

WHOLE-HOUSE TANKLESS WATER HEATERS

Introduction

There are many good water heater technologies available in the marketplace today. This fact sheet is written to provide a more thorough review of whole-house tankless (particularly gas) water heaters as they are a commonly asked about technology. To better understand the options in water heating technology available to consumers, view the U.S. Department of Energy's website: http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12760

Tankless water heaters, sometimes called "on-demand" or "instantaneous" water heaters, work just as their name suggests: they heat water as needed, instead of storing previously-heated water in a tank. When the hot water tap is turned on, cold water travels through a pipe into the unit. A gas burner or an electric element heats the water, which is delivered to the hot water tap. As long as the tap is open, the hot water will flow.

*Note: Though there are also low capacity **point-of-use** tankless water heaters (i.e., units serving only one faucet or appliance), this fact sheet is about high capacity **whole-house** tankless water heaters. Whenever the word "tankless" is used, it refers to whole-house tankless units.*

Advantages

One of the most important benefits of tankless designs is their use of energy only to heat water as needed, rather than keeping a 30- to 50-gallon reservoir of water hot 24 hours a day. And with no tank, there's no need to worry about it bursting and flooding the home.

There are other advantages to tankless water heaters. They are more durable than storage tank heaters, typically lasting 20 years or more, as compared to the 6-to-12-year lifespan of a typical tank heater. And a tankless system is much more compact than a tank heater—looking rather like a large suitcase in size and shape (Figure 1). They can even be installed on the outside of the house, a further saving on space (Figure 2).

In wide use in Europe and other parts of the world, tankless water heaters are still a relatively small segment of the U.S. water heating market. The government's Energy Information Administration reports that as of 2005—the last date for which there are figures—there were 1.1 million tankless units in use. However, the numbers are rising as many homeowners are finding the energy-conserving idea of "heat it as you need it" appealing, to say nothing of the end to running out of hot water.

Disadvantages

The words "instantaneous" and "unlimited" are often used in promoting tankless systems, and it's easy to misunderstand what manufacturers mean when they use them.



Figures 1 and 2.^{1,2} Whole-house tankless water heaters vary in size, capacity, and water flow rates depending on your household needs and the required temperature rise above your local potable water supply. Generally these units are about one foot wide by two feet high by 1 foot deep and weigh 35-80 pounds. Most manufacturers offer both interior and exterior mountable models. When using gas-fired models, direct venting to the outdoors is required. These are but two examples of many units available today.

While the water *does* begin heating "instantaneously" on demand, it still takes time for it to fully heat up and travel through your home's piping to reach your shower or faucet—just as it does with a regular tank heater. A common phenomenon for tankless users is the "cold water sandwich"—even if there's hot water still in the line between the heater and the fixture, you may receive a momentary flush of cold water between the "old" and "new" hot water. This results when the faucet is first turned on, and the heater draws cold water through the system as the heating elements begin warming the water.

And while tankless systems *do* offer "unlimited"—that is, continuous—hot water, the flow rate of that unlimited hot water is based on the capacity of the unit and the plumbing capacity. These are typically sized for your household's *typical* peak water use: for example, two or three people showering at the same time, or one shower and three faucets running simultaneously—not the unlikely scenario where all the faucets, all the showers, the dishwasher, and the washing machine are in use at once.

Also note that a tankless system needs a minimum flow rate to operate, in most cases 0.5 gallons per minute or greater. Below this rate, the heater's burner may not ignite, so you could be out of luck if you

¹ Figure 1 (Left). Tankless Water Heater (2007). From "Depot Walk (Set)," by tom.arthur, uploaded on December 10, 2007. Retrieved on July 1, 2010 from <http://www.flickr.com/photos/tomarthur/2102280267/>. Made available under Creative Commons License, Attribution-NonCommercial-ShareAlike 2.0 Generic.

² Figure 2 (Right). Image_0709_edit, Rinnai R85e tankless water heater (2007). From "New House (Set)," by omiksemaj, uploaded on January 13, 2008. Retrieved on July 1, 2010 from <http://www.flickr.com/photos/omiksemaj/2190763497/>. Made available under Creative Commons License, Attribution-NonCommercial 2.0 Generic.

try to get just a trickle of hot water for shaving. Lastly, unlike the stored hot water of conventional tank systems, tankless designs provide no hot water during power outages (and that includes gas-fired systems, which need electricity for ignition and venting).

While not precisely a disadvantage, keep in mind that water quality may affect the operation of a tankless system. If you live in an area with hard water, the manufacturer may have specific recommendations for keeping your system operating efficiently. Depending on how comfortable you are with "do-it-yourself," you—or a professional—will need to perform maintenance tasks as required by the manufacturer to maintain your warranty.

How Much Energy Can You Save?

