

Hot showers, lower power bills with heat pump water heaters

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A fully ducted water heater, with ducting that collects air to warm water and exhausts used air outside. PNNL researchers found fully ducting a heat pump water heater reduced a home's total annual energy use by 4.2 percent, providing a \$1,982 10-year cost savings for a 1,500-square-foot home.

How much energy was used to heat the water for your morning shower is

probably the least of your groggy, uncaffeinated thoughts.

However, some homeowners are discovering they have even less need to think about early-morning [energy](#) use thanks to an increasingly popular alternative to conventional electric water heaters - the heat pump water heater. Results from a new field study are challenging an earlier understanding that heat pump water heaters are efficient no matter how they're installed. It turns out using ducting for air intake and exhaust impacts both the appliance's and an entire [home](#)'s energy use.

"Heat pump water heaters can use up to 63 percent less energy than traditional electric water heaters," said the study's lead researcher, Sarah Widder, of the Department of Energy's Pacific Northwest National Laboratory. "When water heating makes up about 18 percent of U.S. residential energy use, heat pump water heaters offer a real opportunity for energy savings."

Until now, many have thought those savings would be offset by an increased use in heating systems. That's because heat pump water heaters work by transferring heat from the air into water, which can lower indoor temperatures. This can reduce energy use during the hot summer months, but lead us to heat our homes more in the winter. But PNNL's field tests showed that, depending on how heat pump water heaters are connected to exterior ducting, they can reduce a home's overall power use. The results also showed heat pump water heaters may not affect a home's heating and cooling systems as much as previously thought.

New water heater in town

Due to their high efficiency, heat pump water heaters can be much less expensive to operate than electric resistance water heaters, the large, tall cylinders that warm water in 41 percent of U.S. homes. Heat pump water heaters are increasingly being installed in lieu of their conventional

electric cousins. Heat pump water heaters make up about 1 percent of new water heater sales nationwide. The total number of units sold increased from 34,000 in 2012 to 43,000 in 2013, according to ENERGY STAR.

Before PNNL's field study, the only data on the impact heat pump water heaters have on whole-home energy use was from an idealized computer model that didn't draw on real-world data. To take a deeper look at total energy consumption, Widder and her colleagues installed heat pump water heaters in the PNNL Lab Homes, two especially equipped manufactured homes used to evaluate energy-efficient technologies.

A heat pump water heater was installed in one of the homes without any ducting whatsoever. Another, identical water heater was installed in the second home with one of two configurations: ducting that only vented the appliance's exhaust, or full ducting that both collected outside air and later exhausted used air back outside. Both homes used the same electric resistance heating, cooling and ventilation system.

Sensors placed in each of the Lab Homes measured energy use, indoor and outdoor temperatures, humidity and more. Computers controlling both homes periodically ran hot water and turned on lights to simulate actual occupancy identically in both homes. The PNNL team ran the experiment through the summer and winter of 2013.

Some ducts help, some hurt

Compared with the unducted water heater, the team found fully ducting a heat pump water heater reduced a home's total annual energy use by 4.2 percent. This provided a 10-year cost savings of \$1,982 for the 1,500-square-foot home. Additionally, the researchers were surprised to find exhaust-only ducting actually increased a home's overall energy use by 2.9 percent. This represents an estimated \$1,305 increase in total

home energy costs over 10 years.

The team determined the exhaust-only ducting essentially created a vacuum within the home. Exhaust that was expelled outside through a duct had to be replaced with other air that was drawn in from the outdoors through cracks and holes in the homes' exterior walls. Because the outdoor air was colder than the air the heat pump spit out, exhaust ducting meant the homes' heating and cooling systems had to work harder to maintain comfortable indoor temperatures.

Results also revealed the heat pump water heaters' cooling effect was limited. Both of the homes' average interior temperatures were nearly identical during the experiment, varying by less than 1 degree Fahrenheit in both winter and summer. The researchers concluded this may have partially been because the water heaters were placed in a closet. Being closed off in a separate room could have created a buffer, which would have largely limited cooling to the air immediately around the appliance. More significant cooling occurred within the water heater closet. The unducted water heater's closet experienced temperatures about 5 degrees Fahrenheit cooler in the summer and about 8 degrees cooler in the winter.

"Unless you place a heat pump water heater in the middle of your living room and you sit right next to it, you probably won't feel a chill," Widder said.

Though their field study revealed some surprising data, Widder and her colleagues noted more information is needed to better evaluate the energy efficiency of heat pump water heaters. The study was limited to the climate of Richland, Washington, where the PNNL Lab Homes are located, and to the layout and design of the Lab Homes. Field tests in a variety of homes and climates would provide better data, they said. Additional field data, combined with a more detailed computer model,

could offer the information needed to draw broader conclusions for best practices to install [heat pump water heaters](#) in the Northwest and the whole nation, the authors noted.

More information: Sarah H. Widder, Graham B. Parker, Joseph M. Petersen and Michael C. Baechler, "Impact of Ducting on Heat Pump Water Heater Space Conditioning Use and Comfort," report to DOE, July 2014, [labhomes.pnnl.gov/documents/HP ... PNNL 23526 FINAL.pdf](http://labhomes.pnnl.gov/documents/HP...PNNL_23526_FINAL.pdf).

Provided by Pacific Northwest National Laboratory

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