BENEFITS OF DEMAND-CONTROLLED PUMPINGWhe device as in the photo, an e the water heater until hot v

Much water and energy is wasted in residential buildings, due to poorly designed, poorly installed—and therefore poorly functioning—hot water delivery systems. Homes built in the United States today are typically larger than ever before and include a number of hot water fixtures not seen a generation ago, such as second and third bathrooms and spa-style showers. And water heaters are typically far away from many of the hot water fixtures. All this adds up to long waits for hot water at fixtures and water and energy down the drain to no purpose (see “Hot Water Runs Cold,” *HE* Mar/Apr ’05, p. 28).

One solution to water and energy waste is to deliver hot water quickly to where it is needed. By bringing water quickly to fixtures that are far from the water heater, a demand-controlled pumping system minimizes the waste of water and energy running down the drain while someone waits for the hot water to arrive. When signaled to do so by a hot water user using a push-button control, an electronically demand-controlled pumping system sends cold water back to the water heater until hot water arrives at the sink, shower, or other fixture where it is needed.

Demand-controlled pumping devices include sensors and electronics that automatically adjust to standing ambient temperatures in the hot and cold water lines. When the pump is operating, it measures a change of temperature; it turns the pumping system off when the desired temperature change is met. This keeps warm water from the cold water side of the pump. The pumps adjust to ambient temperatures automatically, anywhere in North America.

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Demand-controlled pumping systems can be installed on trunk and branch systems both in new construction and in retrofits and on structured plumbing systems installed in new construction or during a major rehab.

In retrofit and in typical new-construction applications, the primary benefit of demand-controlled pumping comes in the delivery phase: It reduces the waste of water and energy while users wait for hot water to arrive. The energy savings due to the reduction in water waste are attributable to three factors:

• The water in the circulation loop that is returned to the water heater is generally warmer than the water coming into the house. Less energy is needed to keep the water in the tank hot.

• Hot water that is sent at a high flow rate to fixtures loses significantly less heat through the walls of pipes than slow-moving hot water.

• Since the on-demand pump moves water at a higher flow rate than is typical, the hot water gets to the fixture faster, and less hot water is needed to prime the loop.

Savings Potential

In order to quantify the effects of demand-controlled pumping, a number of researchers have studied the characteristics, and estimated the hot water efficiency, of demand-controlled pumping systems in both trunk and branch and

thest fixtures in a house. According to a study sponsored by the California Energy Commission (CEC), for a given flow rate, R-4 insulation will reduce the temperature drop by half (see Figure 1).

the heat loss in the loop. The waste of water and the time it takes to get hot water will probably remain the same after the retrofit, since nothing is likely to be done to change the volume of water in the branch lines serving each fixture. Tables 3 and 4 provide a means for estimating the savings. In these tables, the steady-state heat transfer efficiency is assumed to be 75% for natural gas and 100% for electricity. For most single-family circulation systems it is reasonable to assume that the temperature drop is 5ºF and that the pump flow rate is 1 gpm.

The standard circulation pump that is being used in over 90% of the homes with this type of hot water distribution is a 3 gpm with 6 feet of head. The average speed of the water is 1 gpm. Anything much faster will damage the walls of the pipe very quickly. The pumps are chosen to have low flow rates, in large part so that face velocity in the smallest-diameter and most turbulent sections of pipe stays below about 8 feet per second.

Using Figure 1 (p. 20), it is possible to estimate the flow rate based on the temperature drop, and vice versa. Assuming that the loop is roughly 200 feet long (not a bad length, given the size of the houses with recirculation systems), the temperature drop at a given flow rate will be roughly twice as much as that shown in the graph, which was calculated for 100 ft. At 1 gpm, this will mean a temperature drop of more than 5ºF. If the flow rate is lower, the temperature drop is higher. If the flow rate is faster, the temperature drop is lower. Since the water heater sees flow rate times temperature drop, it balances out. This means that annual energy associated with a circulation system running 24 hours a day is 292 therms, or 6,388 kWh. If the flow rate is faster, say 2 gpm, or the temperature drop is larger, say 10ºF, or if both are true, select the appropriate energy use from the Tables 3 and 4. If the system has a timer set for fewer hours, proportion these amounts accordingly.

