3.

As you can see from the numbers, although the gas savings are great from reduced hot water use with the low-flow showerheads, the combined potential water savings from new showerheads plus the toilets are very large. In the end, the proposed savings from the water helped drive the total investment package—which included lighting, insulation, windows, and air sealing.

Reports from a Washington, DC, property management company support what we found in Philadelphia—replacing existing showerheads and toilets with newer low-flow fixtures is a very cost-effective measure. The owners of a number of buildings in Washington replaced outdated toilets and showerheads with low-flow models. They noted a payback time of two years at the most.

To get a more specific understanding of the savings that installing low-flow fixtures can produce, we looked at water and sewer use in two groups of buildings in middle-income rental areas in the Washington, DC, metropolitan area. In one group, the management vigorously replaced showerheads and toilets; in the other group, these were not replaced (see Table 1). You can see that there are high and low consumers in both groups. The average difference, however, is 22 gallons/apt/day. In suburban Washington, DC, for multifamily buildings in the $8.50–$9/1,000 gallons range, this would mean $68–$72 in savings per apartment per year. (See Table 2 for a description of DC area water and sewer rates.)

Broad comparisons are complicated by the fact that some of these buildings have cooling towers for A/C, which can be very large users of water, and some of these buildings have swimming pools. In buildings with cooling towers, we saw billings that reflected a sewer credit for the losses, metered separately; this may not be the case everywhere. To our knowledge, none of the buildings use water for lawns. Clearly, though, toilets, showerheads, and faucets are among the first places owners, managers, and auditors should look for savings.

Table 1. Buildings With or Without Toilet/Showerhead Replacement

Buildings Without New Toilets/ Showerheads	Gal/Unit/Day (Average 136)
1	119
2	114
3	116
4	110
5	283
6	179
7	195
8	143
9	132
10	78
11	88
12	100
Buildings With New Toilets/ Showerheads	**Gal/Unit/Day (Average 114)**
1	140
2	113
3	128
4	114
5	103
6	119
7	216
8	129
9	65
10	88
11	44

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This showerhead had a very interesting leaking function.

Water Audits

Although water savings should be a commonplace target for all building managers, we don't usually find instant acceptance of the idea. When preparing for a multifamily building energy audit, SWA's first step is to call the building management and ask for two years' worth of gas, electric, and water/sewer consumption and cost data. This may be the most difficult part of an analysis; a typical response is "I can get you the gas and electric, but we'll have to hunt for the water and sewer data. We thought you were doing an energy audit, so what do you need the water and sewer data for?" The short answer is that water consumption is probably costing a lot of money that can easily be saved.

By looking up the rate structures of water companies, many of which are online, we can give the owner an estimate of how much savings are available by using more efficient fixtures. Water is typically billed in units of 100 cubic feet (ccf, approximately 748 gallons) or 1,000 gallons (kgal); the majority of bills we have seen lately are in ccf. Across the country, consumers have begun to see water and wastewater rate increases that are markedly, and in some cases acutely, higher than average price increases, such as in Washington, DC (42% in 1997), Seattle (24% in 2001), and Buffalo (23% in 2004). Most areas seem to feature a flat or increasing block rate, such that the more you use, the more you pay per unit. Few areas feature a declining block rate, rewarding buildings for using more water (like many electric and gas rates).

There are some things to keep in mind when looking at a water bill for an audit. Make sure you know what the units are on your water bill. When calculating savings, keep in mind that the rate for your savings are the last gallons cut from your bill. That is, use the marginal cost, not the average cost; the former typically makes the retrofits more cost-effective. Check the water provider's Web site for proposed rate changes; almost every water municipality has a proposed rate change looming in the future.

We often have about two days to look at all the systems of a large building; more complex testing of water systems is not typical. Large water consumers such as cooling towers, leaks, and lawn care are often beyond the scope of a short visit. We are normally limited to visual inspections for leaks and conservation practices; interviews with management, maintenance, and residents can often give us valuable information. We are usually able to identify the big stuff through interviews with staff and usage analysis. (But if we are there in winter, we don't see them watering lawns and we don't see the central A/C system spewing water like a sinking ship!)

