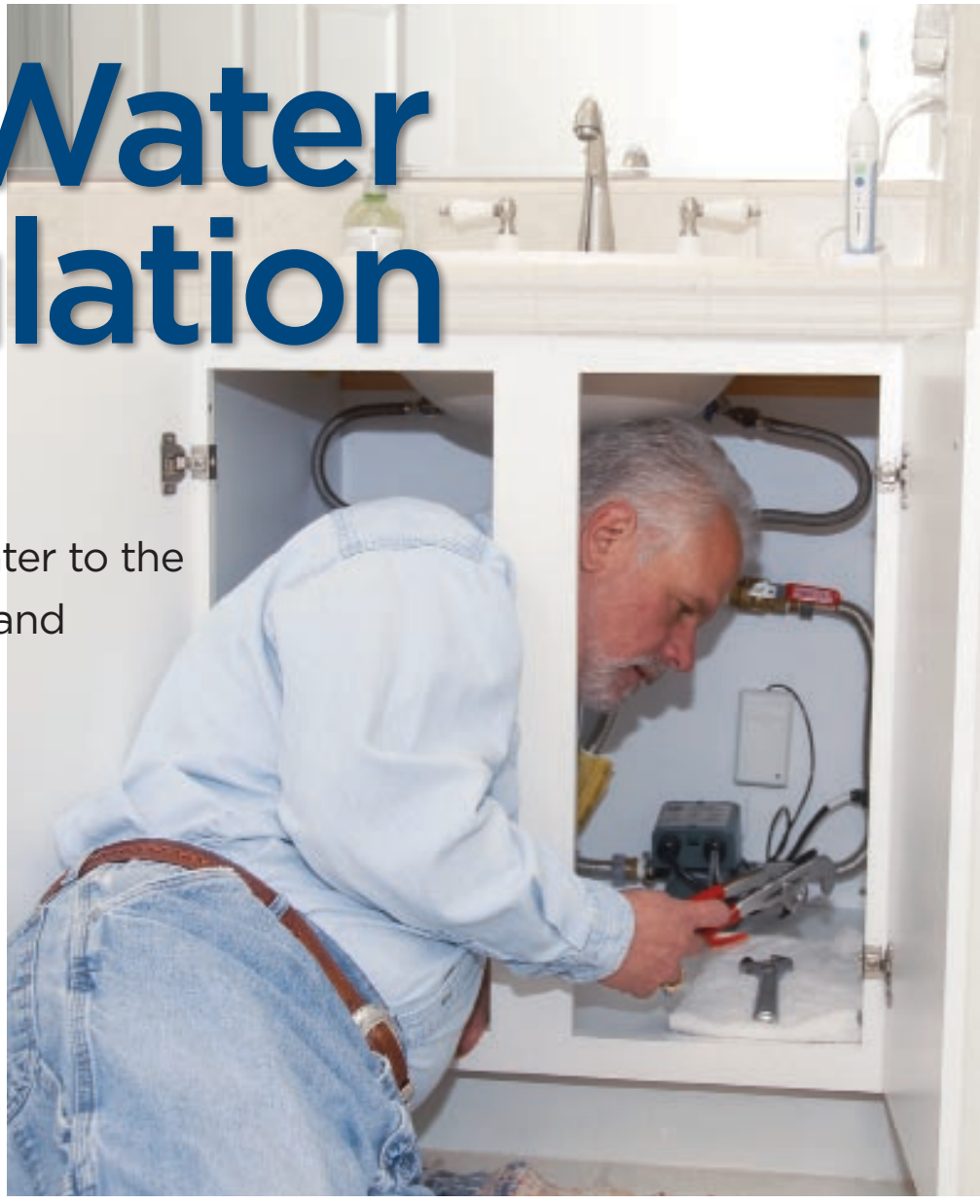
Hot-Water Circulation



By delivering hot water to the tap quickly, on-demand systems save water, energy, and time

by Leigh Marymor

When you turn on a hot-water tap, it can take a long time before hot water actually arrives at the faucet. That's not surprising, considering all the cold water that has to flow out first. For example, a typical bungalow in the San Francisco Bay area — where we work — might have a 60-foot-long ¾-inch-diameter hot-water supply pipe with an additional 10-foot-long ½-inch branch connection to the sink. That much pipe can contain more than 1¾ gallons of cold water. Assuming a flow rate of 2.2 gpm, it would take at least 47 seconds before hot water flowed out of the faucet. If the homeowners have a green conscience and have installed a 1.5-gpm reduced-flow aerator on the faucet to save water, they'll have to wait even longer — 70 seconds — for the hot water to arrive. They're wasting both water and time.

