What's the Big Deal About Tankless Water Heaters?

A WHITE PAPER

Dr. William R. Hoover
Corporate Technology Center

state
INDUSTRIES, INC.

As energy supplies tighten and fuel costs increase, tankless water heaters are gaining attention in some quarters because they do not require the storage of hot water. Tankless water heaters are certainly appropriate in some situations, particularly in point of use applications, but all factors should be carefully weighed before replacing a storage (tank-type) water heater with a tankless (instantaneous) water heater as the central hot water supply for a residential application.

The positive attributes of tankless water heaters that typically are emphasized (or advertised) are:

- **Energy savings**
- **Small**
- **Compact**
- **Easy installation**
- **20-year expected life**
- **Unlimited hot water supply.**

Let's address each of those points.

Energy Savings

In a storage water heater, energy is required to heat the water in the tank and to keep it hot. In both storage and tankless heaters, the basic efficiencies of heating the water are very similar; in fact, the energy consumptions are very similar. In tankless water heaters, however, no energy is consumed in overcoming the standby losses encountered in a storage water heater tank.

The most significant questions for the consumer are "How much energy is lost during standby?" and, more importantly, "How much are the standby losses going to cost me?" According to the U.S. Department of Energy, the Energy Factor of a water heater is a measure of its overall efficiency, which is determined by comparing the energy supplied in heated water to the total daily consumption of the water heater. The Energy Factor testing protocol measures both the energy required to heat the water and the energy required to overcome standby losses. Since all water heaters must have a certified Energy Factor, the comparison of energy consumption can be made by computing the Estimated Annual Cost of Operation as outlined by the DOE and Gas Appliance Manufacturers Association.

For gas and oil water heaters the correct equation used is:

Estimated Annual Cost of Operation = 41045 x Cost of Fuel x 365 /(100,000 x Energy Factor)

(The cost of fuel is given in $/therm.)

For electric water heaters the correct equation used is:

Estimated Annual Cost of Operation = 12.03 x Cost of Electricity x 365/(Energy Factor)

(The cost of electricity is given in $/kilowatt hour)

Gas Storage Water Heaters vs. Gas Tankless Water Heaters

Gas tankless water heaters have advertised Energy Factors ranging from 0.62 to 0.83. A typical U.S. home will use a 40-gallon gas storage water heater. According to the GAMA guide, these water heaters will have Energy Factors ranging from 0.54 to 0.64. For the purposes of this comparison, a national average fuel cost of 0.604 $/therm will be used.

Table I
Estimated Annual Cost of Operation Savings
(Tankless gas water heaters vs. storage gas water heaters)

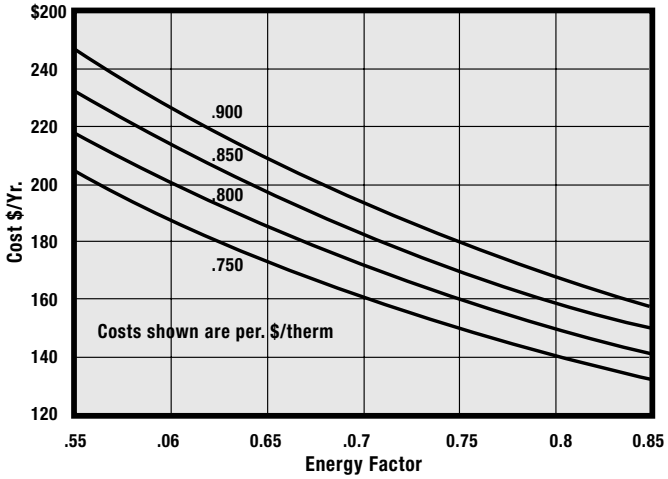
		Storage EF		
		0.54	0.59	0.64
Tankless EF	0.83	$58.55	$44.35	$32.37
	0.725	$42.76	$28.56	$16.58
	0.62	$21.62	$7.42	($4.56)

Table I compares the estimated annual savings for tankless gas heaters vs. storage gas heaters as a function of Energy Factor. Comparing the two types of water heaters using their average Energy Factors (EFs = 0.59 and EFt = 0.725), the expected annual energy savings for a tankless water heater is $28.56. The maximum savings possible would be $58.55, the estimated annual cost savings which could be achieved if the best-performing tankless heater is compared to the worst-performing storage heater.

These are surprisingly low dollar savings when you consider that tankless water heaters are sometimes advertised to have a 30% increase in energy efficiency. There are two reasons for this apparent inconsistency: the relatively low Estimated Annual Cost of Operation for gas storage water heaters and the lack of proportion between the energy cost savings and the Energy Factor improvement. Consider the previous example, where the worst storage water heater was compared to the best tankless water heater. The Energy Factor improvement is 0.29 or 53.7% but the estimated annual cost savings of $58.55 is 34.9% of the rather modest $167.57 Estimated Annual Cost of Operation for the gas storage water heater.