Most people don't notice when a toilet is leaking, though this can waste 5,000 gallons of water per day. There are two things that we try to impress on maintenance staff: careful and frequent visual inspections for leaks (something we often find is not done), and a late-night/early-morning check of the water meter to see how much, if at all, it is running as a possible indicator of leaks—at 3 am, the water use you see is probably mostly due to leaks through some toilets' overflow tubes, due to system pressure increases, or through faulty toilet flappers. (One solution to this problem is the use of a pilot fill valve, such as the Fluidmaster Leak Sentry, which is designed specifically for toilets in multifamily rental units, rather than a ballcock. The pilot valve automatically stops leakage from overflow tubes and faulty flappers.)

Table 2. Water Rates for Greater Washington, DC

Consumption (in Gallons) Billed By Average Daily Consumption Range	Water Rate Per 1,000 Gallons ($)	Sewer Rate Per 1,000 Gallons ($)	Combined Water and Sewer Rate Per 1,000 Gallons ($)
0–49	1.72	2.18	3.90
50–99	1.93	2.54	4.47
100–149	2.12	2.99	5.11
150–199	2.39	3.44	5.83
200–249	2.77	3.76	6.53
250–299	3.00	4.05	7.05
300–349	3.18	4.33	7.51
350–399	3.32	4.54	7.86
400–449	3.44	4.64	8.08
450–499	3.54	4.79	8.33
500–749	3.61	4.89	8.5
750–999	3.69	4.99	8.68
1,000–3,999	3.77	5.20	8.97
4,000–6,999	3.85	5.33	9.18
7,000–8,999	3.9	5.40	9.30
9,000 & Greater	3.99	5.53	9.52

According to the recent American Water Works Association Research Foundation survey, leaks account for 13.7% of total residential water use; it is much more difficult to quantify the rate of leaks than the cost of fixing them. If we observe leaks or poor management practices we report them to the owners, but we don't suggest that we know the quantity of the leaks, how much the leaks will cost to fix, or how much that fix will save (the cost of damage from plumbing leaks is almost incalculable).

In a study titled "National Multiple Family Submetering and Allocation Billing Program," EPA cites a benchmark of 100 gallons per unit per day as the average multifamily consumption rate. Gallons per unit per day is good standard nomenclature, but EPA's data is normalized for factors such as the number of bedrooms, cooling towers, landscaping, and pools.

Bathrooms, Sinks, and Leaks

There are many culprits in water waste and our analysis starts with three areas: bathrooms, sinks, and leaks. We find that quick tests of an apartment's faucets or showerheads are an appropriate way to check whether savings could come from replacing these fixtures. Our tests of faucets and showers give a good approximation of usage. It involves an old water pitcher with tick marks every half gallon, and a watch. Testing for a full minute, or part thereof, to determine gallons per minute gives the most consistent numbers. The goal here is not to get precise data on shower or faucet aerator performance, but to find out whether the units are at a maximum of 2.5 gallons per minute (gpm) for showers and 0.5 gpm for kitchen and bath faucets.

(The 2.5 gpm maximum is an industry norm for low-flow showerheads; some go as low as 1.5 gpm. Although some in the industry don't

Water Savings Calculations

The cost of upgrading water-consuming appliances is straightforward—and so is the math for figuring whether they will be cost effective. (We have to guess at the flow rate if the toilet is not labeled. Typically we will assume an average value of 4 gpf if we have no other guidance.) For example, a 6-gpf toilet changed to a 1.5-gpf model, in an area where the rate is $5 per ccf (water and sewer), works out to 4.5 gallons saved per flush, times 5 flushes per day, which equals 23 gallons per day. (This is a reference from the American Water Works Association, based on a 2001 conference report by William DeOreo.) Multiply this by 365 days per year and the result is 8,200 gallons saved per year; this equals 11 ccf saved, which equals $55 per year, or a 4.5-year simple payback for a $250 toilet. We often find rates much higher than $5.00 per ccf and savings increase with both rates' usage. New toilets, showerheads, and faucets leak less, thus contributing to even more savings.

want to go below a maximum of 1 gpm for sinks, we use the 0.5 maximum as a guide. The primary argument for keeping a higher flow rate in the kitchen is to make the filling of pots with water less tedious. If clients want a higher flow rate in the kitchen, we recommend that they install an aerator with a temporary shutoff to be used when washing dishes.)