According to Gary Klein, an expert on water distribution systems, a typical family of four wastes about 10,000 gallons of water per year waiting for hot water. "Average hot-water usage is about 20 gallons per person per day, with a very large variation," Klein says. "About a third of that, or 7 gallons, is water that runs down the drain while waiting for the hot water to arrive at the tap." With water and sewer costs averaging about $0.006 per gallon nationwide, 10,000 wasted gallons adds up to about $60 worth of water annually.

Figure 1. Whole-house hot-water circulation systems use a pump to move cooled water in the hot-water supply line back to the water heater. Closed-loop systems have dedicated return lines (right), but there are also some open-loop systems (above) with special manifolds that allow the cold-water supply to be used as the return line. The pumps shown here are equipped with timers that limit operation to specified periods of demand.

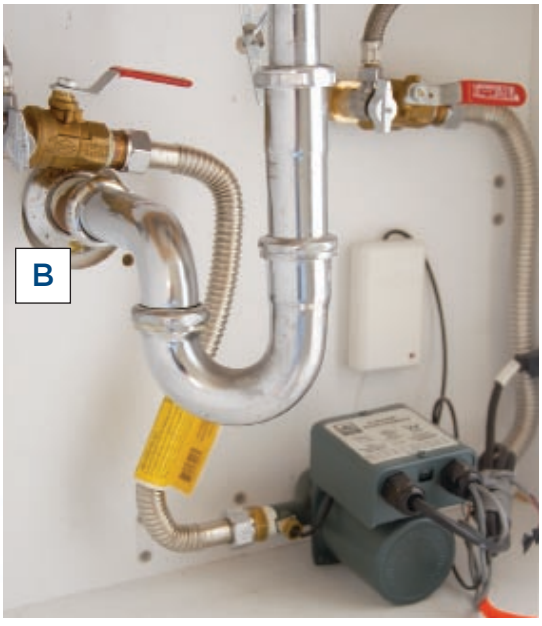
Whole-House Circulation

To help solve this problem, my partner, Jim Lunt, and I have installed hundreds of hot-water circulation systems over the past 30 years. When we began, we took the traditional approach: We'd run a dedicated hot-water return leg from the farthest fixture on a home's plumbing system back to its hot-water heater. These hot-water loops — which are sometimes designed to operate by gravity but more often use a circulating pump — bring heated water directly from the heater to the end of the branch close to each fixture, then return "cooled" hot water back to the heater, where it is reheated. By recirculating water through the loop, the pipes act as an extension of the water heater's reservoir. Because there is not much cold water to purge from the system, it doesn't take long for hot water to arrive at the faucet.

The downside of these systems is that the water heater has to fire frequently to maintain that extended reservoir of hot water. To save energy, we've used timer-controlled circulating pumps that limit hot-water recirculation to certain hours of the day (**see Figure 1**), or we've added aquastats that sense the temperature in the hot-water supply lines so that the pumps won't operate when there's already hot water in the pipes. In some cases we've combined timer and aquastat controls. These measures help reduce fuel costs, but the homeowner still pays an energy penalty for the convenience of hot-water recirculation.

