FEATURE ARTICLE

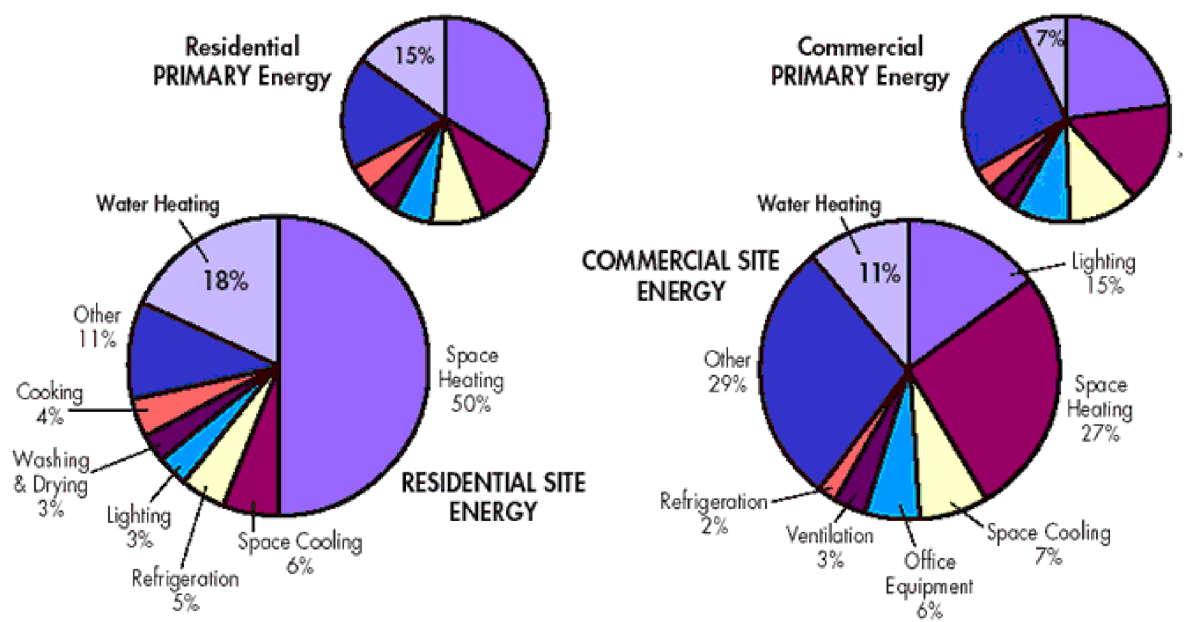
Water Heating: A Look at the Options

Rarely the focus of much attention, water heating accounts for surprisingly large energy loads and environmental impacts. Water heating is typically the second largest energy expenditure in homes (behind space heating) and the fourth largest in commercial buildings (behind lighting, heating, and cooling). In terms of greenhouse gas emissions, a standard residential electric water heater is responsible for nearly half the carbon dioxide emissions of an average passenger car!

This article takes a broad look at water heating. We will examine strategies for reducing hot water demand, measures for boosting overall hot water

system efficiencies, and a wide range of options for heating water. Some strategies discussed in the article apply primarily to residential applications and a few only to commercial, but most can be relevant to both residential and commercial buildings.

Significance of Water Heating



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Water heating accounts for a larger share of energy use in residential buildings than in commercial buildings. Shown here are breakdowns of both site energy and primary energy use on a national basis.

Source: 2002 Buildings Energy Databook, U.S. Dept. of Energy, July 2002

In 2000, water heating in the U.S. accounted for 4.2 quads (4.4 x 10^{12} MJ) of energy use, according to the U.S. Department of Energy (DOE)—11.5% of primary energy use by the building sector (primary energy includes fuel used by power plants to produce electricity). In residential buildings, water heating accounts for over 18% of energy consumed on-site. In a typical home for a family of four, an electric water heater consumes 4,770 kWh per year—more than six times the electricity use of the least efficient refrigerator-freezer you can buy today. While the relative significance of water heating is generally lower in commercial buildings, it is quite large in some industries: 40.4% of energy use in the lodging sector, 26.2% in health care, and 21.9% in education (1995 data from DOE).

Relative to global warming concerns, water heating in the U.S. in 2000 resulted in about 260 million tons of CO_2 emissions (64 million metric tons of carbon), about the same as 64 million new cars driven a national-average 11,700 miles (18,800 km) per year! Within the U.S. building sector, water heating accounts for 11.3% of CO_2 emissions.

In the year 2000, U.S. shipments of water heaters totaled 9.2 million units worth $1.4 billion. Of the total water heaters sold that year, 46% were electric and 54% were gas or oil. Approximately 24,000 solar water heating systems (only 0.3% of all units sold) were purchased in 2000.

Reducing Hot Water Demand

In seeking to reduce energy consumption for a particular end-use, it is almost always less expensive and more environmentally responsible to look for demand-side reductions before addressing the supply side. That is certainly true with water heating.

Specific strategies for reducing demand for hot water include installing low-flow showerheads and faucet aerators, and replacing clothes washers and dishwashers with more efficient models. These strategies, which are fairly straightforward and will be familiar to most readers, are covered in the checklist at the end of this article. Note, however, that there have been significant advances in water-conserving products and appliances in recent years. Product directories, such as our own

GreenSpec® Directory, can lead you to state-of-the-art products to help you reduce hot-water demand.