This quick test often yields surprising results. One building in southern Maryland, just outside of Washington, had seemingly tame showers that actually flowed at anywhere from 5 to 8 gpm, varying from apartment to apartment. A different building nearby had kitchen sinks that flowed at anywhere from 3 to 3.5 gpm, whereas the shower flowed at a slow 1.5 to 2 gpm. In both cases, we suggested respective upgrades to low-flow showerheads and/or faucet aerators with nonremovable restrictors, for both savings and higher-quality spray.

Part of the reason we have found testing so important is that showerheads labeled 2.5 gpm can easily have restrictors removed; faucets that appear to have aerators sometimes don't, or the aeroators aren't functioning properly. One popular model showerhead tested at anywhere from 1.0 to 4.0 gpm. The wide variation in flow rates may be caused by variations in the water pressure. Showerheads that are tested at 80 pounds per square inch (psi) have been found operating at a higher pressure in some buildings. One building operator had to repair all the shower control mixing valves when they failed and started leaking into the wall cavities. The cause was high water pressure, which they corrected by installing a new regulator and adjusting the building supply pressure to less than 80 psi. This is obviously a concern, and we have suggested that building management look for better shower control models (or better pressure regulation, if possible).

The most important outcome of this test is that it suggests that cost savings from a new fixture may be possible. Along with the showers and faucets, we check to see how much the toilets consume. Most of the toilets we have seen in our audits are 4–6 gallon-per-flush (gpf) models (the number is usually printed on the tank). This is typical in buildings built before1975. The date of manufacture of the toilet is often marked on the inside of the tank and/or the underside of the toilet tank lid. If the gpf mark is not there, the age is the next best clue.

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The ancient toilet above not only was a 5+ gpf model, but it was the wrong size for the bathroom, causing the contractors to cut a bypass into the wall for heat to escape while excess water was escaping with every flush.

Low-water-consumption toilets have suffered a terrible reputation (see "Which Toilets Deliver," *HE* May/June '05, p. 19). The earliest ones flushed at 1.6 gpf, yet some took three flushes to eliminate, well, let us say politely, the waste. Some maintenance personnel have refused to put in low-flow toilets after having a bad experience with cheaper models. We are trying to disabuse them of the notion that all low-flow models perform the same. Canadian and American scientists have continued to perform extensive surveys on the performance of many major models of toilets. Maximum performance (MaP) updates, as well as other good research on water conservation, can be found on the Web sites for the California Urban Water Conservation Council (www.cuwcc.org/products_tech.lasso) and the Canadian Water and Wastewater Association (www.cwwa.ca), which was the lead agency for the MaP studies. We recommend that our clients review the results of the MaP study and select a high-performance model.

We usually assume installed costs at $250 for a toilet replacement, $25 for a showerhead, and $5 for a faucet aerator; so for an apartment with one bath, replacements will run under $300.

Beyond Bathrooms, Sinks, and Leaks

After we consider the three major areas of water waste, there are some other, less quantifiable, but ultimately important categories that we feel need to be addressed.

Outdoor watering. Watering systems, either automatic (without an adequate control system) or manual, can be a tremendous waste of water and a great cost to a building. Grasses, ground cover, and gardens that can survive on the local rainfall and climate with little attention (known as xeriscaping) reduce watering, gardening, lawn cutting, gasoline, and labor costs (see "Tucson Blooms with Less Water," *HE* May/June '04, p. 15). Be wary of subcontractors who are responsible for cutting the lawn and are paid for each time they do it; as they increasingly feed and water the lawn to improve the color, they also need to cut the lawn more, making them more money while using more water and dumping more chemicals and pollution from lawnmowers around the building.

