Water Heating for Your Home

Water heaters are responsible for about 15 percent of your home energy usage and emissions. Like air conditioners, they have benefitted from successive waves of government requirements for greater efficiency; the most advanced models today, including heat-pump hot-water systems, are a notably more efficient than their predecessors.

Selecting a New Water Heater

Whether you're replacing an existing water heater or looking for the best model for a new house you're building, choose carefully. Look for a water heater that satisfies your hot water needs, uses as little energy as possible, and minimizes its carbon footprint. And you can help by reducing your hot water needs through conservation efforts.

Standalone Storage Water Heaters

Storage water heaters are by far the most common type of water heater in use in the U.S. today. Ranging in size from 20 to 80 gallons (or larger) and fueled by electricity, natural gas, propane, or oil, storage water heaters work by heating water in an insulated tank. Because heat is lost through the walls of the storage tank (standby heat losses) and in the pipes after you've turned the faucet off (distribution losses), energy is consumed even when no hot water is being used. New energy-efficient storage water heaters contain higher levels of insulation around the tank to reduce this standby heat loss.

Efficiency and tank size: The energy efficiency of a storage water heater is indicated by its energy factor (EF), an overall measure of efficiency based on the assumed use of 64 gallons of hot water per day, regardless of tank size. The first national appliance efficiency standards for water heaters took effect in 1990. Standards were further updated in 2004 and 2015, including a new 'first-hour' rating that, starting with a tank of fully heated water, specifies the number of gallons of water of fully heated water that can be provided in the first hour.

Electric Water Heaters

Standard electric hot-water storage heaters are relatively inexpensive and are generally very effective in providing hot water, but the high cost of electricity and current high levels of CO2 emissions in electricity generation leads to high operating costs and a large carbon footprint. A standard electric water heater uses about 10 times more electricity than an average new refrigerator! Fortunately, heat-pump water heaters using less than half (and some using as little as one-third!) as much electricity as a conventional electric resistance water heater are now available from several manufacturers. Though not for everyone (see page 3), they may be right for you.

Standalone gas-Fired Water Heaters

For safety concerns as well as energy efficiency, look for standalone storage gas-fired water heater units with sealed combustion or power venting. Sealed combustion (or "direct vent") is a two-pipe system — one pipe brings outside air directly to the water heater; and the second pipe exhausts combustion gases directly to the outside. This completely separates combustion air from house air. Power-vented units use a fan to pull (or push) air through the water heater — cooled combustion gases are vented to the outside, typically through a side-of-the-house vent. Power-direct vent units combine a two-pipe system with a fan to assist in exhausting combustion gases.

The most efficient *conventional* gas-fired storage water heaters are ENERGY STAR models (see 'References', p. 4) with energy factors between 0.67 and 0.70. New federal regulations enacted in 2015 require water heaters of 55 gallons or more to meet even more stringent efficiency standards that require the use of new technologies such as electric heat pumps or high-efficiency condensing gas boilers. Only recently have such products become available for home use.

In very tight houses, drawing combustion air from the house and passively venting flue gases up the chimney can sometimes result in lower air pressure inside the house. In turn, this can lead to "backdrafting," a situation when the air pressure inside is so low that the chimney airflow reverses and dangerous combustion gases are drawn into the house.

Indirect Water Heaters

An indirect water heater uses the main furnace or boiler to heat a fluid that's circulated through a heat exchanger in the storage tank. The energy stored by the water tank allows the furnace to turn off and on less often, which saves energy. An indirect water heater, if used with a high-efficiency boiler and well-insulated tank, can be a relatively inexpensive means of providing hot water, particularly if the heat-source boiler is set to "cold start."

'Flash' Water Heaters

'Flash' or 'demand' water heaters do not have a storage tank. A gas burner or electric element directly heats water only when there is demand. Hot water never runs out, but the flow rate (gallons of hot water per minute [gpm]) may be limited. By eliminating standby losses from a tank, energy consumption can be reduced by 10–15%. Before buying a flash water heater, though, be aware that they aren't appropriate for every situation:

- Multiple flash heaters are often needed to meet household needs.
- Electric flash heaters require considerable electricity when operating, often requiring special circuits of 30 to 60 amps at 240V.
- Newer flash gas water heaters modulate their output over a broad range; typical outputs might range from 15,000 to 180,000 BTU/hr—a 12:1 range in hot water output, depending on load (washing hands versus filling a clothes washer). Gas must be piped to each heater location.
- Flash heaters often need to be installed near their usage point, sometimes in cramped spaces such as undersink or closet, which can be expensive.

A small electric flash unit might make sense in an addition or remote area of the house, thereby eliminating the heat losses through the hot water pipes to that area.

Comparison of costs and CO2 emissions

The table below shows comparisons of approximate installation and operating costs, as well as emissions, among the different types of water heaters discusses above.

