Electric Tankless Water Heating: Competitive Assessment

1285-5-04

Global Energy Partners, LLC
AN EPRI, DMJMH+N COMPANY

EPRI

EPRI Retail Technology Application Centers

Electric Tankless Water Heating: Competitive Assessment

1285-5-04

Final Report, March 2005

Global Project Manager
R. Milward

Global Energy Partners, LLC • 3569 Mt. Diablo Blvd., Suite 200, Lafayette, CA 94549
Tel. 925-284-3780 • Fax 925-284-3147 • www.gepllc.com

DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITIES

THIS DOCUMENT WAS PREPARED BY GLOBAL ENERGY PARTNERS, LLC (GLOBAL), A SUBSIDIARY OF EPRISOLUTIONS, INC., AND IS ONE OF THE FAMILY OF COMPANIES OF THE ELECTRIC POWER RESEARCH INSTITUTE, INC. (EPRI). NEITHER GLOBAL NOR ANY PERSON ACTING ON ITS BEHALF:

(A) MAKES ANY WARRANTY OR REPRESENTATION WHATSOEVER, EXPRESS OR IMPLIED, (I) WITH RESPECT TO THE USE OF ANY INFORMATION, APPARATUS, METHOD, PROCESS, OR SIMILAR ITEM DISCLOSED IN THIS DOCUMENT, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, OR (II) THAT SUCH USE DOES NOT INFRINGE ON OR INTERFERE WITH PRIVATELY OWNED RIGHTS, INCLUDING ANY PARTY'S INTELLECTUAL PROPERTY, OR (III) THAT THIS DOCUMENT IS SUITABLE TO ANY PARTICULAR USER'S CIRCUMSTANCE; OR

(B) ASSUMES RESPONSIBILITY FOR ANY DAMAGES OR OTHER LIABILITY WHATSOEVER (INCLUDING ANY CONSEQUENTIAL DAMAGES, EVEN IF GLOBAL OR ANY GLOBAL REPRESENTATIVE HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES) RESULTING FROM YOUR SELECTION OR USE OF THIS DOCUMENT OR ANY INFORMATION, APPARATUS, METHOD, PROCESS, OR SIMILAR ITEM DISCLOSED IN THIS DOCUMENT.

ORDERING INFORMATION

Requests for copies of this report should be directed to Global Energy Partners, LLC 3569 Mt. Diablo Blvd., Suite 200, Lafayette, CA 94549. Telephone number: 925-284-3780; fax: 925-284-3147

CITATIONS

This report was prepared by

Global Energy Partners, LLC
3569 Mt. Diablo Blvd.
Lafayette, CA 94549

Principal Investigators
J. Prijyanonda
R. Milward

The report is a corporate document that should be cited in the literature in the following manner:

Electric Tankless Water Heating: Competitive Assessment, Global Energy Partners, LLC, Lafayette, CA: 2005. 1285-5-04.

PRODUCT DESCRIPTION

Tankless (also known as “demand,” “point-of-use,” or “instantaneous”) electric water heating has the potential to displace gas water heating in certain markets to beneficially grow electric load for utilities that are interested in increasing their electricity sales. For utilities that are interested in promoting energy efficiency, electric tankless water heaters potentially offer elimination of standby losses when used in place of storage tank hot water systems. However, electric tankless water heaters can potentially increase electricity demand as well. As such, utilities would benefit from understanding the competitive advantages and challenges of electric tankless water heaters relative to other water heating options prior to embarking on any program to support this technology.

Results & Findings

This report presents an analysis of the competitive advantages and disadvantages of electric tankless water heaters, and identifies possible market barriers to this technology.

Challenges & Objectives

The objective of this report is to provide an unbiased look at the different types of tankless water heaters on the market – including both electric and natural gas as well as whole-house and point-of-use – and the advantages and disadvantages of each type from the point-of-view of both the homeowner and the utility.

Approach

This objective was accomplished through interviews with tankless water heater manufacturers and a thorough review of secondary sources of information, including articles, reports, and the Internet.