FEEDBACK

Boosting System Efficiency of Water Heating

Typical Small-House Gas Water Heating System Efficiency Losses

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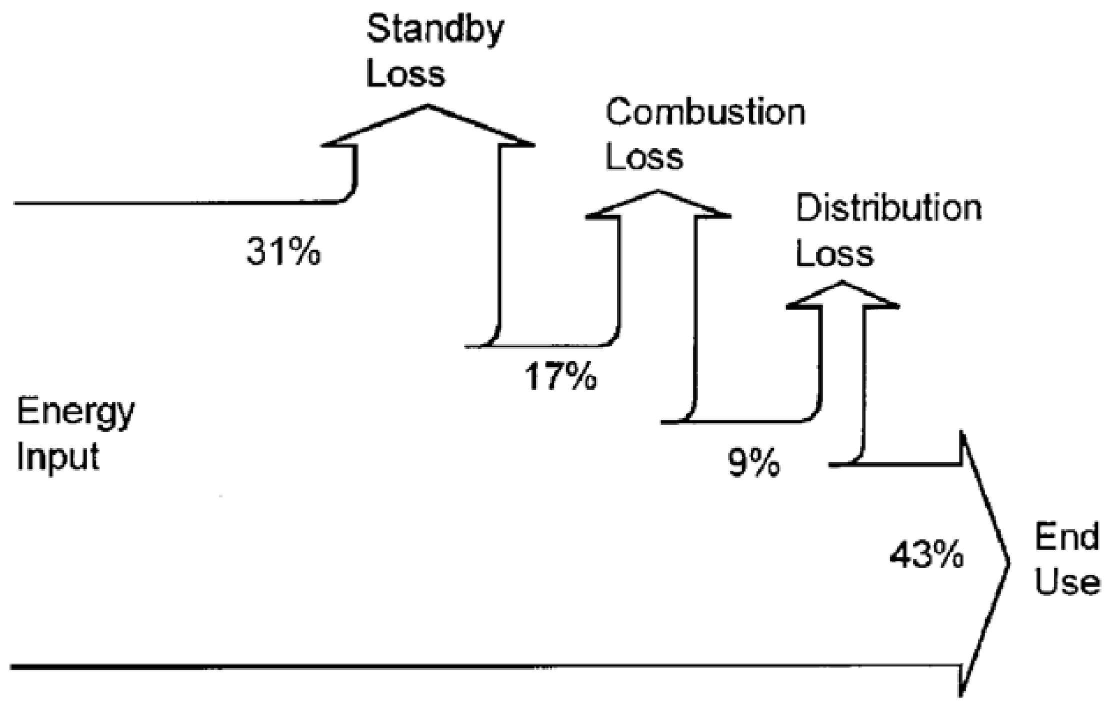

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A typical gas-fired water heater delivers only about 43% of the input energy to the end-user.

Source: “Residential Hot Water Distribution Systems” by James Lutz et al., ACEEE Summer Study, 2002

After reducing the demand for hot water, our next priority should be to eliminate inefficiencies in a water heating

system. This includes how we heat the water (combustion efficiency, standby losses, etc.) and also how we distribute hot water.

Nearly all efforts to reduce water-heating energy use to date have been focused on water heater efficiency. Efficiency can be expressed a number of ways. “Recovery efficiency” is a measure of how efficiently water is actually heated. A more common expression of efficiency is the Energy Factor (EF), which accounts for both the recovery efficiency and losses from the storage tank or a pilot light. EF values are based on standardized testing developed by the U.S. Department of Energy that assumes 64 gallons (240 l) of hot water draw per day. (More on efficiency and water heater selection later.)

Neither of these efficiency metrics, however, addresses distribution losses. “DOE views water heating as the province of an appliance—the water heater,” notes researcher Dan Cautley, P.E., of Washington, D.C. Distribution losses, due primarily to heat leaking from pipes, can be dramatic. In a paper presented this year at the American Council for an Energy-Efficient Economy (ACEEE) Summer Study, researchers James Lutz, Gary Klein, David Springer, and Bion Howard show that in a typical small house, 9% of the water-heating energy is lost in the distribution system (see figure below). In a large house, multifamily building, or commercial building with a hot-water recirculation system, distribution losses can be far greater.

Dr. Carl Hiller, Ph.D., P.E., of Davis, California, one of the nation’s leading water heating experts (he ran the Electric Power Research Institute [EPRI] water heating program for 15 years until that program was eliminated a year ago), laments how little we really know about hot water distribution. “We really haven’t done enough science,” he told

EBN. In one study Hiller managed for EPRI—at a high school in Tennessee—a continuously recirculating, gas-fired hot-water system was replaced with electric point-of-use water heaters, and water heating energy consumption was reduced by 91% while operating costs were reduced by about 75%! Remarkably, the electric resistance system used only as much electricity as the pumps on the gas-fired hot water recirculation-loop system, while gas use was totally eliminated. In Sacramento, California, Hiller said that nearly all homes are built slab-on-grade with uninsulated hot water distribution pipes laid in the ground beneath the slab. Heat loss from the hot water pipes in these homes is tremendous, he said, and homeowners wait a long time for hot water to reach more distant fixtures. When hot-water recirculation systems are installed (a very common practice), the hot-water distribution system essentially becomes a radiant ground-heating system that loses heat even in the summer!