Figure 1 plots the Estimated Annual Cost of Operations for gas water heaters as a function of Energy Factor and gas cost. The chart can be used to determine that cost for each of the heaters of interest, and the estimated annual savings can be calculated by subtracting one value from the other.

Figure 1 Estimated Annual Operating Cost For Gas Water Heaters



Electric Storage Water Heaters vs. Electric Tankless Water Heaters

Storage units score better in the electric category. Electric tankless water heaters have advertised Energy Factors ranging from 0.98 to 0.995. A typical U.S. home probably uses a 52-gallon electric storage water heater. According to the GAMA guide, these electric storage water heaters have Energy Factors ranging from 0.86 to 0.94. For the purposes of this comparison, a national average electric cost of 0.0841 $/kilowatt hour will be used.

The Estimated Annual Cost of Operation is higher for electric water heaters because electric energy is more expensive than energy from natural gas. For example, the annual operating cost of a 52-gallon electric storage water heater with a mid-range Energy Factor (0.90) is $410.31 while a 40-gallon gas storage water heater with a mid-range Energy Factor (0.59) costs about $153.37 annually.

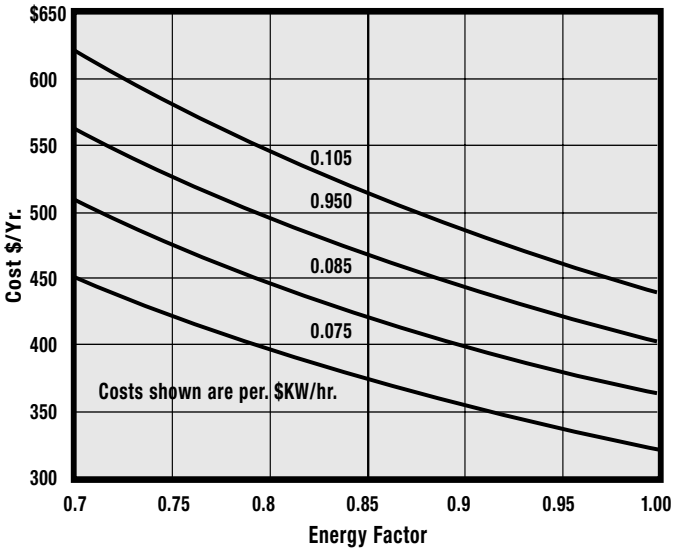
Table II
Estimated Annual Cost of Operation Savings
(Tankless electric water heaters vs. storage electric water heaters)

		Storage EF		
		0.86	0.90	0.94
Tankless EF	0.995	$58.26	$39.18	$21.72
	0.988	$55.63	$36.55	$19.09
	0.98	$52.58	$33.49	$16.03

Using **Table II**, where we compare a mid-range electric storage water heater to a mid-range tankless water heater, the estimated annual cost savings is $36.55 or 8.9%. The maximum possible estimated annual savings goes up to $58.26 when comparing the worst electric storage heater with the best electric tankless water heater.

The annual operating cost for electric water heaters can be determined using **Figure 2**.

Figure 2 Estimated Annual Operating Cost For Electric Water Heaters



This graph plots the Estimated Annual Cost of Operation for electric water heaters as a function of energy factor and electricity cost. The estimated annual savings can be obtained by subtracting one value from the other.

In summary, according to the Energy Department's Energy Factor ratings and Estimated Annual Cost of Operation formulations, both tankless gas and electric water heaters do save energy and operating costs over their storage counterparts. However, based on calculations comparing the least efficient gas storage water heater with the most efficient tankless water heater, the maximum estimated annual cost savings is just $80. That figure is even less when comparing electric models. In addition, the upcoming NECA II requirements mandate that storage water heaters be made more efficient which will reduce the potential energy cost savings provided by tankless heaters.

Small, Compact, Easy to Install, 20-year Expected Life…

It is true that tankless water heaters are generally small, compact, wall-hung units. How easy they are to install is dependent on the situation. Installation during new construction would be straight forward. On the other hand, installation in a retrofit situation could be quite expensive.

Continued on page 4

The installation of an electric tankless heater usually requires two 50 amp, 220V circuits. During a conversion from an electric storage heater, an electrician will be required to bring the additional power to the tankless heater if that much power is available in the home. The larger gas tankless heaters require 4- to 7-inch-diameter power venters because of their high BTU input. Since most residential gas heaters have a 3-inch flue and are unpowered, there could be significant conversion costs associated with installing a larger-diameter flue and the necessary electric power.