Keywords

Water heating
Tankless water heater
Instantaneous water heater
Demand water heater
Point-of-use water heating

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1
INTRODUCTION

Tankless (also known as "demand," "point-of-use," or "instantaneous") electric water heating has the potential to displace gas water heating in certain markets to beneficially grow electric load for utilities that are interested in increasing their electricity sales. For utilities that are interested in promoting energy efficiency, electric tankless water heaters potentially offer elimination of standby losses when used in place of storage tank hot water systems. However, electric tankless water heaters have the potential to increase electricity demand, as well. As such, utilities would benefit from understanding the competitive advantages and challenges of electric tankless water heaters relative to other water heating options prior to embarking on any program to support this technology.

Background

Water heating accounts for about 15.5 percent of residential-sector fuel use, which corresponds to 1.75 quads of energy consumption. Electric water heating represents 9.5 percent of residential electricity consumption.[1] The majority of residential water heaters (54 percent) are natural gas models and about 38 percent of are electric.[2]

In the commercial sector, water heating accounts for 10 percent of commercial-sector fuel use, which corresponds to 0.8 quads of energy consumption.[3] Fuel consumption for water heating is highest in lodging establishments, hospitals, and restaurants (0.27, 0.22, and 0.19 quads, respectively). Water heating's share of fuel consumption for these building types is 35, 18, and 32 percent, respectively.[4]

Electric utilities have typically found it difficult to compete in the water heating market because of the unfavorable economics of electricity relative to gas. Where available, natural gas or liquid propane gas is typically the fuel of choice for heating water, particularly in the commercial sector.

---

[1] U.S. Department of Energy. Office of Energy Efficiency and Renewable Energy. 2004 Buildings Energy Databook. January 2005. 17 March 2005. < http://buildingsdatabook.eren.doe.gov/>.

[2] U.S. Department of Energy. Energy Information Administration. 2001 Residential Energy Consumption Survey. April 2004. 17 March 2005. <http://www.eia.doe.gov/emeu/consumption>.

[3] U.S. DOE EERE. January 2005.

[4] Sezgen, Osman and Jonathan G. Koomey. 1995. *Technology Data Characterizing Water Heating in Commercial Buildings: Application to End-Use Forecasting.* LBL-37398. Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, CA. December.

In the residential sector, the most common type of water heating technology is the storage tank. This technology heats water from the residence's domestic supply to the desired temperature (usually between 120°-140°F) within a sealed tank that ranges in size from 20 to 80 gallons. The heated water is stored within the same tank at the desired temperature until a faucet or other use draws off water. It is the storage of heated water in the tank that produces the inefficiency most associated with storage tank water heaters: "standby losses." The heat conducted and radiated from the walls of the tank – and through the flue pipe in gas-fired water heaters – are the standby losses, and they represent 10 to 20 percent of a household's annual water heating costs. Even if no hot water is drawn from the tank, the heater must operate periodically to maintain the water's temperature, which decreases due to the standby losses.

The most common types of water heating technologies in the commercial sector are storage tank systems and recirculating-loop water heating systems. Recirculating-loop water heating systems also typically have a hot water storage tank. However, to reduce the wait time for hot water at the faucet or point-of-use, the hot water is pumped continuously around a distribution loop, from which individual users draw hot water as needed. Once again, standby losses – which besides the losses for storage tank systems, also include the heat lost through the distribution loop of recirculating-loop systems – require that the heater operate periodically to maintain the water temperature.

Tankless water heaters can potentially help reduce the standby losses associated with hot water heating. Tankless water heaters are very common in Europe and Japan. Although they are slowly becoming more common in the residential market of the U.S. because of recent improvements in flow technologies, they still have very low penetration in both the residential and commercial markets.

Description of Tankless Water Heating Technology

A tankless water heater works by using heating elements that are activated by the flow of water when there is demand for hot water (e.g. someone takes a hot shower, etc.). Water is heated instantly as it flows through the tankless water heater. Since it does not store hot water in anticipation of demand, there is no storage tank (thus the term "tankless"). Tankless water heaters heat are available in either electric and natural gas models.

In electric tankless water heaters, the heating elements convert electrical energy into heat, and the elements are usually placed in direct contact with the water so that heat is directly transferred into the flow. The electric elements heat up when the flow of water begins and turn off when the water flow stops. Figure 1-1 shows the internal components of a typical electric tankless water heater.