Turning down the temperature on a storage water heater is often recommended as a way of reducing standby losses, and it can also help with distribution losses in the system. But Charlie Stephens, a policy analyst with the Oregon Office of Energy, argues that this solution is overrated for several reasons. First, lowering the temperature reduces the first-hour rating, or the amount of hot water available for use. Second, many lower-end shower controls (the ones with a single, rotating handle) activate the cold water first, and then add more hot water as you turn the handle until the flow is warm enough. With these controls, having lower-temperature hot water means that you actually use more water to shower. Finally, most dishwashers and some clothes washers require use an electric booster heater to raise the water to the temperature they need, becoming, in effect, an electric demand water heater (more on that below). To reduce standby losses, "Just insulate the tank better," says Stephens.

When the water heater temperature is kept low, Legionnaire's Disease also becomes a concern. (Legionella bacteria require stagnant water at a temperature between 68° and 110°F (20–43°C), a biofilm layer of slime and sediment, and nutrients to grow. While these conditions could exist in water heaters—particularly electric water heaters below the lower element, where the temperature is lower—concerns are generally greater with combination space-and-water heating systems in which potable water can stagnate in a hydronic fan coil or radiant-floor loop.)

The troubling issue of recirculation systems

Wait Times for Delivery of Hot Water in 50' (15 m) of Pipe

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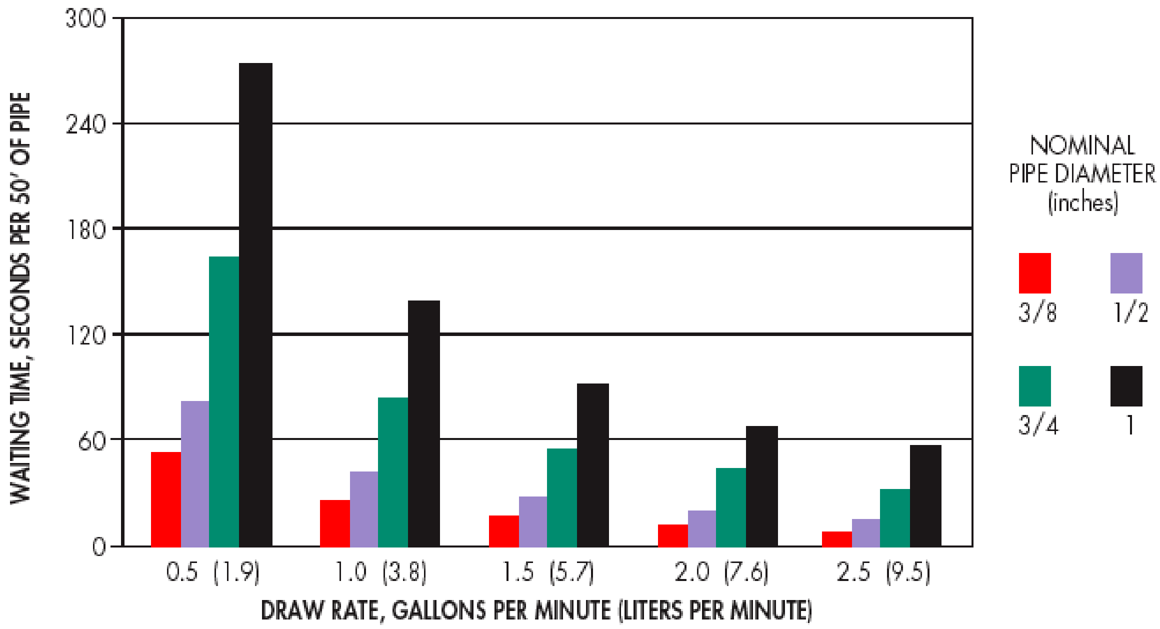

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The larger the pipe diameter, the longer the wait for hot water. Shown here is the wait time in seconds for different pipe diameters and flow rates.

Source: "Residential Hot Water Distribution Systems" by James Lutz et al., ACEEE Summer Study, 2002

In a U.S. home, up to 10,000 gallons (38,000 liters) of water per year are wasted waiting for hot water to reach the tap. The amount of water thus wasted depends on the diameter of the pipes and the distance between the water heater and the tap. As shown in the graph below, there can be a fivefold difference in the wait time between $^3/_8$"-diameter (10 mm) pipe and 1"-diameter (25 mm) pipe. The smaller the pipe, the more quickly hot water reaches the tap and the less the water and energy waste. Larger-diameter pipe also wastes more energy because more hot water remains in the pipe after the tap is turned off, and the heat in that water is lost to the surroundings. The primary advantage of pipe insulation in a building without a recirculation system is that a user won't have to wait for hot water if hot water was used fairly recently.