On-Demand Circulation

These days we primarily install on-demand hot-water systems. We like them because they deliver the hot water rapidly to all the taps on the branch, cutting



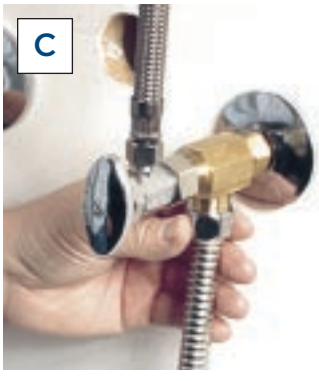


Figure 2. On-demand hot-water kits are small enough to fit in a bathroom vanity cabinet (A,B). The kit shown in (A) includes a wireless switch for mounting on the counter and a remote receiver for installation in the cabinet. When retrofitted to existing plumbing, the pump is located at the fixture farthest from the hot-water heater. A pair of tees installed behind the angle stops (C) create an open loop between the hot- and cold-water lines. When the pump is activated, the slug of cool water in the hot line is pushed back to the water heater via the cold-water line. The pump runs only a few seconds, until a sensor detects a rise in the temperature in the hot line.

way down on the amount of cold water wasted down the drain. They offer the same convenience as a whole-house system but without the energy penalty. We install both Metlund (800/638-5863, gothotwater.com) and Taco D'Mand (401/942-8000, taco-hvac.com) systems. Taco makes the circulating pump for both.

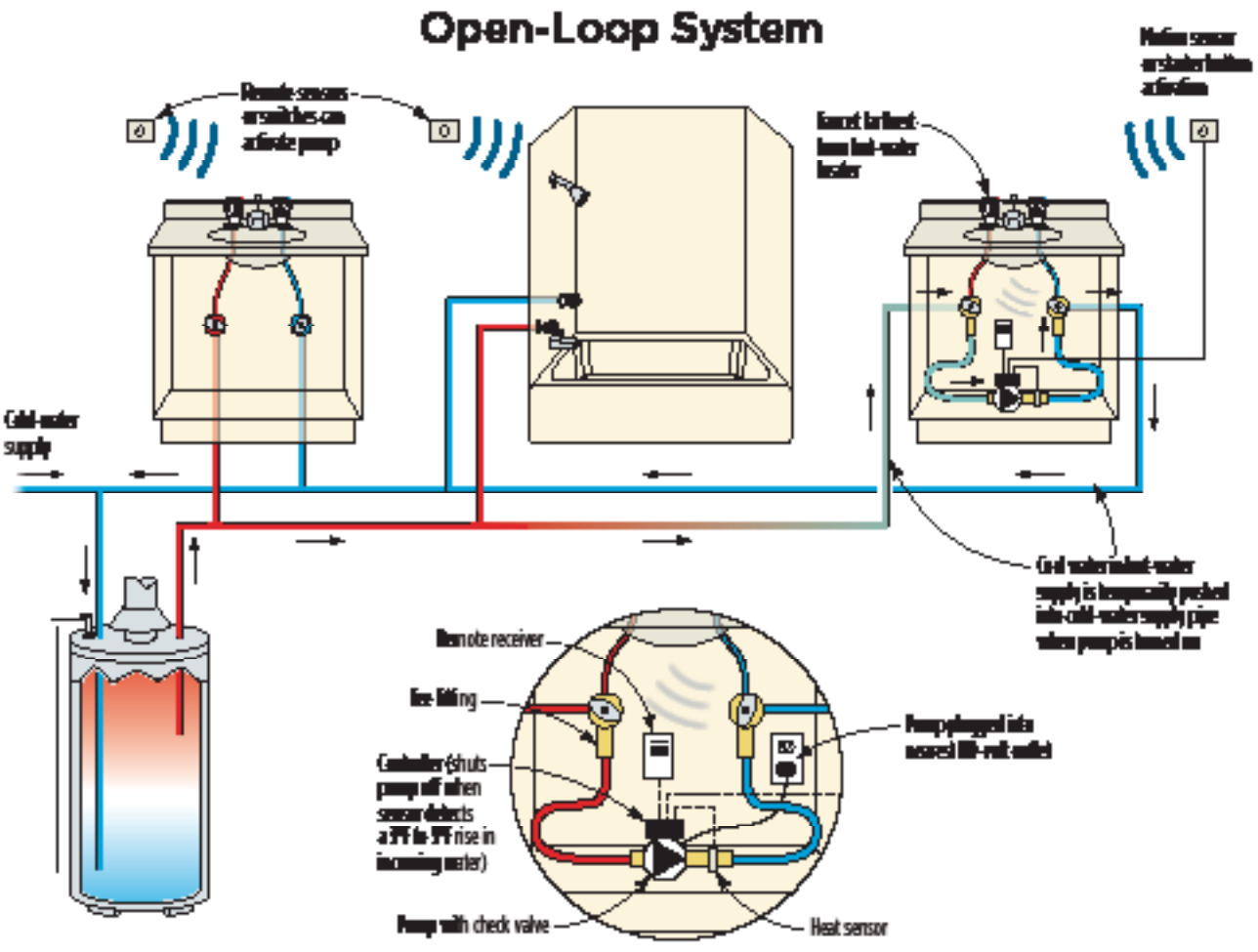
On-demand systems feature a high-head pump capable of quickly moving the slug of cold water standing in the hot-water supply pipe toward the farthest faucet on the branch, along with the fully heated water from the water heater behind it. This is in contrast to most whole-house circulation pumps, which are low-head and therefore move the water at much slower flow rates.