In gas tankless water heaters, the heating elements are in the form of heat exchangers that transfer heat from the hot combustion gases to the water. Because of the combustion process, a gas tankless water heater requires access to combustion air, and an exhaust vent is required for expelling the flue gases. Gas models use either a pilot light or electronic ignition as their ignition source. Like electric models, the start of the water flow initiates the flow of gas into the combustion chamber, where it is ignited by the ignition source.

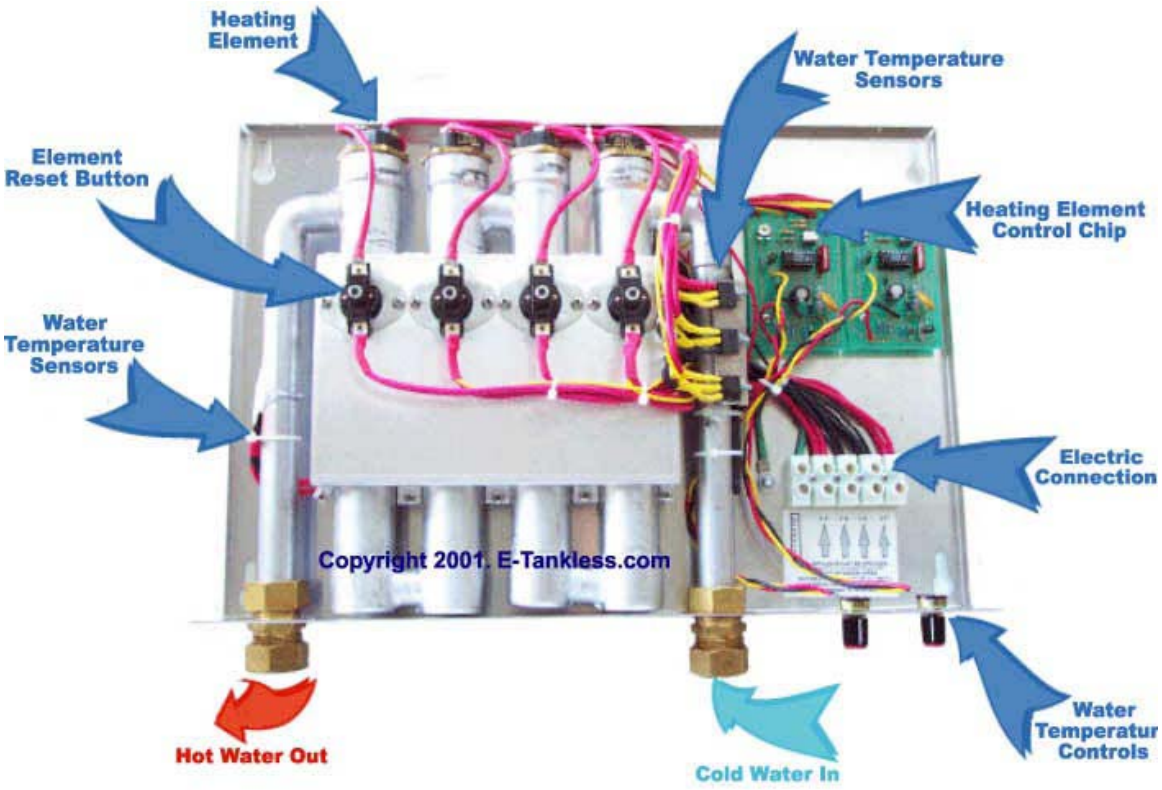

Figure 1-1
The Components of a Electric Tankless Water Heater
(Illustration courtesy of S.E.T.S. Systems Inc.)

Water flow rate is usually measured in units of "gallons per minute" (gpm). It is important to note that as the demanded flow rate of hot water increases, the tankless water heater's ability to raise water temperature decreases (and vice versa). For example, if the demanded flow rate of hot water from a given tankless unit is 4 gpm, then it may be able to increase the temperature of incoming water by only 50°F. However, if the demanded flow rate from the same tankless unit is 1 gpm, then it may be able to increase the temperature of incoming water by 90°F. Thus, when rating the capacity of a tankless water heater, it is necessary to note both the maximum flow rate as well as its corresponding rise in water temperature.