Tankless water heaters *are* more energy-efficient than tank-style heaters. In a Central Florida study by the Florida Solar Energy Center, a tankless gas model saved 27% of the energy relative to a standard natural gas tank water heater.³ The U.S. Department of Energy says "For homes that use 41 gallons or less of hot water daily, on-demand water heaters can be 24%–34% more energy efficient than conventional storage tank water heaters. They can be 8%–14% more energy efficient for homes that use a lot of hot water—around 86 gallons per day."⁴

But that energy efficiency may not translate into dollar savings. Installing a tankless system is expensive, and may involve upgrading house utilities, such as natural gas or electric service. This means there will likely be a longer payback period than for a regular tank-type water heater. And as discussed in the disadvantages above, flow rate limitations mean you'll have to evaluate your family's water use patterns in order to determine the tankless system capacity you'll need. (How to calculate your energy and cost savings is discussed in a later section.) Keep in mind that the amount of energy you can save by converting to a tankless system varies according to your home's unique circumstances, including the following:

1. Your home's water heating energy source
2. Your home's water heating temperature "rise"
3. How much water your household typically uses, with instantaneous peak flow rates being more important to tankless system sizing than total water consumption over time

Heat Source

While there are electric, propane, and natural gas whole-house tankless water heaters on the market, most experts recommend against purchasing an electric model because it generally doesn't deliver hot water quickly enough for most users. It often requires upgrading your home's electrical service and, when operating, can draw as much power by itself as your entire home. If every home in the neighborhood had an electrical tankless water heater, the high instantaneous power draw during times of common use, such as morning showers, could combine to raise the local electric utility peak loads. Additionally, using natural gas as a *direct* on-site heat source—rather than burning fossil fuels at the power plant to generate

³ Colon, C. and Parker, D., June 2010, Side-by-Side Testing of Water Heating Systems: Results from the 2009-2010 Evaluation, FSEC-CR-1856-10. Accessed July 12, 2010 at <http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1856-10.pdf>

⁴ "Demand (tankless or instantaneous) water heaters." U.S. Department of Energy, Energy Savers web site. Retrieved on January 27, 2010 from http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12820

electricity, which is then used on-site to generate heat—reduces the impact on climate change and energy conversion losses.

However, watch out for models with a constantly burning pilot light—this can gobble up some of the energy you're hoping to save by switching from a tank-style heater. Check with the manufacturer regarding how much gas is consumed by the pilot light in the model(s) you're considering. This can vary from model to model, so be sure to factor the fuel cost into your buying decision. Better yet, look at models with an intermittent ignition device (IID), which lights the gas heating elements only as needed.

Incoming Water Temperature

It's elementary, Watson: the colder the water is when it enters your house, the more it'll have to be heated for use. This temperature difference is called the *rise*. Experts recommend domestic hot water temperatures of 100-120° F⁵, depending on system design, your personal preferences and water temperature comfort levels. (The building code requires the use of protective anti-scald valves at point-of-use fixtures when hot water supplies exceed 120° F.) In Florida, thanks to our warm climate, the incoming temperature averages about 72-77° F; so the rise is only 30-50°, depending on the time of year, location within the state and how hot you like your morning shower. (Compare this to the 60-70° F rise needed by a home in one of the northern states due to colder air temperature and water supply temperatures.) With a lower rise, a tankless heater can heat more water, faster, and with a higher gallon-per-minute (GPM) output. A model that produces 9.8 GPM when installed in Florida will produce only 5.6 GPM in Vermont because the colder water there requires the temperature to be raised 58 degrees, rather than 28 degrees. More importantly from an efficiency standpoint, less water “rise” requires less energy used to achieve the desired set point.

Note: Be aware that many manufacturers use a hot water temperature of 105° F in calculating temperature rise and flow rates. Other information sources (Department of Energy, *Consumer Reports*, this fact sheet) assume a water temperature of 120° F. Make sure you know your personal comfort zone and the temperature being used as the basis for temperature calculations!

Household Water Use

Determining how much hot water your household uses is one of the most important factors in choosing a correctly-sized tankless water heater for your home. Choose a model that's too small, and you won't have enough hot water available at peak usage times. Choose one that's too large and you'll spend too much on both the unit itself *and* subsequent operating costs.

It's best to consult a plumbing professional to properly determine your household's hot water use and thus, the size of tankless unit to buy. But you can estimate your needs enough to start shopping through these three steps:

1. List the number of hot water devices you typically expect to use *simultaneously*.
2. Add up their flow rates (see the link to the *Consumer Reports* calculator later in this fact sheet).
3. Determine the balance between flow rate and temperature rise for models you are considering. (Most manufacturers list their models' flow rate at a particular temperature rise, so you need to know both when considering the capacity of a particular model.) This is the capacity (i.e., size) you'll want for your home's tankless water heater.