How on-demand pumps work. When the on-demand pump comes on, any cool water in the hot supply pipe is pushed into either a dedicated recirculation line toward the water heater (closed-loop configuration) or back into the cold-water supply pipe (open-loop configuration). As soon as the temperature sensor installed in the hot supply detects a 3°F to 5°F rise in the incoming water, the system's electronic controller shuts the pump off.

Open- vs. Closed-Loop Systems

On-demand pumps are small enough to fit in a bathroom vanity cabinet or below the kitchen sink (**Figure 2**). We usually place the pump under the faucet that's farthest from the hot-water heater, especially in a retrofit project. In a simple open-loop — or non-recirculating — installation, the pump module connects to the hot- and cold-water supplies with tee fittings located just before the angle stops. The pump can simply be plugged into the nearest 110-volt outlet. If the electrical circuit is already in place, it usually takes less than two hours to retrofit a house with on-demand hot water.

Hot water return. However, with new construction or during a large renovation, when extensive plumbing work is being done, we prefer to install a dedicated hot-water return leg from the farthest fixture on the branch line back to the water heater, creating a closed loop (**Figure 3, facing page**). This extra plumbing adds cost and isn't absolutely necessary, but it allows us to place the on-demand pump at the water heater rather than in a bathroom, which eliminates a potentially



bothersome source of vibration and noise.

The dedicated leg also eliminates the possibility that small slugs of warmed water will be pushed into the cold-water supply line, which, in our experience, can happen with certain open-loop systems. For example, we've found that the temperature-sensitive cartridges in the Grundfos Comfort system, an open-loop whole-house circulation system, often fail, allowing hot water to come out of the cold-water tap. With a hot-water return pipe, this can never happen.

Controls

On-demand pumps are activated by the user — either manually or via motion sensors. As a result, hot water is delivered only when it is actually needed. Eliminating the timer significantly reduces the actual runtime of the pump compared with a whole-house circulation system. It also minimizes standby heat loss from the hot-water pipes and keeps the water heater from firing unnecessarily.

Manual switches. The typical manual system uses

Figure 3. When possible, the author prefers to install the on-demand circulating pump at the water heater in a closed-loop configuration. The pump can be activated by any number of manual switches or motion detectors located near fixtures on the hot-water line.