High-performance tankless gas water heaters are complex appliances with modulating gas and air flows, and sometimes with modulating water flows.

These complications lead to initial homeowner purchase costs in the range of $500 to $1,200, with some high-performance models costing over $2,000. In addition, these units typically require annual servicing by a trained technician. It is also important to keep in mind that the figures cited here are for the product only; installation would be an additional cost. Particularly in the cases of retrofit installations, that figure could be substantially higher than a standard tank-type unit.

While most manufacturers of tankless water heaters advertise that their appliances have a 20-year life expectancy, their warranties are usually much more modest. They suggest that since all of the parts on their units are replaceable, one would not need to replace the entire water heater. However, there is not an extensive service/repair network which could make obtaining repairs problematic.

In contrast, storage water heaters often cost less than $300, have a simple retrofit installation, require no regular servicing and have a well-established service/repair network. In addition, these heaters can be purchased with a 12-year warranty. This means that even if a tankless heater lasted 20 years without repair, the end user could have purchased two storage heaters over the same period for less total cost.

In Summary

The high acquisition, installation and service costs of tankless water heaters will likely offset the modest energy cost savings they provide over storage water heaters.

An Unlimited Hot Water Supply?

The manufacturers of tankless water heaters stress that their units provide an unlimited supply of hot water. That is true, as long as you do not exceed your tankless model's ability to heat water. In a storage water heater, the amount of hot water immediately

Figure 3 Gas Tankless Flow Rates

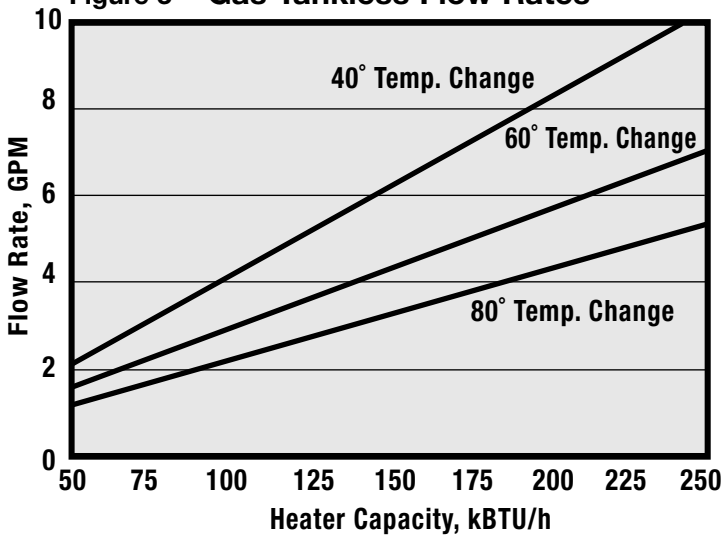
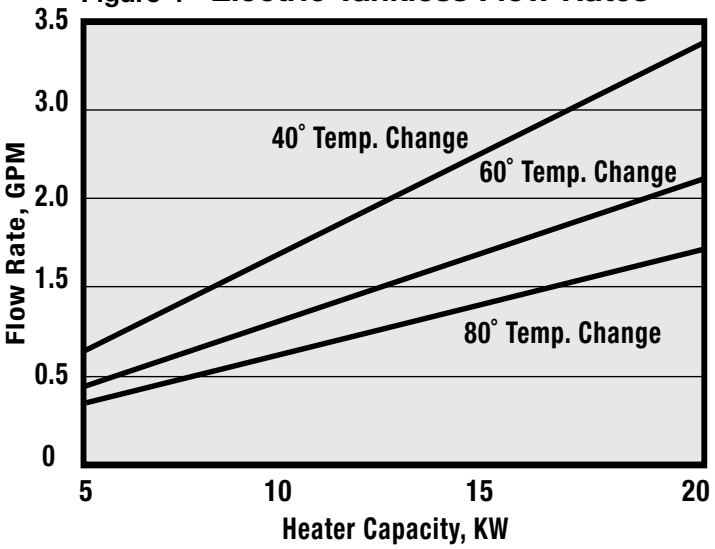


Figure 4 Electric Tankless Flow Rates



available for use is not dependent on the flow rate or the inlet temperature. For example, if there are 40 gallons of 140˚F water in a 50-gallon storage heater, you can use all 40 gallons. The amount is not dependent on how fast you use it or on the temperature of the inlet water.

Because tankless units heat the water as it is used, the energy requirements placed on the heater depend on both the amount of water being used (flow rate) and the temperature increase required for that water. Obviously, large flow demands, very cold ground water and elevated hot water temperatures place larger demands on the tankless heater.

