Tankless Water Heaters *On-Demand Only*

MYTH VS. REALITY

Hot water usage in American households consumes between 15 and 30% of a home's energy demand, according to the US Department of Energy. Surprisingly, the technology used to heat water in the US is antiquated and highly inefficient when compared to the tankless or on-demand technologies now used regularly in Europe and Asia. This primer attempts to explain the new technology and benefits behind whole-house natural gas-fueled tankless water heaters (TWHs).

Myth 1: Only a tank can provide a large amount of hot water.

Heating a tank of hot water is neither an effective nor an efficient way to supply hot water. As hot water drains from the tank, in-flowing cold water lowers the overall temperature of the water in the tank. Traditional tank-based water heaters are not designed to heat the in-flowing cold water rapidly enough to keep the out-flowing water at a constant temperature. In contrast, properly sized TWH systems are designed to keep out-flowing water at a constant temperature.

Myth 2: A tankless hot water system can't provide enough continuous hot water for an entire household.

The reality is that the heat-exchanger technology used in TWHs is specifically designed to provide a full and inexhaustible flow of appropriately heated water to an entire household.

Myth 3: Tankless water heaters must heat the water so hot that it is dangerous to use them.

Actually this fear is more relevant to traditional tank-based water heaters than to TWH systems. Tankless systems are safer to operate since they heat the water to only slightly above the level of intended use. Traditional tank-based water heaters have to overheat the stored water so that it will remain hot enough as the in-flowing cold water mixes with it.

Myth 4: Tankless water heating systems cost more to operate.

Like any profitable investment there is an immediate outlay of cash, but when you factor in the lower operating cost and longer (20-year) service life, TWHs save their owners a substantial amount of money. In fact, as illustrated below, it is difficult to construct a scenario where owners of a new natural gas TWH system will earn a return on investment of less than 45%.

PERSONAL BENEFITS

Even before financial savings are considered, there are four benefits of using TWHs that make using them worthwhile: hot water supply, space savings, long service life and easy maintenance, and convenience and safety.

Supply of hot water. Properly sized and adjusted TWH systems can provide an effectively endless supply of hot water. Given our long experience with the frustrations inherent in traditional tank-based water heating systems, an endless supply of hot water can be difficult to imagine. Prior to converting our vacation home, we were skeptical that TWHs could live up to their reputation. But seeing was believing. The test we did following installation of the TWH (see Practical Considerations below) made us immediate converts.

Space savings. Tankless hot water systems can be installed indoors or outdoors. In either case they are wall mounted and surprisingly compact. Since they have electronic instead of open-flame pilots, they can be put in closets and other tight areas that could not accommodate a conventional hot water tank. A typical large unit measures only 14"W x 24"H X 9"D plus the attendant plumbing. Some TWH systems include a small electric recirculating system and tank, which can be placed on the floor or also suspended from the wall.

Service life and maintenance. Once installed, a TWH system should last much longer than the traditional tank-based alternatives and should be easier to maintain. Typical tank-based water heaters last between 7 and 10 years, depending on use and water conditions. Most TWH systems have a 20-year useful life...and in contrast to tank-based heaters, nearly every component can be individually replaced without replacing the complete unit. Traditional tank-based systems can also be maintenance intensive: pilot lights can blow out and need relighting, tanks can and frequently do leak at the most inopportune times, and as tanks age and calcite deposits build up inside, they often start to make pinging or other noises as they heat water. In contrast, TWHs are relatively maintenance free and should require very little attention over their esti-

mated 20-year lives. During a 20-year period, homes using tank-based hot water heaters may require as many as two tank-based replacements, with each replacement requiring time and money and potentially causing great inconvenience.

Safety and Convenience. Since TWHs have neither an open-flame pilot nor a tank of stored hot water, they are free of many of the safety issues that accompany tank-based systems. Also, the temperature setting on TWHs is digital and precise, unlike the coarse twist knob settings on most tank-based heaters. This means that if you need to raise the temperature of the hot water during cold months because of cold or uninsulated plumbing, you can do this simply and precisely with the TWH digital temperature setting. Also, the temperature on tank-based systems is often kept much higher than is needed with a TWH system. Therefore, the chance of scalding is greater with tank-based systems.

Financial Savings. Compared to tank-based systems, TWHs are cheaper to use both because they are cheaper to operate (in two ways) and because their service life is more than twice that of a tank-based system. On an operational basis, TWHs heat water more efficiently than do traditional tank-based water heaters. The standard measure of energy efficiency for water heaters is a metric called the Energy Factor or “EF”, numbers shown on the yellow Energy Guide tags on water heaters and certain other appliances. EFs for tank-based natural gas water heaters are mostly in the low 60s, while EFs for natural gas fueled TWHs are usually in the mid 80s. Therefore, when doing the basic job of heating cold water to hot water, TWHs are about 20 to 25 percent more efficient than tank-based systems. In addition, traditional tank-based systems consume energy in their “stand-by” mode, i.e. when they are maintaining the temperature of an already heated but idle tank of hot water. Energy used during stand-by mode can range from 15 to 30 percent of the total energy that a tank-based system uses. Taken together, these two sources of operational efficiency result in TWHs being 20 to 40 percent more economical to operate.