For residential hot water needs, such as showers and clothes washing, hot water at a temperature of 120°F is typically required. If the incoming supply water temperature is 50°F, then the tankless water heater will need to raise the water temperature by 70°F. In this particular case, the flow rate at which a tankless water heater can raise the water temperature by 70°F is the maximum capacity of the unit. The tankless unit is properly sized if this flow rate is sufficient for meeting the hot water demand within the home at any point in time. The demand can be determined by adding up all the hot water uses that could occur simultaneously. Figure 1-2 provides examples of typical hot water demand for various residential uses.

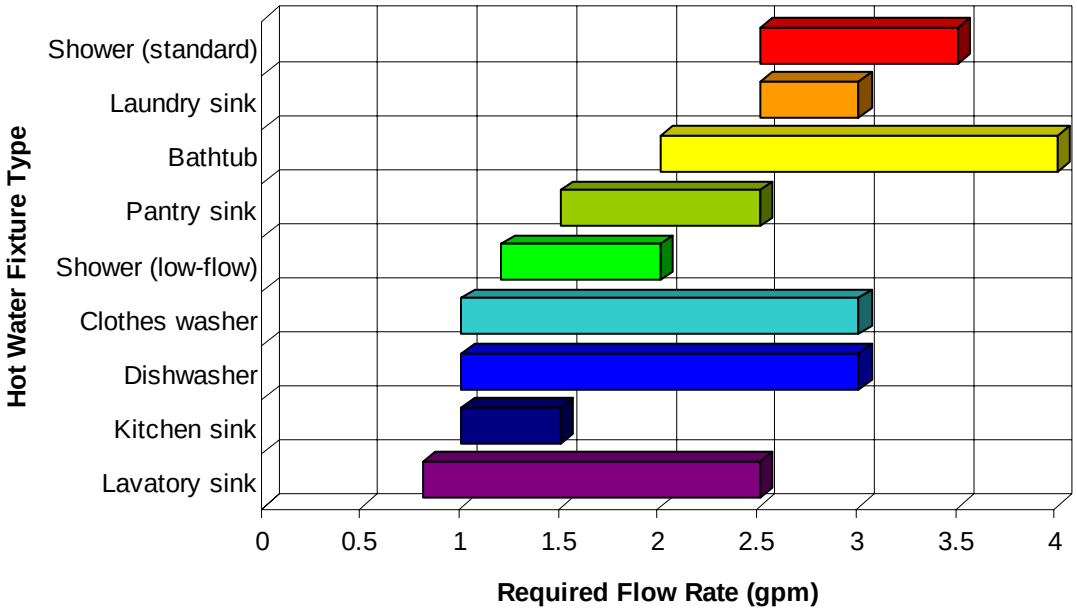

Figure 1-2
Typical Residential Hot Water Demand [5,6]

If the total demand for hot water exceeds the tankless water heater's maximum flow rate capacity, then it will not be able to heat the water to the desired temperature (as previously mentioned, a hot water temperature of 120°F is typically required for common household applications such as showers and clothes washing). In conclusion, the outlet water temperature is a function of the size of the unit's heating elements, the water flow rate, and the temperature of the incoming water.

Historical Sketch of Tankless Water Heaters

Tankless water heaters have been available in Europe for some time and have achieved a significant market share there. A 1998 study by the Austrian Energy Agency for the European Commission found that, overall, about 30 percent of European residences use tankless electric water heaters. The penetration rates for individual countries include the following:

- 50 percent of households in Greece
- 35 percent of households in Sweden
- 13 percent of households in Finland
- 6 percent of households in the Netherlands
- 2 percent of households in Belgium

[5] U.S. Department of Energy. Office of Energy Efficiency and Renewable Energy. January 2003. 1 March 2005. "Demand (Tankless or Instantaneous) Water Heaters." <www.eere.energy.gov/consumerinfo/ factsheets/bc1.html>.
[6] Dulley, J. Update Bulletin No. 678. March 2004. < www.dulley.com>.

- 1 percent of households in the United Kingdom

While these figures are relatively high, it appears that tankless electric water heaters have hit their peak market penetration in Europe. Only in Finland is the number of instantaneous electric heaters expected to rise over the next decade.