Pinhole leaks in copper pipes. Pinhole leaks, which sometimes form in copper plumbing that has been in service for just a few years, can have a devastating effect on buildings. (Some homes in Maryland have reported problems in as little as 15 years of service; however, the majority of the reports are for buildings that were built in the 1930s. It is estimated that one in three homes in the Washington Suburban Sanitary Commission territory built between 1930 and1939 have this problem.) Pinhole leaks are the result of extreme pitting and corrosion inside the pipes; this is caused by chemical reactions between the pipe itself and the water it is carrying.

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In addition to the waste of water, the damage that is caused by these leaks can be quite extensive because the leaks often go undetected until a catastrophic building failure occurs. The state of Maryland found the occurrence of pinhole leaks in residential buildings to be frequent enough that a study was commissioned to determine the extent and cause of this problem. Initially, the copper pipe itself was thought to be defective. However, in its final report, the Maryland Department of Housing and Community Development concluded that changes in water chemistry mandated by EPA's Safe Drinking Water Act of 1974 may be the most likely factor contributing to this problem.

(The initial findings are that the combination of higher pH, often caused by chemical disinfection treatments, and low organic matter, and the interaction of chlorine and aluminum solids with the copper piping set off a chemical process that accelerates the pitting process. This is something that no one—the copper industry, EPA, or the water utilities—has predicted. Additional research is recommended to determine what other combinations may have adverse effects.)

While the problem with leaking copper pipes continues to be a source of interest for researchers, the current recommendation in the state of Maryland is to treat the water with orthophosphates to reduce the corrosion inside the pipes. Pipes that are already leaky either must be replaced or can be relined with epoxy (the estimated cost to epoxy is $3,000–$5,000 for a 1 1/2 bath home). Given the high profile of this problem, generated through an aggressive public awareness campaign, this is sure to be an issue in real estate transactions and insurance companies for years to come. Anyone conducting energy performance audits or making improvements to existing buildings should be aware of this brewing controversy.

Car washing. Tenants should be required to use an offsite car wash, where they have to pay to use the water. We've also found a large housing company where local Boy Scouts, Girl Scouts, and other groups promote car washes as fundraisers in the parking lot, using the company's water. If you want to contribute the cost of the water, meter it and then ask the local group to provide you with a statement of your contribution as a tax deduction.

Sidewalks. Brooms are a fabulous device for cleaning sidewalks. Many maintenance staff members feel that it's important to wash the sidewalks down every morning, even when the temperatures drop below freezing. Sidewalks get soiled, particularly in high-traffic urban areas, but reducing the washing of sidewalks is important. (The Water Broom is being used widely for this task and may be the best and most acceptable substitute for hose-end spraying.)

Although this slop sink is used for filling buckets, it doesn't always need to flow at 6 gpm; it also doesn't need to have water at 139°F, which can burn human skin.

Roof collection tanks. If an inch of water falls on a 1,000-square-foot roof, 625 gallons of water suitable for watering plants or washing equipment can be harvested. Consider the addition of a cistern or tank to collect this water, which in the absence of city storm drains and gutters will puddle around the building during medium and heavy rains, causing more mud and dirt to be tracked into the building.

Cooling towers. In buildings with central cooling, water is consumed in cooling towers through evaporation and blow-down of water. Efficient control of cooling tower water provides quick opportunities to save money and avoid costly repairs. Cost-effective solutions include the installation of controls that automatically monitor the concentration of dissolved solids and pH and then bleed water or add chemicals as appropriate. It is also good practice to install submeters for both makeup and blowdown water and log usage regularly. In addition, energy efficiency measures that are implemented will decrease the load on the cooling tower and will reduce water lost through evaporation. Many local authorities offer incentives and rebate programs to multifamily building owners. The proper thermostatic control of the tower fan will optimize the total operating cost—energy and water—of a cooling system.

Laundry. We recommend front-loading washing machines for common laundry facilities. Since most buildings have a contract with a laundry operating service, making this switch often involves little more than requesting the change to upgraded equipment. Energy Star laundry equipment is always recommended to reduce water and overall energy consumption, as well as to reduce mechanical drying times.

As part of any multifamily-building energy audit, we encourage everyone to look at the water bills and test the fixtures. The water may be costing more than you think, so a little extra time spent testing those fixtures and analyzing water bills could present an opportunity for simple savings.

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