Savings due to the retrofit of a demand controlled pumping system are roughly proportional to the reduction in hours of operation. The demand-controlled pump will move the water faster at closer to 5 gpm, but due to the higher flow rate, the temperature drop will be closer to 1ºF.

Table 3. Energy Use for a Circulation System and Gas Water Heater (Therms)

Continuous Pumping at 1 gpm				
	Temperature Drop			
Days	1°F	5°F	10°F	20°F
1	0.16	0.8	1.6	3.2
30	5	24	48	96
365	58	292	584	1,168
Pump Flow Rate (gpm)				
1	58	292	584	1,168
5	292	1,460	2,920	5,840
10	584	2,920	5,840	1,680

Assuming that the pump operates a relatively long time of 30 minutes as needed over the day, the savings will be 98%, or 286 therms, or 6,260 kWh per year.

The demand pumping system trades off cool down with the need to continuously reheat the water in the loop. However, if the recirculation system is insulated (as it should be), the pump will need to prime the line only a few times a day. Once the line is hot, the insulation will keep it hot for 30–60 minutes. This is long enough to cover many of the grouped uses in a typical daily hot water use pattern. Each use of hot water during this period brings hot water to the relevant fixture, keeping the water in the line to that point hot for the next hot water event. At some point the pipes will cool down below a useful hot water temperature and the next user will need to prime the line again. So while some energy is lost when the pipe cools down, it is much less than the energy needed to keep the line hot all day. Note that most demand pumping systems run much less than 30 minutes a day, so the savings are likely to be larger.

Significant Savings

Based on this analysis, the savings on trunk and branch hot water distribution systems due to a conservative 15% reduction in water consumption result in energy factor enhancement coefficients ranging from 1.12 to 1.17 for the range of water heaters that we evaluated.

The savings in structured plumbing hot water distribution systems due to a conservative 20% reduction in water consumption—the latter due to the demand-controlled pump and the smaller volume branch lines—plus an additional savings equivalent to another 10% reduction in water use due to insulation, result in energy factor enhancement coefficients ranging from 1.27 to 1.42 for the range of water heaters that were evaluated.

The on-demand pump primes the line just before hot water is desired. The small-volume branch lines minimize water waste. The insulation keeps the circulation loop hot for the next use, so that the next user sees hot water very quickly as it comes through the branch line.

The savings for retrofitting existing recirculation systems are energy, not water, related, as they are in the first two applications. Retrofitting a demand-controlled pump will reduce the energy needed to operate the pump and keep the circulation loop hot by up to 98% (a savings of 286 therms or 6,260 kWh per year). This reduction is roughly proportional to the reductions in the pump run time of the existing system.

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Glenn Chinery of EPA developed the algorithm used in this study to convert percentage hot water savings into enhanced energy factors for water heaters.

FOR MORE INFORMATION:

The following companies offer demand-controlled pumping products:

ACT Incorporated, Metlund Systems (www.gothotwater.com)

TACO (TACO-hvac.com)

Uponor Wirsbo (www.wirsbo.com/index.php?id=122&pid=24)

All of these products comply with the applicable plumbing and electrical codes.

Mayer, P.W., W.B. DeOreo, et. al. *Residential End Uses of Water Study (REUWS)*. Denver: American Water Works Association Research Foundation, 1999.

Progress Report on Building America Residential Water Heating Research. Davis Energy Group, Nov 14, 2003. Used with permission of David Springer.

M. R. Ally, J. J. Tomlinson, and B. T. Ward. *Water and Energy Savings using Demand Hot Water Recirculating Systems in Residential Homes: A Case Study of Five Homes in Palo Alto, California*. Oak Ridge National Laboratory, Oak Ridge, Tennessee ORNL/TM-2002/245, October 21, 2002.

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