⁵ The Centers for Disease Control and Prevention states, “Water heater thermostats should be set at about 120°F (49°C) for safety and to save 18% of the energy used at 140°F (60°C). Antiscald devices for faucets and showerheads to regulate water temperature can help prevent burns.” (Retrieved on July 1, 2010 from the “Hot Water Safety” section in <http://www.cdc.gov/nceh/publications/books/housing/cha09.htm>)

For example, let's say you rarely expect to simultaneously run more than one hot water faucet— with a flow rate of 0.75 gallons per minute—at the same time as two shower heads, each with a rate of 2.5 gallons per minute. By adding these three fixture flow rates together, you estimate you need a tankless water heater with a capacity to continuously supply at least 5.75 gallons per minute. This is your *peak period use*. Once you know your peak period use, you can look for a tankless model that will deliver that flow rate at a temperature rise consistent with your household needs.

Look at the plumbing layout of your house. If you have a heavy-use fixture like a multiple-head shower, a hot tub, or a Jacuzzi, you may need to consider installing a secondary—"point-of-use"—unit to handle the extra hot water demand. Similarly, if your home is larger, with a distant bathroom or two, you might want an auxiliary point-of-use unit, so there isn't a significant wait for hot water to "arrive" at these distant fixtures.

Consumer Reports makes the point that you want to estimate your *typical* peak period use, not how much hot water is used when you have a houseful of guests.⁶ On the other hand, at least one manufacturer encourages users to consider what they call "realistic" use:

"...for example if you have 3 showers in your home, but you only use one shower, you might think the smallest unit is plenty for your situation. The problem is if you have visiting guests over or if [you] ever sell your home, the hot water demand may be different and the heater may be undersized, possibly causing difficulty in selling your home."⁷

Consumer Reports has a calculator⁸ on their Web site to help you with your estimates at <http://www.consumerreports.org/cro/appliances/heating-cooling-and-air/water-heaters/how-to-size-a-water-heater/tankless-water-heater-calculator/tankless-water-heater-calculator.htm>

Calculating Energy and Cost Savings

Now, having figured all that out, how much energy would a tankless system save you, compared to a standard storage tank heater? First, you need to look at the *Energy Factor* (EF), a number typically reported with system specifications which indicates a water heater's overall energy efficiency based on the amount of hot water produced per unit of fuel consumed over a typical day. The higher the Energy Factor, the more efficient the heater. Unfortunately, simply knowing the EF is not enough to accurately estimate your potential energy savings. One of the simplest energy consumption calculations, the Water Heater Analysis Model (WHAM), factors in seven major variables as follows:⁹

- **System-determined variables**
 1. Water heater recovery efficiency (i.e., how efficiently the heat from the energy source is transferred to the water) and cycling losses (i.e., the loss of heat as the water circulates through inlet and outlet pipes and within any storage volume)
 2. Water heater rated input power
 3. Water heater standby heat loss coefficient (i.e., the percentage of heat loss per hour from the stored water compared to the heat content of the water)
- **Location- and household-determined variables**
 4. Water heater thermostat set point

⁶ "Tankless water heaters: They're efficient, but not necessarily economical." *Consumer Reports*, October 2008. Retrieved on July 1, 2010 from <http://www.consumerreports.org/cro/appliances/heating-cooling-and-air/water-heaters/tankless-water-heaters/overview/tankless-water-heaters-ov.htm>

⁷ Retrieved on July 1, 2010 from <http://noritz.com/homeowners/services/faqs>.

⁸ No subscription is required for use of this calculator.

⁹ A more complete description and listing of the WHAM equation can be found in "Calculating Water Heater Energy Use" from *Home Energy Magazine Online* (July/August 1999) available at <http://www.homeenergy.org/archive/hem.dis.anl.gov/eehem/99/990707.html>

Conserve Your Hot Water

Remember, even the most energy efficient water heating system won't save you money if you don't also practice water conservation and efficiency measures† such as:

Free measures:

- Setting the water heater temperature at 120° F or lower
- Practicing conservation behaviors that lead to reduced hot water use (e.g., turning off faucets while brushing your teeth, while hand cleaning dishes, washing fewer but larger loads of laundry, running the dishwasher only when it's full, etc.)