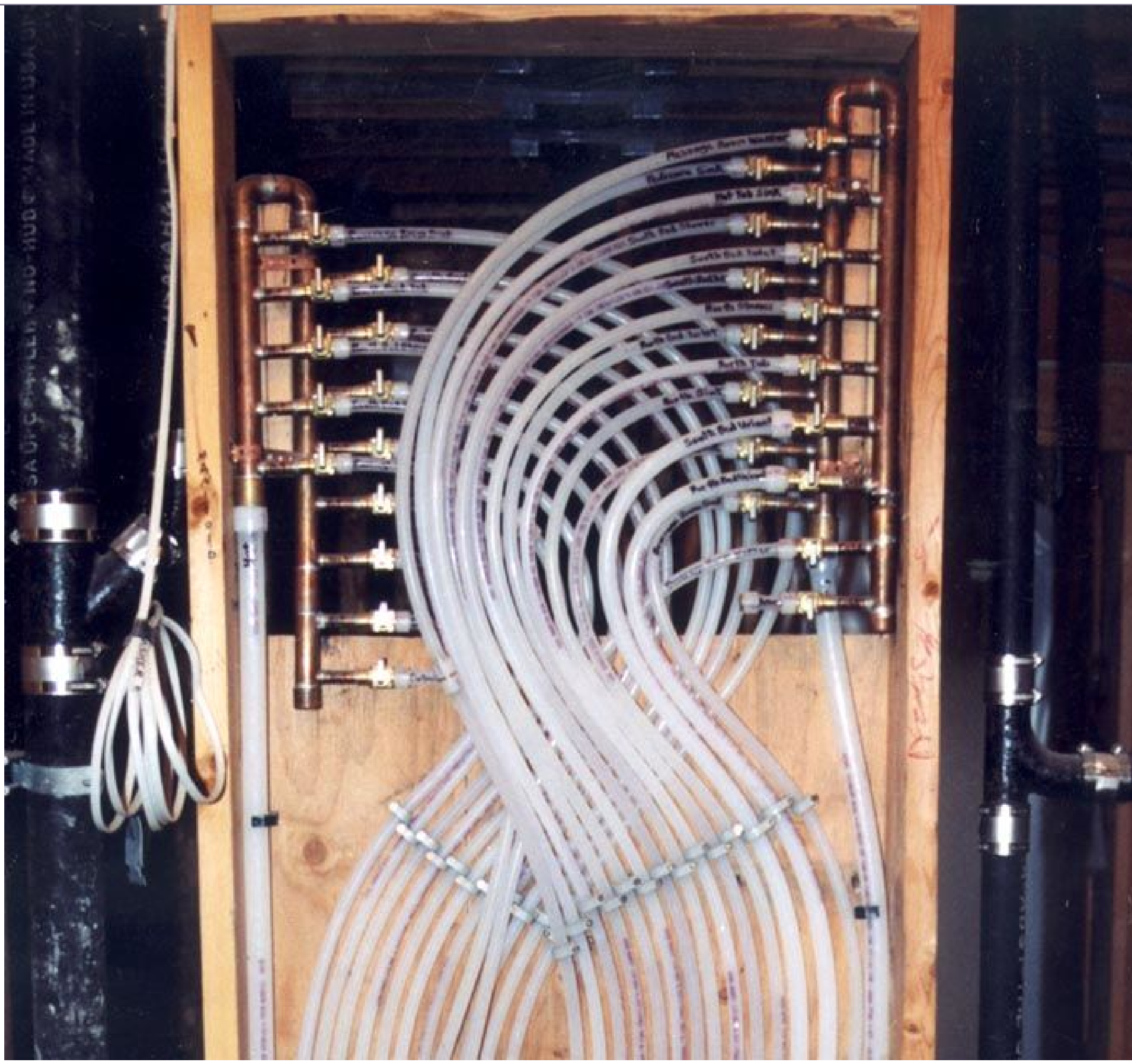
To eliminate the delay in waiting for hot water, recirc systems are installed. Hot-water piping is installed in a loop, and a small pump circulates hot water through these pipes so that hot water will be available almost instantly, even at fixtures furthest from the water heater. If a recirc system is used, pipe insulation is critically important. Otherwise, the hot water piping loop becomes a year-round radiator—wasting water-heating energy year-round and increasing cooling loads in the summer. Even with pipe insulation, recirc systems use a lot of energy, both in wasted heat and to run the pumps.

From an environmental standpoint, continuous hot-water recirc systems should be avoided if possible. If instant hot water is required, at the very least the recirc system should be put on a timer to turn it off at night and other times when hot water use is minimal. The pump manufacturer Grundfos, headquartered in Olathe, Kansas (www.grundfos.com (http://www.grundfos.com)), offers a timer-controlled hot-water recirc system. Far better is a button-controlled system that delivers hot water only when needed by activating a small pump that quickly cycles the cool water standing in the hot water pipes back to the water heater, bringing hot water to the tap. The Metlund® Hot Water D'mand® system, made by Advanced Conservation Technologies, Inc. of Costa Mesa, California (www.metlund.com (http://www.metlund.com)), puts this principle to work. For more, see

EBN

Vol. 4, No. 2 (/articles/IssueTOC.cfm?Volume=4&Issue=2).

Small-diameter and home-run piping systems



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Small-diameter, flexible tubing can be used for hot and cold water supply lines, reducing the amount of water that stays in the pipes between uses.