The first tankless water heaters available in the U.S. were designed to provide near-boiling (190°F) water instantly at the kitchen sink for hot beverage service. Later, in the 1980's, tankless models intended to produce hot water for faucets and showers became available. However, the use of tankless water heaters in the U.S. has grown at a slow pace since then. Even now, the U.S. Department of Energy's Residential Energy Consumption Survey (RECS) does not include tankless water heaters as a type of water heating technology in its survey of home energy-consuming equipment.

Objectives of this Study

The objectives of this study are to:

- Assess the advantages and challenges of electric tankless water heaters;
- Assess the load impact potential of electric tankless water heaters;
- Identify available products and appropriate markets/applications for electric tankless water heaters.

Technical Information Collection

Several manufacturers of tankless water heaters were interviewed to determine, among other details, the following information:

- The type(s) of tankless water heaters they manufacture (whole-house, point-of-use, natural gas, electric),
- Where their products are sold (home improvement centers, plumbing supply stores, etc.),
- Market barriers/obstacles to tankless water heaters, and
- How electric utilities can help them sell more tankless water heaters.

2
APPROPRIATE APPLICATIONS

This section discusses the different applications of electric tankless water heaters. Residential and commercial applications are addressed separately. In terms of market outlook, each manufacturer of tankless water heaters interviewed for this study indicated that they expect to see strong sales growth in both sectors, although one manufacturer indicated that they are more active in promoting tankless water heaters for commercial applications.

Residential Applications

In residential settings, users have two basic options for installing the electric tankless water heaters: (1) whole-house installation, or (2) point-of-use installation. Both of these are discussed below.

Whole-House Installation

A whole-house installation refers to the situation where a single tankless water heater provides hot water for the entire home. This type of installation is analogous to the centrally-located standard tank water heater. In fact, a common practice in retrofit situations is to remove the existing tank water heater and install the tankless water heater in the same physical space as the tank water heater.

As previously mentioned, the water heating capacity of electric tankless water heaters are ultimately limited by the ability of the house's electrical system to supply enough power to operate the unit. Most homes in the U.S. typically have an electric service in the range of 100-150 amps. Older homes tend to have only 100 amps or lower. Given this condition, installing electric tankless water heaters in retrofit situations will often require an upgrade in the home's electrical system to 200 amps or more (depending on the capacity of the unit to be installed). Even with the upgrade, however, most homes are still limited to an electric tankless water heater with a maximum flow rate of 3.0 gpm due to large power draw of the unit. A check back at Figure 1-2 reveals that 3.0 gpm is barely enough for servicing a maximum of two simultaneous hot water needs (e.g. two showers running at the same time, etc.). As such, gas tankless water heaters tend to be more appropriate for whole-house installations than electric tankless water heaters because gas tankless units can go up to 7.0 gpm in residential applications.

Figure 2-1 shows an example of a whole-house installation of a gas tankless water heater. Note the presence of vents at the top of the unit for combustion air and exhaust of the flue gases.

Figure 2-1
Whole-House Installation of Gas Tankless Water Heater
(Illustration courtesy of Controlled Energy Corp.)

During one of the interviews conducted as part of this study, one manufacturer mentioned that the whole-house installations of tankless water heaters seem to be more popular than point-of-use installations amongst homeowners. However, this same person also said that his company sells more gas tankless units than electric tankless units, and the gas tankless units tend to be larger in capacity and thus more appropriate for whole-house applications than electric tankless units.

The main drawback of installing tankless water heaters at the whole-house level is that the hot water must still travel to the fixture. This means that the hot water will not "instantaneously" arrive at the fixture; users will still have to wait for hot water to arrive just as with the standard tank water heater. If the hot water pipes are uninsulated, the hot water can lose 10°F or more by the time it arrives at the fixture.[7] Also, there will be heat loss from any unused hot water remaining between the tankless water heater and the fixture.

Point-of-Use Installation

Point-of-use installations of tankless water heaters are sometimes called "instantaneous" or "demand" because the user receives hot water almost immediately after the fixture is turned on. The tankless water heater is installed at the point-of-use, such as under the kitchen sink or in the bathroom. The proximity to the fixture virtually eliminates waiting time for hot water to arrive at the fixture, and also greatly reduces any heat loss that can occur if the hot water pipes are uninsulated. The following Figure 2-2 shows a point-of-use installation of an electric tankless water heater.