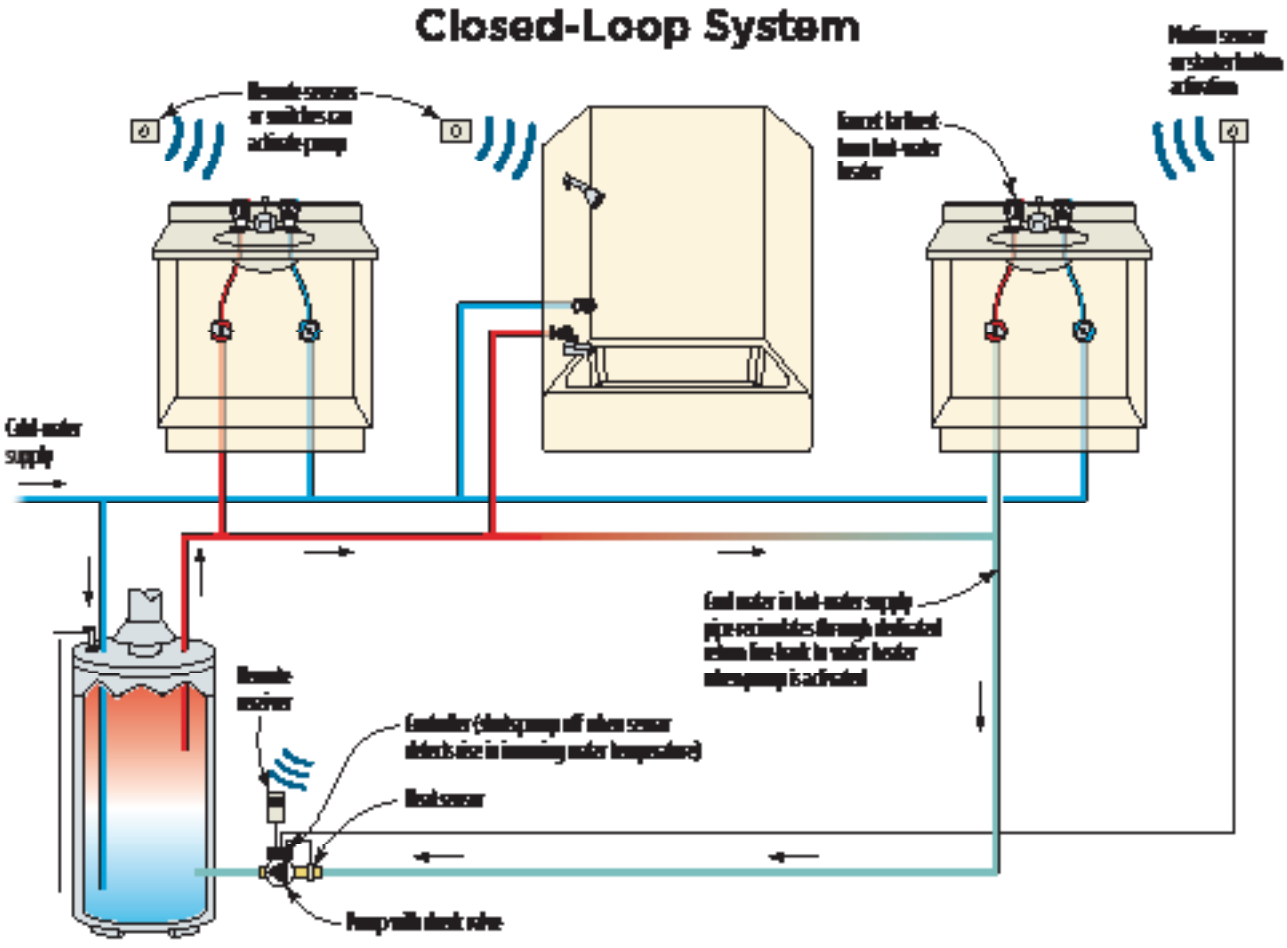
a hard-wired low-voltage push button — just like a doorbell switch — to trigger the pump (**Figure 4, facing page**). After pushing the button, which is generally located on the countertop or cabinet face, the user waits 10 to 20 seconds (or until the low whirring sound of the pump stops) before turning on the hot tap. If the wall framing is reasonably accessible, we can hard-wire several low-voltage switches together — one at each tap on the branch — to control the pump. If the framing isn't particularly accessible, we'll use wireless remote-control switches along with a small receiver connected to the master controller.

Motion-detector switches. Some of our customers prefer that the system be triggered automatically, by motion detectors. Like on/off switches, these wireless motion sensors can be placed in several bathrooms and configured to communicate with a single pump, which, depending on the system, is located either downstream at the farthest fixture or back at the water heater. When the motion detector in any bathroom is activated, hot water moves along the main line supplying all the branches. The pump runs for only about 20 seconds at a time, so if it is activated but the faucet isn't turned on, the energy penalty is minimal.

We typically install any necessary low-voltage wiring but leave the AC work to the electrician. Because even the largest on-demand pump draws a mere 1 or 2 amps, the only electrical requirement is an outlet located near the water heater or in the vanity cabinet. In some code jurisdictions, these outlets may need to be GFI-protected.