Estimated Installation/Operation Costs & CO2 emissions for Various Types of Water Heaters

Type of system	Storage Volume (Gallons)	Efficiency	Average Installed cost w/o rebates (1)	Annual energy cost (2)	lbs CO2 emissions annually	Annual lbs CO2 emissions saved by HPHW
Conventional gas storage	40	0.6	$1,300	$295	2216	918
High-efficiency gas storage	40	0.8	$1,400	$221	1662	364
Condensing gas storage	50	0.9	$2500	$197	1477	179
Conventional oil-fired storage	30	0.55	$1,400	$439	3221	1922
Conventional electric storage	50	0.9	$1,300	$613	2885	1587
High-efficiency electric storage	50	0.95	$1,500	$581	2733	1435
Flash gas-fired (no pilot)	<2	0.82	$3000+	$216	1622	323
Heat-pump hot-water storage	**50**	**2**	**$2000**	**$276**	**1298**	-

(1) Installed costs may vary significantly depending on brand/model and complexity of installation.

(2) Based on 52 gal/day hot water needs for a typical family of four and energy costs of gas at $1.60/therm ($16.43/1000ft³), oil at $3.00/gallon, and electricity at $0.17¢/kWh. If your hot-water usage rate or energy prices are lower or higher, scale the 'Annual Energy Cost' and CO2 emissions accordingly.

From the above table we see that when both installation and operating costs are taken into account, one of the least expensive systems to buy (conventional electric storage) is one of the most costly to operate and has the largest CO2 emissions footprint. A condensing gas storage heater is highly efficient and low-cost to operate due to the low cost of natural gas, but is expensive to install. An electric heat-pump water heater, though relatively expensive, has a low operating cost and the smallest CO2 emissions footprint of any system

Should I consider a hot-water heat pump for my home?

Good candidates:

1. **If your tank is older than 15 years, get ready NOW for a heat-pump water heater (HPHW) and save.**
2. **If you switch from conventional electric storage to a heat-pump water-heater, you can avoid over 1600 lbs of CO2 emissions and save ~$330 per year in electricity costs.**

Not good candidates (i.e. very long payback period):

I currently have a conventional gas or oil hot-water heating system in good working order.

What incentives are available?

1. Concord residents: Town of Concord is considering a $750 rebate on any heat-pump hot water installation.
2. Residents of Carlisle and other towns: MassSave members are eligible for a $750 rebate on qualified 50-gallon models replacing a conventional electric water heater with a heat-pump system, plus 0% loans up to $25k and 7 years.

What are typical payback periods?

1. Replacement of conventional electric hot-water heater: typically ~4 year payback period for a family of 4
2. Replacement of old oil-fired hot-water heater: Depends on situation, but annual operating cost should immediately drop by approximately half (typical annual oil cost for family of four is $400 to $500 at current oil prices). Payback period will be variable depending on situation, but typically about ~8 years.
3. If you have a solar-PV system that generates excess electricity for your home, a heat-pump hot-water system can further reduce both recurring costs and CO2 emissions. Payback period depends on the size of your solar-PV array.

Heat-Pump Water Heaters - Pros & Cons

Advantages:

- 40-50% energy cost savings compared to conventional electric and oil (at current gas/oil prices)
- 40%-50% reduction in emissions of global-warming gases
- Can partner nicely with a home solar-PV system to reduce both recurring costs and CO2 emissions
- Can help cool your home in summer

Disadvantages:

- No energy cost saving vs. natural gas (unless coupled with home solar-PV system of sufficient capacity)
- Adds somewhat to home heating load (because it cools local air)
- High install cost (typical up to $1,000 cost premium over conventional systems)
- Noise:
    - Louder than a refrigerator
    - Quieter than a dehumidifier
- Not a good match w/conventional electric home heating
- Needs ventilation in small-space installation
- Needs condensate drain (or pump)

Questions to Ask Your Installer

- Is my utility room large enough (if installed in a room)? Will it require ventilation?
- How will you drain the condensate? Do I need a condensate pump?
- Will cold air blow on me?

What else can I do to save energy on hot water?

1. Take short, efficient showers instead of baths
2. Install low-flow shower fixtures
3. Set hot-water thermostat to lowest comfortable water temperature
4. Install a timer to turn off your hot-water heater at night; switch off when away
5. Insulate all hot-water pipes, particularly those near your water heater
6. Use cold water for most laundry loads
7. Consider upgrading to an ENERGY STAR clothes washer (see References)
8. Wash only full loads in your dishwasher
9. Install a well-insulated hot-water tank

What about solar-thermal hot water?

There was a time less than 20 years ago that using rooftop solar-thermal collector panels to heat domestic water made sense. But now, in an age where solar-PV is far cheaper than 20 years ago, it makes more sense to use a solar-PV array to power some or all of a heat-pump hot-water system. And there are other reasons that solar-thermal hot-water systems are not competitive:

1. A solar-thermal system is expensive to install, both due to the high-cost of the collector panels and the high cost of installing insulated plumbing from your roof to your basement (typical cost $10,000).
2. Unlike a PV system, most solar thermal systems have many moving parts (pumps and solenoid valves).
3. In freezing climates, solar thermal systems are sometimes subject to freeze damage.
4. Solar thermal systems require regular maintenance, including antifreeze replacement.
5. Unlike owners of a grid-connected PV system, who can be credited for their excess electricity production during the summer, owners of a solar thermal system can't sell their excess energy production.
6. On average, PV systems probably last longer than solar thermal systems.

References

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