[7] Seitz, David. "The Guide to Tankless Water Heaters." Endless Hot Water from Seisco. 2001. 1 March 2005. <www.seisco.com/pages/gas_vs_electric.html>.

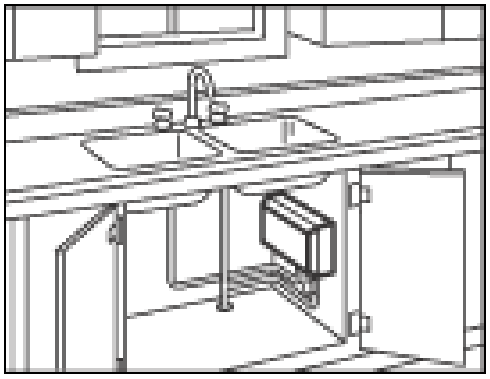

Figure 2-2
Point-of-Use Installation of Electric Tankless Water Heater
(Illustration courtesy of Controlled Energy Corp.)

In residential point-of-use installations, electric tankless water heaters are more common than gas tankless water heaters because the electric units' smaller physical dimensions allow them to fit into small spaces such as the cabinets under a sink. Also, electric tankless units do not require combustion air and an exhaust vent, and thus can be placed virtually anywhere in the home. A homeowner choosing to install tankless water heaters at the point-of-use may have several small units located at different locations in the house. However, the total number of units that can be installed is still limited by the home's electrical system capacity.

Commercial Applications

All the manufacturers of tankless water heaters interviewed as part of this study claimed that tankless water heaters could be used in any commercial application requiring hot water. Hot water consumption patterns in most commercial buildings are characterized by either of the following: (1) very high hot water demand, or (2) very low hot water demand. Hotels and hospitals are examples of the former category, while small retails and offices are examples of the latter. Although several manufacturers make large-capacity tankless water heaters (for example, Keltech Inc. produces electric units that have 288 kW heating elements and can provide up to 80 gpm of hot water flow rate), the economics of these large units make them feasible only in specialized industrial processes.

On the other hand, tankless water heaters are highly suitable for point-of-use installations in commercial applications where there is only an occasional demand for hot water. In situations where there is low demand for hot water, the financial benefits of reducing or eliminating standby heat losses by using point-of-use installations tend to make them more favorable compared to the alternative of using a standard tank water heater. The following are examples of applications of point-of-use installations in commercial settings:

- According to new safety standards, emergency eyewash stations in certain types of industrial facilities are required to supply warm water. An example of one such facility is a pulp and paper processing facility in British Columbia (BC), Canada. The facility's engineer decided to install tankless electric water heaters at each emergency eyewash station because it was

much more economical compared to running new hot water lines from the facility's industrial boilers.

- Science World, a museum in Vancouver, BC, has an exhibit called "Water Table" that allows children to make dams or float a boat down a stream in order to teach them about water currents. They wanted to make the water warm so that the children would not end up with cold hands. The museum decided to install an electric tankless unit to heat the water for the exhibit because they discovered that it would be too expensive to plumb in hot water lines from their industrial boilers and there was no room in which to store a water heater tank in the Kidspace area.
- A recent EPRI project comparing point-of-use electric water heaters with a gas-fired recirculating-loop water heating system showed that, from a total system perspective, the electric tankless water heaters used about half the energy of the gas recirculating-loop system. Based on a small-scale field test in a Portland, Oregon high school with typical hot water fixtures (e.g. restroom sinks, janitorial sinks, etc.), the comparison showed the electric tankless water heaters reduced annual energy consumption by 91 percent compared to the gas-fired recirculation system, and operating costs by approximately 75 percent. If installed at the time of gas water heater failure, the electric tankless water heaters would have a payback period of less than 5 years. In new construction situations, the payback would be considerably faster.[8]

[8] *Field Test Comparison of a Potable Hot Water Recirculation-Loop System Vs. Point-of-Use Electric Resistance Water Heaters in a High School*, EPRI, Palo Alto, CA: 2002. 1007022.

3
COMPETITIVE ANALYSIS OF ELECTRIC TANKLESS WATER HEATING

The objective of this chapter is to compare the electric tankless water heater technology to two other alternatives: (1) the conventional gas-fired storage (tank) water heater, and (2) the gas tankless water heater. The electric tankless water heater technology will be evaluated relative to these two alternatives on a number of technical and financial issues.

