

## Gas Tankless Water Heaters

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**G**as tankless water heaters (also referred to as instantaneous or demand water heaters) have been gaining in popularity relative to conventional gas storage water heaters in the U.S. With energy factors of 0.80 or higher,<sup>1</sup> gas tankless water heaters are more efficient than gas storage water heaters, which typically offer energy factors of 0.60.

The majority of domestic hot water in the U.S. is supplied by storage water heaters. Water is heated in an insulated storage tank, in most cases either by an electric resistance heating element or by burning natural gas or LPG.\*

The heating rate, for either electric or gas storage systems, is less than the typical maximum household hot water demand. This difference is balanced, for a period of time, by the volume of hot water stored in the tank.

Electric storage water heaters have electric resistance heating elements immersed in the water in the storage tank and lose efficiency primarily from heat loss through the tank insulation. Typically 5% to 10% of efficiency is lost, depending on the thickness of the insulation and the amount of hot water consumed versus the size of the tank.

Gas storage water heaters have a gas burner under the water storage tank, with a flue running longitudinally through the center of the tank. Heat is transferred from the flame to the bottom of the tank. The flue provides additional surface to transfer heat from the combustion gas

to the water, before the combustion gas flows out the flue.

In addition to heat loss through the tank insulation, gas storage water heaters lose efficiency by heat loss up the flue, both when the burner is on and during standby operation.

The steady-state thermal efficiency (heat into the water divided by the higher heating value of the gas) is typically 75%, with the other 25% lost out the flue.

During standby operation, additional heat is lost by natural convection-driven air circulation up the center flue. As the hot water in the tank heats air in the flue, the air rises and flows out the flue, carrying with it a finite amount of heat. The combined effect of these losses yields the typical energy factor of 0.60 as noted earlier.

A gas tankless water heater has a modulating gas burner that fires as needed to supply hot water at an approximately constant temperature, meeting hot water demand on a real time basis. The burner only fires when water flow through the system is detected. Beyond the heat stored in the relatively small mass of the heat exchanger and the equally small volume of water in the heat exchanger, there is

no thermal energy in the heat exchanger that is subject to being dissipated and lost during periods when no hot water is being drawn.

Typical products for residential applications have a maximum nominal input of up to 200,000 Btu/h (60 kW), which is capable of continuously providing 4.2 gpm (0.27 L/s) of water at a 77°F (25°C) temperature rise. This is equal to the temperature rise used in the DOE efficiency test procedure: 58°F (14°C) cold water supply temperature and 135°F (57°C) hot water delivery temperature, representative of average conditions in the field), enough to supply two showers continuously.

Comparison of the energy factors of tankless and storage water heaters does not provide a completely accurate prediction of the difference in energy use that would be experienced in the field. The energy efficiency of a gas storage water heater varies with the total daily hot water consumption (increasing with increased hot water use, as standby losses become a less significant part of the total energy used), but is not sensitive to the size of hot water draws.

However, the energy efficiency of a gas tankless water heater is insensitive to the total daily hot water consumption, but is degraded by frequent, small hot water draws.

Field and laboratory measurements coupled with available field data on draw profiles<sup>1</sup> shows that at typical use conditions, the effect of small water draws is to reduce the energy factor as measured by the current DOE test procedure by about 7%. For example, a gas tankless water heater with an energy factor of 82% would deliver hot water at an efficiency of 75%, about 15% higher than a typical gas storage water heater. Therefore, the gas tankless water heater can be expected to consume 20% less energy to heat a given amount of water, assuming that the 64 gallon (240 L) daily hot water consumption in the DOE test procedure is representative of the actual hot water consumption.

Note that the DOE test procedure does not account for heat losses from hot water

\* A small amount, less than 5%, of domestic hot water is heated by other fuels.<sup>2</sup>

distribution piping, which tends to be a larger effect with small draws (with either water heater type).

Tankless water heaters can be retrofitted in an existing home in many cases. In the typical installation, the tankless water heater package is a rectangular box that is mounted on a wall, and the flue exits through the side wall approximately 2 ft (0.6 m) above the top of the water heater package using a special venting kit. When replacing a gas storage water heater, the installation requires new water and gas connections, along with new venting.

## Energy Saving Potential

The annual primary energy consumption in the U.S. for water heating in residential buildings in 2006 was 2.6 quadrillion Btus (quads).<sup>2</sup> Of this, 1.15 quads was consumed by natural gas or LPG water heating systems. Assuming that the majority of the natural gas and LPG was consumed in gas storage water heaters, replacement with tankless water heaters would result in annual energy savings of approximately 0.23 quads.

The side wall venting of the tankless water heater may create the opportunity to replace some existing electric resistance water heaters, where gas service is available, but a gas storage water heater wasn't used originally because a chimney-type flue did not exist.

## Market Factors

Tankless gas water heaters are about double the initial equipment cost of storage gas water heaters. For example, at a "big box" home improvement outlet, the price of 50 gallon (190 L) storage gas water heaters ranges between \$450 and \$600, while the price of several tankless models ranges between \$800 and \$1,000 (with another \$200 for vent kits). However, a tankless water heater will save the average household (i.e., 2.6 occupants) approximately \$115 per year in energy costs, and more in households consuming more hot water.<sup>3</sup>

In new construction, the installation cost of a gas tankless water heater will be similar to the installation cost of a gas

storage water heater, including the installation of cold water and hot water connections, a gas supply line, and flue gas venting. The resulting simple payback on the higher initial cost of a tankless water heater will be around five years for the average household.

When replacing an existing gas storage water heater, the installation cost of the tankless water heater will likely be higher than the cost of replacing the gas storage water heater with another gas storage water heater, because the tankless water heater will often require modifications to the vent piping and/or water and gas connections. Added installation costs will obviously result in a longer simple payback period. However, utility incentives, tax credits, and longer equipment life may offset a portion of the higher initial costs of tankless systems.

A basic market obstacle to replacing existing water heaters with upgraded technology is the "emergency" situation that normally precipitates replacement of a water heater. The homeowner doesn't notice the water heater until a leak in the tank develops, at which point the homeowner opts for the fastest, least cost replacement that is offered by the plumber.

## References

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