The required capacity of a tankless water is dependent on the homeowner's lifestyle and the geographic location. **Figures 3 and 4** show the maximum flow rate of hot water from a tankless water heater as a function of heater size or capacity (BTU/hour or Kilowatts) as well as the temperature increase that is required. As might be expected, higher flow rates and higher temperatures increase the required heating capacity for a tankless water heater.

Continued on page 5

Required Temperature Increase

The temperature increase needed depends on both the incoming water temperature and the hot water temperature. Incoming temperature is a strong function of climate. While the incoming water may be less than 40˚F in some northern parts of the United States, the incoming temperature may be 65˚F in our southern states. A typical storage water heater is operated at 125˚F; to duplicate that temperature, the desired temperature increase could vary from 60˚F to more than 80˚F depending on geographic location.

Alternatively, some tankless water heater producers suggest that since most people shower and wash hands with a water temperature of 105˚F, the thermostat on their tankless heaters should be set at 105˚F. This would reduce reasonable temperature increases from 40˚F in southern climates to more than 60˚F in the north. Such a setting is acceptable if satisfactory performance is still achieved from dishwashers and clothes washers at that water temperature and if the home's occupants can become accustomed to opening only the hot water tap when washing their hands or showering.

Taking that issue one step further, many homeowners become frustrated with these restrictions, and call their local contractor. It can become a rather annoying cycle for contractors to get continual callbacks from homeowners who simply want them to turn up the temperature on their water heaters. Worse yet, is when contractors get calls from homeowners who want more hot water than their tankless heater can provide. In this situation, the only solutions are costly and are likely to result in very unhappy customers.

Desired hot water flow rate

The required flow rate is much harder to define. **Figure 5** shows typical flow rates in gallons per minute (gpm) for various household devices. If it is acceptable to refrain from using the clothes washer and the dishwasher while washing hands or showering, then both gas and electric tankless heaters would provide adequate hot water flow. If, however, the flexibility of using a multiple devices simultaneously is desired, then careful consideration must be given to the maximum flow rate capacity of tankless heaters. For example, taking a shower while the clothes washer is operating could require approximately 6 gpm of hot water. No electric tankless water heater can provide the heating capacity to meet this demand, and the largest gas tankless (180,000 BTU/hour) heaters can handle that type of load only if the desired temperature increase is less than 50˚F.

Figure 5 **Water Usage Table**

Low-flow faucet	0.5-1.5 gpm
Low-flow shower	1.2-2.0 gpm
Unrestricted shower	4.0 gpm
Clothes washer	4.0 gpm
Whirlpool tub	4.0 gpm
Dishwasher	1.5 gmp
Lavatory	1.0 gpm

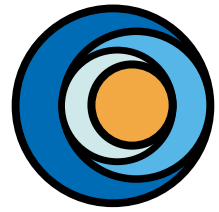
Clearly, tankless water heaters can provide unlimited hot water if the demands are modest. If, however, the homeowner desires the flexibility of using several hot water-consuming devices simultaneously and requires a temperature increase of 60˚F or more, the ability of tankless water heaters to provide sufficient hot water needs to be very carefully examined. Depending on the design of the tankless water heater, one of two things will happen when it experiences too much demand for hot water: It may deliver cooler water or it may maintain the water temperature but reduce the flow rate.

Some manufacturers of tankless water heaters suggest that additional hot water flow capacity can be achieved by using more than one tankless water heater in tandem. This is a feasible, but expensive, idea provided there is sufficient electrical power or gas supply available in the home. While tankless water heaters are physically small devices, they are very high-rate energy consumers—at 180,000 BTU/hour, a tankless gas water heater consumes much more gas per minute than large residential furnaces. Similarly, at about 20 kW, an electric tankless heater will be the fastest consumer of electrical energy in the average household.

Conclusion

Tankless water heaters have advantages. They are compact and are easy to drain; consequently, they could be ideal for applications where space is a premium or in small vacation homes. In addition, they could serve quite effectively in point of use applications. However, their use as the central source of hot water in a residence should be carefully considered. While tankless water heaters offer some modest energy cost savings over storage water heaters, those minimal gains are at the expense of higher initial costs, higher installation costs, higher maintenance costs and the potential need for lifestyle changes to accommodate the limited flow rate output of tankless water heaters. In addition, with the coming increase in Energy Factor required by NECA II, the Energy Factor differences between tankless and storage water heaters will become even smaller.

If a customer regularly runs out of hot water from his storage water heater, the most cost-effective solution is the purchase of a larger, correctly sized, high-efficiency storage water heater. For those who want enhanced energy efficiency, the most cost-effective solution is the purchase of a correctly sized, high-efficiency storage water heater.



state
INDUSTRIES, INC.

500 Lindahl Parkway, Ashland City, TN 37015