Technical Issues

The most important technical issues concerning electric tankless water heater and its two alternatives are:

- Hot water flow rate,
- Hot water temperature control,
- Installation,
- Service life, and
- Energy savings.

Hot Water Flow Rate

As discussed in the previous chapter, the hot water demand on a water heater is the sum of the individual flow rates of all fixtures (e.g. showers, sinks, clothes washers, etc.) that draw hot water at any given point in time. If this sum is greater than the water heater's maximum rated flow rate, then the water heater will not be able to generate enough hot water to satisfy the demand from all the fixtures. In addition, the temperature of the hot water generated by the water heater is also a reverse function of the flow rate; the faster the flow rate, the lower the temperature of hot water, and vice versa.

Users of conventional storage water heaters usually do not need to be concerned with flow rates and hot water temperature issues because there is a large amount of hot water (typically 20 to 80 gallons in residential installations) stored in the tank that can satisfy the entire hot water demand from many fixtures simultaneously. The only way users cannot get sufficient amounts of hot water is in the rare occasions when the hot water demand is high enough such that the water heater is not able to replenish its tank at a faster rate than the demand for hot water.

Both electric and gas tankless water heaters can supply hot water only up to their maximum rated flow rate. If this maximum flow rate is exceeded, then water will exit the tankless water heater before it reaches the desired temperature.[9] For this reason, tankless water heaters cannot support many simultaneous uses of hot water. Many manufacturers claim that their tankless water heater products can supply an "unlimited" amount of hot water. This claim is only realistic if the tankless water heater is installed in settings where it would only have to serve one or two uses of hot water simultaneously.

For reasons that will be discussed later in this chapter, a user opting for an electric tankless water heater would be able to install a unit that is smaller in capacity than if he were to install a gas tankless water heater. In residential applications, this translates into an electric tankless water heater with a maximum rated flow rate of about 4 gpm. Such a unit may be able to supply only two showers simultaneously or perhaps one shower, a dishwasher, and a sink simultaneously. If the household is a large family that could use a large amount of hot water at the same time, then it is easy to see that a single electric tankless water heater could not adequately meet the family's demand in a whole-house installation. This family would have to install several electric tankless water heaters at the point-of-use. However, installing the electric tankless water heater at the point-of-use has the advantage of being able to provide "instantaneous" hot water. A single gas tankless water heater may be better able to satisfy a small family's hot water demand in a whole-house installation, since these units can go up to about 6-7 gpm in residential applications.

Both electric and gas tankless water heaters have a minimum flow rate threshold below which the unit will not activate and generate hot water. Tankless water heaters have flow-detection devices that will activate the unit once the water flow rate exceeds a certain point. Each manufacturer has its own flow-detection technology. Thus, if a faucet draws a maximum of 0.5 gpm of hot water, and the tankless water heater has a minimum flow rate requirement of 0.7 gpm, no hot water would be supplied to the faucet. However, a review of several manufacturers' specifications of their tankless water heater products revealed that electric tankless units currently sold in the market are available with lower minimum flow rate requirements than gas tankless units.[10] As such, gas tankless water heaters are generally not appropriate for point-of-use applications where the unit would be serving only one or two fixtures. Conventional tank water heaters can supply hot water without having to meet a minimum flow requirement.

Hot Water Temperature Control

Conventional storage water heaters maintain a constant hot water temperature, and any hot water drawn from the storage tank flows to the fixture at a constant temperature (ignoring pipe losses) regardless of the flow rate. As previously mentioned, the hot water temperature generated by tankless water heaters is dependent upon the flow rate. In fact, without temperature controls, the temperature of the hot water generated by the tankless unit will be highest immediately after the

[9] Carter, T. "Tankless Water Heaters – Some Surprising Facts." *Ask The Builder*. <www.askthebuilder.com/451_Tankless_Water_Heaters_-_Some_Surprising_Facts.shtml>.

[10] Flow rate data for selected tankless water heaters produced by 16 manufacturers is available in Dulley, 2004.

flow surpasses the unit's minimum flow rate threshold. As the flow rate increases after that point, the hot water temperature decreases proportionately.