Sizing the Pump

The single-speed pumps used in on-demand systems are sized according to the length and diameter of the pipe in the branch and the flow resistance through



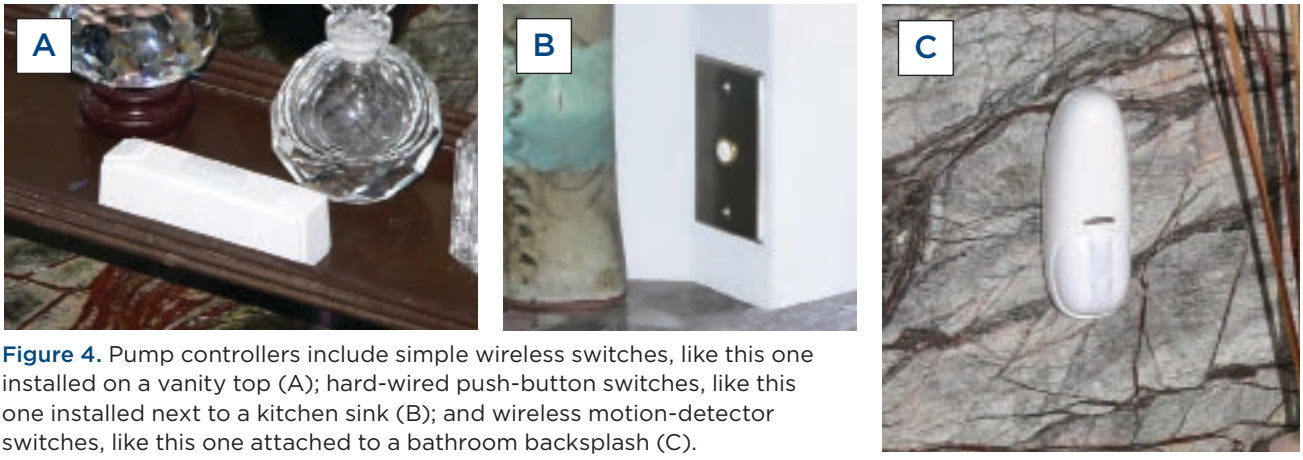


Figure 4. Pump controllers include simple wireless switches, like this one installed on a vanity top (A); hard-wired push-button switches, like this one installed next to a kitchen sink (B); and wireless motion-detector switches, like this one attached to a bathroom backsplash (C).

the piping and the water heater, known as "head loss." The higher the head capacity of the pump, the more resistance it can overcome. For example, the smallest of the three Taco pumps used in Metlund and Taco systems produces 1/40 hp at 3,250 rpm, is rated at 8 gallons per minute, and has a total head of 10 feet. The largest pump produces 1/8 hp, is rated at 28 gallons per minute, and has a total head of 30 feet. Matching the pump to the system is important. If we oversize the pump, we risk pipe corrosion, which happens when water pumped too rapidly erodes the copper pipe wall. (This is more of a problem with whole-house recirculation pumps, especially ones that operate almost continuously.) On the other hand, if the pump has a lower head than the piping system, it won't circulate any water at all.

Figure 5. Unlike traditional whole-house circulation systems, on-demand pumps can be used with tankless water heaters without voiding the manufacturer's warranty. The author uses a 3/4-inch hot-water return line and increases the pump size to make sure there is enough flow to activate the burner and to account for friction losses within the heater itself.

On-demand pumps can be used with tankless water heaters, but because these heaters require a minimum flow of water before they activate, we always spec the largest pump size (**Figure 5**). The pump also has to overcome friction loss, caused by the turbulence of water moving through the piping within the heater itself.

Cost

Prices for on-demand systems vary depending on the size of the pump and the type and number of controllers, but we typically charge between $750 and $1,250 per installation. Prices for the least-expensive hard-wired undersink kits start at about $400 and range up to about $900; plumbing a dedicated return leg or wiring a new outlet can add significantly to the installed cost. In homes where hot-water supply pipes travel in more than one direction — for instance, to two separate wings of the house — more than one pump may be required.

Payback. On-demand systems will always cut down on wasted water, but payback depends on such factors as the owners' usage habits; the size and design of the piping; annual runtime of the pump and local utility rates; and local water and sewage fees, which can be high in areas subject to water shortages. In our area it may take a few years, but these systems do pay for themselves.

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