As an aside, it is worth noting that electric water heaters (both tank-based and tankless) enjoy energy factors in the 90s. But there is a continuing debate about whether this results in a better solution for the consumer. In favor of electric heating is the fact that electric water heaters use their energy source (electricity) extremely efficiently. However, natural gas heaters have several advantages: (1) in most US markets, electricity is considerably more expensive than natural gas on an equivalent energy basis, (2) electricity heats somewhat more slowly than natural gas, resulting in moderately greater waste of drawn water while waiting for the hot water to reach the faucet, and (3) the production of electricity itself produces a higher emission of greenhouse gases and other pollutants than does natural gas. In this primer we compare only natural gas-based water heaters. For those who wish to review the debate between electricity and natural gas, read these web pages:

Favoring electricity:
http://www.e-tankless.com/gas-vs-electric

Favoring natural gas:
http://www.foreverhotwater.com/the-facts-about-tankless.php

While natural gas TWHs do operate more efficiently than their tank-based counterparts, their longer service life also contributes significantly to their better overall financial performance. TWHs can cost 50 to 100% more than tank-based heaters to buy and install. However, TWHs last more than twice as long as tank-based systems. To calculate the financial benefits of owning a TWH system, the higher initial costs have to be netted against the cheaper ongoing operating costs and the longer service life. To achieve comparability, the financial analysis needs to have a 20-year horizon; otherwise the higher initial cost of the TWH will tilt the analysis against the TWH. But when a full 20-year period is considered and the multiple tank replacements are factored in, the financial benefits of owning a TWH system become compelling.

To illustrate the potential financial advantages of owning a TWH, we performed a sensitivity analysis of the benefits for a range of home size and fuel costs. To conduct this analysis, we reviewed the available on-line calculators and chose the calculator sponsored by Rinnai, a leading European manufacturer of TWH systems, at (**http://www.foreverhotwater.com/tank_compare/**). While the calculator is opaque relative to certain specifics within the financial calculation, it allows transparency and user flexibility relative to both usage conditions and fuel types and costs. This flexibility allowed us to analyze the benefits for a range of home sizes (based on people, showers and large tubs) and for a range of fuel costs. For the fuel cost scenarios, we consulted the Energy Information Administration of the US Department of Energy (**http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/current/pdf/table_023.pdf**) and selected three states to represent low, moderate and high-cost natural gas. The three fuel cost scenarios are:

- Scenario 1 (low cost) California $1.186/hundred cubic feet,
- Scenario 2 (moderate cost) New Jersey $1.344/hundred cubic feet, and
- Scenario 3 (high cost) Connecticut $1.624/hundred cubic feet.

The calculator's results illustrate both annual operating savings as well as overall savings (including the initial purchases and the replacements) over the 20-year period. Since these various cash flows occur in different years across the 20 years, a return on investment (ROI) is also shown. The ROI calculation weights the cash flows by the time periods in which they occur and discounts cash flows that occur in later periods. We handicap the analysis against the TWH by ignoring the potential $300 federal tax rebate. For information on the tax credit read: **www.tanklesstaxcredit.com/guidelines.html**.

__Did you know__...that hot-water usage in the average US household is between 15-30% of a home's overall energy demand? It's a fact, according to the US Department of Energy.

Financial Comparison of TWH v. Traditional Tank-based Water Heater

Home Scenario	A. Small Home		B. Medium Home		C. Large Home	
Residents	2		4		6	
Shower Heads (high flow)	1		3		4	
Tubs (60 gallons +)	1		2		3	
	TWH	Tank-based	TWH	Tank-based	TWH	Tank-based
Purchase Cost	$ 1,100	$ 600	$ 1,100	$ 600	$ 1,100	$ 600
Installation Costs	$ 500	$ 350	$ 500	$ 350	$ 500	$ 350
Rebates	none	none	none	none	none	none
Gallons/hour	246	34	246	34	246	34
Fuel Cost Scenario 1	Low-cost natural gas: $1.186/ccf of natural gas (California)					
Operating Costs	$ 105	$ 146	$ 210	$ 292	$ 315	$ 438
20-year savings	$ 3,355		$ 4,468		$ 5,580	
Return-on-Investments (R	48%		64%		80	
Fuel Cost Scenario 2	Average cost natural gas: $1.344/ccf of natural gas (New Jersey)					
Operating Costs	$ 119	$ 166	$ 238	$ 331	$ 358	$ 497
20-year savings	$ 3,518		$ 4,766		$ 6,014	
Return-on-Investments (R	52%		68%		86%	
Fuel Cost Scenario 3	High cost natural gas: $1.624/ccf of natural gas (Connecticut)					
Operating Costs	$ 144	$ 200	$ 288	$ 400	$ 432	$ 600
20-year savings	$ 3,762		$ 5,281		$ 6,800	
Return-on-Investments (R	54%		75%		97%	

For a small house, in the low-cost fuel scenario an outlay of $1,600 for a new TWH system is projected to produce total savings of $3,355 over 20 years and earn an ROI of 48%. For a medium-sized house in a moderate-cost fuel scenario, the projected savings is $4,766 over 20 years and the ROI is 68%. And for a large home in a high-cost fuel scenario, the projected savings is $6,800 over 20 years and the ROI is 97%.