Source: Uponor Wirsbo

A fairly new plumbing alternative can provide significant water and energy savings with hot-water distribution. Small-diameter, cross-linked polyethylene (PEX) tubing is gaining popularity for water supply plumbing (cold and hot) in homes and small commercial buildings. This approach is sometimes referred to as "home-run" plumbing, because the tubing usually runs back to a central manifold instead of branching in tees, as with copper plumbing systems. Individual PEX lines run to end-use fixtures and appliances; in this way the system is analogous to an electrical wiring system. By eliminating most fittings and elbows, friction losses are significantly reduced, lessening the reduction in flow that results from the smaller-diameter tubing. For the individual runs to fixtures, $^3/_8$" (10 mm) and $^1/_2$" (13 mm) tubing is most common; $^1/_2$" is recommended when more than 2.5 gpm (9.5 lpm) is required. Larger-diameter tubing (up to 1", or 25 mm) is used to supply the manifolds. According to the NAHB Research Center, PEX plumbing systems had a 6.2% market share in new residential construction by 1999, and they expect the market penetration to reach 9% in a forthcoming 2002 survey.

One of the big advantages of PEX plumbing, according to energy expert Bion Howard, is that a builder can do all the PEX tubing rough-ins using in-house labor and hire a licensed plumber only for the connections. "The tubing is more expensive than copper, but the labor is less expensive," he told

EBN. With a long history of use in radiant-floor heating systems (see

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Vol. 11, No. 1 (/articles/IssueTOC.cfm?Volume=11&Issue=1)), PEX tubing has held up very well. "They learned a lot from the polybutylene meltdown," notes Howard, referring to problems with polybutylene household plumbing systems that were briefly popular.

Capturing wastewater heat

Various industries have made tremendous strides in energy efficiency over the past few decades by eliminating "once-through" processes—whether reclaiming wash water, recirculating cooling water, or capturing waste heat from industrial processes. In homes and non-industrial commercial buildings there has been almost no effort to do the same. Domestic hot water is a once-through product. Even if we were 100% efficient at generating and distributing that hot water, over 90% of it would still go down the drain. "Drain water may be one of our largest untapped resources," notes Dan Cautley.

Currently, only one product is widely marketed for capturing waste heat from drainwater in homes and commercial buildings: the GFX (see

EBN 6, No. 8 and

Vol. 8, No. 9 (/articles/IssueTOC.cfm?Volume=8&Issue=9)). The GFX (for

gravity film exchange), produced by Doucette Industries, Inc., is comprised of a section of copper drain pipe surrounded by a tightly wound coil of smaller-diameter copper tubing through which cold water flows en route to the water heater. When installed as a section of the drainage line beneath showers or other hot-water uses, the wastewater forms a film along the inside of the GFX drain pipe, and heat is transmitted through the wall of that pipe and into the smaller-diameter pipe to preheat the water going into the water heater. It captures useful heat when the draining of hot water is simultaneous with usage (as in showering), but not with batch draining (as with a bathtub). The product is elegantly simple, fairly inexpensive, and does not clog as did some earlier efforts to capture heat from wastewater.

Stephens projects that a GFX system capturing waste heat from showers can reduce water heating energy use by 12–15%. When installed during new construction, he reports, the price has been running between $500 and $800, significantly less in multifamily buildings. "I expect the price to drop when the application becomes more widespread and plumbers are competing to install them," he predicts. His office provides tax credits covering one-quarter of the component costs for the installation. Oregon currently has 200 units going into a multifamily project.

Water Heating Fuel & System Options

Selection of a water heater involves decisions about the type of fuel used, how and where the water is heated (especially the issue of storage vs. demand water heaters), and whether water heating can be combined with space heating. These issues are addressed below.

Electric-resistance water heaters

Electric water heaters rely almost exclusively on electric-resistance heating elements. The conversion of electric current into useable heat is extremely efficient—close to 100%—but the true efficiency drops by about two-thirds when one considers power generation and transmission by the utility company (the *primary energy* use). As noted previously, water heater efficiencies are generally listed as the Energy Factor (EF). Minimum EF ratings for electric, gas, and oil water heaters are established by the Energy Policy Act of 1992 (which amended the National Appliance Energy Conservation Act of 1987). Current minimum EF ratings for water heaters, as well as new standards to take effect in 2004, are listed in the table below.

Electric-resistance water heaters become more economically attractive with *off-peak* electric rates or special programs from the utility company that allow a water heater to be turned off remotely when the company is operating at or near peak capacity. These measures also help to level electric demand profiles, thus allowing a utility company to operate fewer power plants. Because no venting is required for electric water heaters, they can be insulated extremely well, reducing standby heat loss to well below that of the best gas- or oil-fired water heaters.

Electric heat-pump water heaters

The oft-touted alternative to the direct use of electric current for space heating is the use of a heat pump; these can also be used for water heating. A heat pump uses electrical energy not to generate heat but to mov heat from one place to another (using the same principle as a refrigerator). A heat-pump water heater extracts heat from a cooler space (typically air in the space where the water heater is located) and delivers that heat into the water tank—even though the water tank is at a higher temperature than the surrounding air. It does this by alternately condensing and evaporating a special refrigerant fluid. The electricity powers pumps and fans. Heat-pump water heaters have the potential to more than double the "efficiency" of electric water heating—to well over 200%. Because heat-pump water heaters cool the surrounding air as they extract heat from it, they essentially provide free air conditioning during the summer, but they increase heating costs during the heating season.