Low-cost measures:

- Installing low-flow showerheads and faucets
- Installing shut-off valves in showerheads and faucets, which dribble when closed so as to maintain water in the pipe at the selected temperature while soaping, shampooing or shaving
- Insulating hot water pipes
- Fixing all leaks

Moderate- to high-cost measures:

- Installing ENERGY STAR clothes washers and dishwashers
- Installing a drain-water heat recovery system
- Minimizing the piping runs to the kitchen, laundry room and bathrooms when building new or remodeling

† http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=13030

5. Inlet (i.e., supply) water temperature
6. Ambient air temperature immediately surrounding the water heater
7. Volume of water drawn through the system per day

Discouraged? Don't be: the U.S. Department of Energy has cost calculators that make it much easier to work out annual and lifetime energy costs and determining payback for water heaters. These are available at the following links:

- Estimating a Storage, Demand, or Heat Pump Water Heater's Costs:
http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=13010
- Energy Cost Calculator for Electric and Gas Water Heaters:
http://www1.eere.energy.gov/femp/technologies/eep_waterheaters_calc.html

More complete calculations (like the TANK and WATSIM simulations) can be complex and the results will vary according to household water consumption patterns. However, “using the DOE test procedures for calculations, a whole-home gas tankless water heater with a 0.82 Energy Factor would consume 183 therms per year—a savings of 30%, or 78 therms, in comparison to the typical gas storage water heater.”¹⁰ Keep in mind that models may include freeze protection features that require additional electricity and/or gas and that units do use electricity in standby mode.¹¹

¹⁰ Excerpted on July 1, 2010 from

http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/WaterHeaterAnalysis_Final.pdf

¹¹ “Rinnai’s On-Demand Water Heater.” Energy Design Update, December 2003, Vol. 23, Issue 12, pp. 11-13.

Generally, look for a high efficiency model, especially those branded as ENERGY STAR[®] qualified models, which are products that meet strict energy efficiency guidelines set by the U.S. Environmental Protection Agency and the U.S. Department of Energy. Don't forget to consider the operational cost of the water heater you select, especially if you are switching from one fuel source to another (e.g., replacing an electric tank water heater with a tankless natural gas system). Lastly, don't forget to include the utility charges in the form of administrative fees that you would need to pay if switching from electricity to gas.

Installing a tankless system

Converting to a tankless system can be a major job, and one that you probably don't want to attempt on your own. Tankless models often need upgraded gas piping, make-up air/ventilation piping—work that is beyond the capacity of the usual do-it-yourselfer—as well as electric service for their electronic controls and fan. Here are some things to consider regarding installation.

Water quality

If you have hard water in your area, ask the supplier about the effect of the minerals on your model. They may recommend specific add-ons to your system, annual flushing or other service, or addition of a water-softening system. Some manufacturers' warranties do not cover damages resulting from scale build up or failure to properly maintain the systems. Don't forget to account for these costs in your calculations.

Hire an expert

Use an installer that is certified by the manufacturer to install and service your unit. Some companies will extend the warranty if you do. Make sure the installer is knowledgeable about, and licensed to work with, gas systems (some plumbers are not) and how to make the necessary alterations. Poor installation may cause other gas appliances to operate improperly when the heater is running.

Utilities may need to be upgraded

Tankless heaters can use a lot of gas when operating at maximum capacity (sometimes over 200,000 BTU/hour). Often, the typical home gas system is not properly sized for the demand and will need to be upgraded from the typical low-pressure system to a high-pressure 2 PSI system to accommodate the larger load. This higher pressure means regulators will need to be installed for each existing appliance as well—and it can be difficult to find the required space to install the bulky regulators behind an oven or fireplace.

Furthermore, tankless water heaters require upgraded ventilation systems with different piping requirements and materials. Some installers suggest it's generally easier to mount the heater on the outside of the house, rather than inside so as to avoid the extra cost and materials required for interior venting.

Other useful features

Consumer Reports suggests the following are additional features to consider:

- an oxygen-depletion sensor that shuts off the water heater if carbon monoxide is detected
- a film wrap around the heat exchanger that will shut off the device if it gets too hot

Get paid to go tankless

As mentioned earlier, tankless water heaters are expensive, both to purchase and to install, which means they have a longer payback period than conventional tank storage heaters. However, many tankless models qualify for rebates and tax incentives that can help cover those costs and make the overall financial picture more attractive. The U.S. Department of Energy maintains a Web site called the Database of State Incentives for Renewables and Energy (DSIRE)¹², with easy-to-search pages listing federal, state, and local tax incentives, rebates, and other financial support to subsidize the conversion to more energy-efficient technologies.

Additional References and Resources

Consumer Reports – Tankless Water Heaters <http://www.consumerreports.org/cro/appliances/heating-cooling-and-air/water-heaters/tankless-water-heaters/overview/tankless-water-heaters-ov.htm>

North Carolina Cooperative Extension – Tankless Water Heaters: A New Option for Homeowners <http://polk.ces.ncsu.edu/content/Hot+water+on+demand>

U.S. Department of Energy – Demand (Tankless or Instantaneous) Water Heaters http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12820

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First published July 2010.

This is a fact sheet in *The Carbon Challenge Series* for the Florida Energy Systems Consortium (FESC). The goal of the consortium is to become a world leader in energy research, education, technology, and energy systems analysis. For more information, go to www.FloridaEnergy.ufl.edu

¹² <http://www.dsireusa.org/>