In fact, every home size and every fuel cost scenario produces a meaningful cash savings and an attractive ROI. If we take a cautious view of these estimates and conservatively reduce them by half, the least attractive return would still be 24%. How often can we make financial investments with reasonably predictable returns of 24% or better and improve daily aspects of our lifestyle in the process?

It is valuable to look at two additional elements in the financial analysis. First, the fuel costs are assumed to remain unchanged over the 20-year period. To the extent that fuel costs rise, the operating savings will improve the above projected savings and ROIs. Second, the longer service life of the TWH figures significantly in the overall cash savings. In a practical sense this means that over a 20-year period, owning a TWH allows you to avoid the inconvenience of having to replace the tank-based system every 9 years (as projected in the Rinnai calculator).

So for the effort of converting from a natural gas fired tank-based system to a TWH system, you can:

- enjoy endless hot water,
- regain valuable floor space in your house,
- operate a safer water heating system,
- benefit from a longer service life, and
- earn a significant return on investment.

Who wouldn't want to make such a change?

> ***Did you know**...that a Tankless Water Heater is safer to operate than a conventional tank-based system?*

ENVIRONMENTAL BENEFITS

The environmental benefits from converting to a TWH system are twofold: reduction in greenhouse gas emissions from using the more energy efficient TWH and a reduction in landfill waste from the longer service life (and smaller size) of the TWH units.

To estimate the reduced carbon dioxide emissions, we assumed that the supply of natural gas is one hundred percent methane. By knowing the amount of carbon dioxide that is produced when methane is burned, we were able to estimate the total carbon dioxide released annually and over the 20-year life of a TWH system.

The table below projects the reduction in carbon dioxide achieved by converting from a traditional natural gas tank-based water heater to a natural gas TWH. A medium home would reduce its carbon dioxide production by 7.23 tons over a 20-year period. Total emissions from all household operations for an average American home total approximately 248 tons of carbon dioxide over a 20-year period. Thus, converting to a TWH system would reduce an average US household's carbon dioxide emissions by about 3%.

Reduced Emissions of Carbon Dioxide (tons)

Home Scenario:	A. Small Home	B. Medium Home	C. Large Home
Tons of Carbon Dioxide	3.6	7.2	10.8

Since tank-based water heaters have a service life of only seven to ten years and since every US home has a water heater, the total landfill contribution from retired water heaters is quite large. In fact, the US Department of Energy estimates that Americans deposit 7.3 million traditional tank-based water heaters into landfills each year. Converting American homes to 20-year life TWH systems would eventually cut the number of water heaters deposited in landfills to less than half of that number. Further, since TWHs are much smaller than tank-based water heaters, the volume placed in landfills would decrease even more.

> ***Did you know**...that, according to the US Department of Energy, Americans deposit an estimated 7.3 million traditional tank-based water heaters in our landfills annually?*

PRACTICAL CONSIDERATIONS

In the summer of 2006, we converted our vacation home from three large interconnected tank-based water heaters to two interconnected Rinnai TWHs. Since the vacation home is unoccupied at various points in the year, our primary motivation in converting to TWHs was to eliminate the waste from the stand-by heating of the three water tanks. Our initial research led us to focus on three features of the various TWH candidates:

- Energy Factor (EF)
- Flow rate (in gallons per minute (GPM))
- Modulated control of the heat exchanger

Besides conducting a general web search about TWH systems, we found an excellent web site maintained by the US

Department of Energy, which has a range of information on TWH systems and other water heating topics: **www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12760**

Our vacation home is located near a ski resort in Utah, and when it gets used it gets used a lot. So we were duly skeptical about whether these modest-sized on-wall tankless units could keep up with our demand for hot water after we all return from a day of skiing. Because of the size of the house, the plumber recommended interconnecting two large TWHs to cover the whole house.

The installation took place over two days. Appropriate shut-offs and by-passes were installed between the old and new systems. Since the existing plumbing had a recirculating system for hot water, we decided to install a five-gallon electric hot water heater to coordinate with the recirculating system. Recirculating systems are designed to reduce potable water waste by reducing the time (and amount of water) before hot water reaches an open faucet. Thus, they save water at the cost of additional energy use. However, in Utah, water is a fairly precious commodity.

We remained skeptical until we turned the by-pass valve and tested the new system by turning on all the showers and sinks. After 10 minutes the water was still as hot as at the beginning. With the traditional tank-based water heater system, when four or more showers were running at once, the temperature of the water started to fall within a few minutes. The water remained so hot during our post-installation test that we lowered the digital setting for the two TWH units.

In the process of saving money and reducing our carbon emissions, we also gained a considerable amount of space. The tandem TWH system we installed takes no floor space, compared to the three feet by eight feet of floor space that our traditional system occupied.

- Hal Hinkle, Tim Hinkle, Kasia Duda