Unfortunately, heat-pump water heaters are expensive, and there have been reliability problems with a number of products brought onto the market in the past 20 years. Many early heat-pump water heaters required significant throughput of air (the heat pump's heat source)—as much as 600 cubic feet per minute (cfm) (283 l/s). They were also noisy. The future of heat-pump water heaters may be looking up, though. Several heat-pump water heaters are now on the market, including the new WatterSaver, which is designed as a direct replacement for a conventional electric water heater (see related product review (/auth/article.cfm?fileName=111006e.xml)).

Gas- and oil-fired water heaters

Minimum Energy Factors for Water Heaters

Minimum Energy Factors for Water Heaters

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Type of Water Heater	Formula for Calculating EF Current Standard (1991)	Resulting EF by Rated Volume (gallons) 30	40	50	60	80
Electric	.93 – (.00132 x rated volume)	.89	.88	.86	.85	.82
Gas-fired	.62 – (.0019 x rated volume)	.56	.54	.53	.51	.47
Oil-fired	.59 – (.0019 x rated volume)	.53	.51	.50	.48	.44
	Standard Effective 1/20/2004					
Electric	.97 – (.00132 x rated volume)	.93	.92	.90	.89	.86
Gas-fired	.67 – (.0019 x rated volume)	.61	.59	.58	.56	.52
Oil-fired	.59 – (.0019 x rated volume)	.53	.51	.50	.48	.44

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Source: Oregon Office of Energy

Source: Oregon Office of Energy

Natural gas and propane water heaters are virtually identical, though vary in the burner orifices, gas valves, and pilot lights. Both offer the potential for very high burner efficiencies; Energy Factors are dependent also on standby losses, which are higher than with electric water heaters because of the uninsulated flue extending up the center of the tank. Most gas-fired water heaters also have pilot lights, which reduce the EF somewhat. While the EF ratings are lower (see table below), gas water heaters usually cost less to operate than electric storage water heaters on a delivered-Btu-per-dollar basis.

Higher efficiencies are achieved with gas- and oil-fired water heaters that rely on

condensing technology. Condensing water heaters, including Polaris, Lennox, and Heat Transfer products, have very efficient heat exchangers that extract almost all of the energy out of the flue gases. So much heat is extracted that the flue gases cool to the point where water vapor (one of the two primary combustion gases) condenses into liquid, which captures the

latent heat contained in the water vapor. Gas-fired condensing water heaters have EFs as high as .84 to .86. Condensing combustion appliances should not be vented into standard chimneys, however, because the acidic condensate can corrode masonry; they are typically vented through a side wall, with drains installed for the condensate.

Oil-fired stand-alone water heaters are far less common than gas-fired models and tend to be more expensive. They include power burners that mix oil and air into a fine mist, which is ignited by a spark. Minimum EF ratings are shown in the table below.

Solar water heaters

Solar provides the greenest water heating option. A well-designed and properly sized solar water heating system should provide most or all hot water requirements of a typical family during the summer and a reasonable fraction during the winter. There are several generic types of solar water heaters, including pumped flat-plate collector systems, thermosiphoning flat-plate collector systems, and integral-collector-storage or "batch" systems.

In a pumped flat-plate collector solar water heater, either water or a nontoxic antifreeze solution is pumped through a collector, usually in copper tubing on a black absorber surface in an insulated box glazed with low-iron (high-solar-transmission) glass. This solar-heated fluid in turn heats potable water in a storage tank via another pump and heat exchanger.

A thermosiphoning flat-plate collector system usually has potable water in the collector, which is positioned below the storage tank. As the water in the collector heats up, it rises naturally and flows into the top of the storage tank, being replaced by cooler water drawn from the bottom of the tank. Because potable water circulates through the collector, this type of system is most appropriate for warm climates or in freeze-protected locations, such as sunspaces.

An integral-collector-storage (ICS) solar water heater combines the solar collector and storage components. In some ICS systems, a black tank is situated in an insulated box that is glazed on the top and front—often with reflectors shining additional sunlight onto the tank. More commonly, an ICS system is more like a flat-plate collector, but with much larger-diameter copper pipes.

No matter which type of solar water heater is used, it usually serves as a preheater for a conventional storage-type water heater. An electric water heater with only an upper element, instead of both upper and lower elements, works well as solar backup.

Solar water heating systems cost as little as $1,000 installed when a fairly simple design is used, a number of identical systems are purchased at the same time, and they are installed in new homes. More complex systems installed in existing houses or commercial buildings can cost over $5,000. Most solar water heating systems cost $2,000 to $3,000 installed. Even at $3,000, solar water heating can be financially attractive when life-cycle costs are considered, since their operating costs are low. (See

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Vol. 8, No. 7/8 (/articles/IssueTOC.cfm?Volume=8&Issue=7/8) for more on solar water heating.)

Storage vs. demand water heaters

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The Takagi Flash TK2 demand water heater delivers 240 gallons per hour (900 l/h), handles flows ranging from 0.6 to 6.9 gpm (2.3–26 l/min), and is about the size of a suitcase.

Source: Low Energy Systems, Inc

Storage water heaters account for the vast majority of water heaters in use and installed annually in North America. These consist of an insulated tank with either an integral burner for heating the water with gas or oil, or one or two electric-resistance elements. The advantage of storage water heaters is that because hot water is stored, it can be heated with a relatively small burner or heating element, while still providing ample hot water. Even when much of the water is used up, the tank remains stratified, with remaining hot water staying at the top where it is drawn off. Recovery time depends on the size of the burner or electric elements. (Hot water recovery is an important property of a storage water heater; it is generally presented as the "first hour rating" in gallons or gallons per hour.)

The disadvantage of storage-type water heaters is the

standby loss from the large difference in temperature between the inside and outside of the tank—often 60˚F (33˚C) or more. Inexpensive storage water heaters may have just an inch of polyurethane insulation, providing as little as R-7 (RSI-1.2). A typical (tall) 40-gallon (150 l) water heater rated at R-7 and maintained at 130˚F (54˚C) in a room averaging 60˚F (16˚C) will lose about 170 Btu (0.18 MJ) per hour in standby losses just from its outer surface. In other words, even if no hot water were drawn off the tank, that water heater would use about 1.5 million Btu (1,600 MJ) per year. Even an R-16 (RSI-2.8) water heater in those conditions would lose 0.75 million Btu (790 MJ) per year. With gas or oil storage water heaters that have pilot lights, the pilot itself throws out a lot of heat (typically about 300 Btu/hour [0.3 MJ/hr]), which can make up some of the standby heat loss from the tank. While it is generally believed that the pilot light energy in a gas-fired water heater is captured, most of the pilot light heat actually escapes up the center flue, according to Stephens. Depending on water heater location in a building and on the climate, standby losses may either increase a building's cooling load or reduce its heating load.

The alternative to a storage water heater is heating the water as it is used. That's the principle of a

demand or

instantaneous (tankless) water heater. These heaters can be located at the point of end-use (in a bathroom or kitchen), or centrally located with hot water distributed through conventional hot-water pipes. Demand water heaters can be gas or electric. Because hot water is not stored, the heating capacity must be great enough to meet the hot water demand. That can take a lot of power, and it can limit hot water use.

A relatively small 115,000 to 125,000 Btu/hour (120–130 MJ/hr) residential, gas-fired, demand water heater, such as most models made by Bosch/AquaStar, can only provide about 2.5 gpm (9.5 lpm) at a typical temperature rise. That's enough for a small house with water-efficient fixtures and appliances if the homeowners are willing to be avoid operating multiple hot-water-consuming devices at the same time (showers, dishwasher, clothes washer), and if they don't plan on taking baths. A larger demand water heater, such as those from Rinnai and Takagi, can produce as much as 185,000 Btus/hour (195 MJ/hr), which is sufficient for most household needs, including use of multiple devices at the same time or filling a bathtub.

Even the smaller of these gas-fired demand water heaters require significant airflow to support combustion. A 125,000 Btu/hour (130 MJ/hr) Bosch/AquaStar demand water heater operated at full capacity consumes about 2 cubic feet per minute (cfm) (0.94 l/s) of natural gas, which requires approximately 30 cfm (14 l/s) of air for complete combustion. And a large 180,000 Btu/hour (190 MJ/hr) Rinnai or Takagi demand water heater requires up to 45 cfm (21 l/s) of air at full capacity. Such large airflow requirements can limit the options for placement. To get around the venting issues, Rinnai offers a freeze-protected model designed for outdoor installation (see

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Vol. 9, No. 2 (/articles/IssueTOC.cfm?Volume=9&Issue=2)).

Traditionally, gas-fired demand water heaters all had pilot lights. While the heat from a pilot light in a

storage water heater may help to replace standby heat loss from the tank, that can't occur in a demand water heater; the pilot light energy is simply lost. Stephens says that a continuously burning pilot light in a demand water heater drops its Energy Factor by 10–12 points. Fortunately, a number of manufacturers now offer demand water heaters with electronic ignition. These products have EFs between .78 and .85. Currently, no condensing models are available in the U.S., though Targa at one time offered such a product (see

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Vol. 7, No. 4 (/articles/IssueTOC.cfm?Volume=7&Issue=4)) with an EF as high as .94.

With gas-fired demand water heaters, one should consider both the maximum firing rate (how much hot water can be delivered at a particular temperature rise) and the minimum firing rate. Many demand water heaters have relatively high minimum flow or minimum firing rates, which can mean that if you don't run enough hot water flow, the water heater may not even kick on. The Bosch/AquaStar models, for example, have a minimum flow rate of 0.5 gpm (1.9 lpm) and a minimum firing rate of 25,000 or 35,000 Btu/hour (26–37 MJ/hr). The Rinnai Continuum has a minimum flow rate of 0.6 gpm (2.3 lpm) and a minimum firing rate of 19,000 Btu/hour (20 MJ/hr).

Another important consideration with demand water heaters is whether the output temperature is thermostatically controlled. Some models, such as most from Bosch AquaStar, are designed to raise the water temperature by a set amount. These "delta-T" models generally work fine with municipal or spring water, though some seasonal adjustment in the temperature rise may be required. This type of demand water heater, however, is

not appropriate as backup heat for a solar water heating system, in which the solar-preheated water temperature may vary considerably. More sophisticated demand water heaters from Takagi and Rinnai can provide hot water at a set output temperature no matter what the input water temperature—but they also cost more. These systems are much better suited for solar water heating systems.

With electric demand water heaters, the current required to provide even 2 gpm (8 lpm) is significant. A 28 kW model from Microtherm, Inc. in Houston, Texas, for example, provides a maximum temperature rise of only 63˚F (35˚C) at a 3.0 gpm (11 lpm) flow rate—and draws a maximum of 116 amps at 240 volts! (Most homes have 200-amp service, some only 100.) Providing that much power requires very large (and expensive) breakers and large-diameter wire (costing several dollars per foot), and the electric-demand water heaters themselves are fairly expensive. Electromagnetic fields (EMF) generated from such current flow could be substantial (see

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Vol. 3, No. 2 (/articles/IssueTOC.cfm?Volume=3&Issue=2)).

FEEDBACK

Using an electric demand water heater instead of an electric storage water heater will save about 250 to 450 kWh per year in standby losses, or about 10% of a typical family's water heating use, according to Stephens. Depending on local electricity rates, it can take a long time to recoup the higher cost of a demand system. More significantly, electric-demand water heaters have a very negative impact on utility power systems. "Domestic water heating loads occur predominantly in what we call 'shoulder peak' periods," says Stephens. These periods occur in the morning before people leave their homes, and late afternoon, as everyone is arriving home. While electric-storage water heaters spread out the utility impact of these peak usage periods, electric-demand water heaters do not. "For the power grid, this isn't good," says Stephens.

The bottom line is that electric-demand water heaters do not make sense in most applications. However, in applications where small electric demand water heaters can be installed in place of a continuous recirculation system, this may be an attractive option.

Checklist: Strategies for Improving Water Heating Performance or Efficiency

(/feature/water-heating-look-options/checklist/1)

Indirect water heaters

Indirect water heaters generally operate as one zone off a boiler that is used for space heating. They consist of an insulated tank and a heat exchanger to transfer heat from the boiler into the stored water. Because combustion does not occur at the storage tank, the tank can be better insulated than a conventional gas- or oil-fired storage water heater.

An indirect water heater is highly preferable to a

tankless coil (a common feature in gas- and oil-fired boilers) because heat from the boiler is not called for every time hot water is drawn. (A tankless coil essentially uses a boiler as a demand water heater, so the boiler has to fire up every time hot water is needed; they can make sense during the winter in cold climates, when the boiler is hot much of the time, but they are not recommended for year-round use.)

Coupled with a high-efficiency boiler, indirect water heating is often one of the most cost-effective water heating options. There are some inherent efficiency losses (from the heat exchanger), and electricity is required for pumping boiler water through the indirect tank, but this can still be a very efficient system. It can also be adapted to solar water heating, with solar panels providing preheating.

Combination heating and water heating products

A step beyond indirect water heaters are integrated space- and water-heating appliances. Several approaches can be taken with these "combo" systems. There are integrated boilers, such as the Lennox CompleteHeat™ or American Water Heater Polaris Comfort™ systems. These are high-efficiency boilers with integral storage tanks for hot water—quite different from the tankless coil systems that can be added to standard boilers.

A less expensive approach is to use a water heater both for water heating and for space heating through a

fan-coil—a hydronic coil installed in the air handler that distributes conditioned air throughout the house or small commercial building. While this approach is compelling in principle, it involves some tricky details that make it very difficult in production homes, according to Peter Yost of Building Science Corporation. These problems are described in the report "Combo Space/Water Heating Systems—Duo Diligence," available online at

www.buildingscience.com (http://www.buildingscience.com).

Final Thoughts

When it comes to conserving energy, water heating is lot like space heating or cooling—it makes sense to focus first on reducing demand. With water heating, we can do this by installing water-conserving plumbing fixtures and appliances. Next, we should look at how hot water is distributed and try to improve efficiency there, or try to recover heat from water as it goes down the drain. Finally, we should examine how we heat the water.

The greenest option for water heating is a solar-thermal system. Beyond that, the options become quite complex and often dependent on other factors, such as climate and what type of heating system is used. If you are in a cold climate and have a hydronic heating system with a high-efficiency boiler, an indirect water heater may be the best bet. If off-peak electric rates are available, a simple, inexpensive electric-resistance water heater can be a very attractive option, especially since the tank can be very well insulated.

Otherwise, a high-efficiency demand water heater with electronic ignition, an integrated space-and-water-heating system with a condensing boiler, a heat-pump water heater, or a gas water heater with electronic ignition and sealed-combustion could be good options. All of these options are more expensive than a basic storage water heater, so the life-cycle costs should be calculated. With whatever type of water heater is selected, make sure it is installed properly with heat traps or pipe insulation to minimize thermosiphoning, and add extra insulation to the tank.

– *Alex Wilson*

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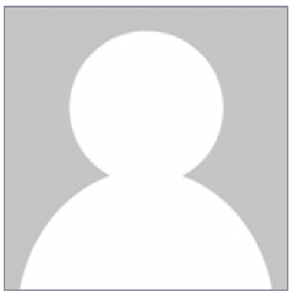

BuildingGreen Basic Member

January 2, 2006 - 10:16 am

This article as well as others I've seen elsewhere reference condensing water heaters. Where are the links to sources? rjrandall47@yahoo.com (mailto:rjrandall47@yahoo.com)

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