As such, one can imagine that the hot water temperature generated by a tankless water heater could fluctuate uncomfortably, especially if the unit is installed in an area where the inlet water pressure can vary unpredictably. Also, since the temperature is highest at very low flow rates, there is the danger of users being scalded by hot water. In order to address this issue, some electric and gas tankless water heaters currently on the market have modulating functionality that allows the units to supply hot water at a constant temperature at different flow rates. The user simply sets the desired outlet water temperature, and the unit will maintain this temperature regardless of the flow rate by modulating the heating elements accordingly. One manufacturer indicated that, from a technological standpoint, it is easier to implement modulation functionality in electric tankless water heaters than in gas tankless water heaters.

Installation

Installation of a conventional gas-fired storage water heaters generally requires the following; (1) a gas line, (2) adequate space for the entire tank-water heater unit, (3) adequate access to combustion air, and (4) flue exhaust for the post-combustion gases. A gas tankless water heater would require a lot less physical space, since a typical unit can be hung on a wall. It would typically require no larger than 24 inches square of wall area and extend from the wall only about 8 to 10 inches.[11] Otherwise, a gas tankless water heater has the same requirements as a conventional gas-fired storage water heater.

Most gas tankless units will require a gas supply pipe and line pressure greater than conventional gas-fired storage water heaters (at least seven inches of water column). Air requirements for combustion are on the order of 50 cubic feet per 1,000 BTUh of rated input. Therefore, if the gas tankless water heater is located in a closet, there must be louvers or vents allowing sufficient air into the closet for combustion. Exhaust of the flue gases may be sized anywhere from a 3-inch to a 6-inch vent for most residential models.[12] These air and exhaust requirements make it difficult to install a gas tankless water heater in enclosed spaces typically found in point-of-use applications.

Like their gas counterparts, electric tankless water heaters also do not require much physical space for installation. However, electric tankless units have the advantage of not requiring combustion air and flue exhaust, thus making it highly appropriate for installations at virtually any location including point-of-use applications.

[11] Tidwell, J. and Clamp, A. "Tankless Water Heaters: Energy Savers or Demand Busters?" Coopertive Research Network. September 2004. <www.cooperative.com/crn/private/MES/TechSurveillance/2004/MES_Q3_ Report.html>.

[12] NAHB Research Center, Inc. *Domestic Hot Water System Modeling for the Design of Energy Efficient Systems*. Prepared for NREL. April 2, 2002.

It takes approximately 147 Watts of electricity to heat water flowing at one gallon per minute by one degree Fahrenheit.[13] As such, electric tankless water heaters draw a large amount of electrical current such that most installations will require an upgrade in electric service. For instance, the heating elements in electric tankless water heaters installed in residential applications demand electricity in the range of 2.4 kW to 28 kW. In contrast, conventional electric storage water heaters usually do not demand more than to 5 kW. The smaller tankless units may operate on 120 volts while the larger units over about 3.5 kW will operate on 240 volts.

For the homeowner, these electrical requirements require an electric service that can provide a large amount of electric current. One manufacturer indicated that older homes typically only have 100 amps of electric service capacity, while newer homes may have up to 200 amps of electric service. Considering that large electric tankless water heaters for residential applications can draw 120 to 160 amps of current, most older homes will require an upgrade to their electric service in order to accommodate the electric tankless unit. Newer homes with 200 amps of service will likely also require an upgrade, since these homes will only have 40-80 amps remaining for other electrical uses if no upgrade is made. Without an upgrade, the largest electric tankless unit that newer homes can accommodate is likely to be one of only 3 gpm of capacity.[14]

An upgrade to a home's electric service usually involves changing to heavier gauge wires and installing a circuit breaker that can handle the higher electric current draw. Furthermore, a larger and more expensive meter loop and main panel for the house may also be required.

Service Life

Conventional storage water heaters typically lasts 10 to 15 years. In contrast, the manufacturers of electric and gas tankless water heaters interviewed as part of this study indicated that tankless units have a longer life expectancy than conventional water heaters. The U.S. Department of Energy also indicated that tankless units last more than 20 years.[15]

The main driver of a water heater's life is the accumulation of minerals such as calcium inside the unit. A conventional storage water heater stores large amounts of water within its tank for relatively long periods of time, and minerals dissolved in the water can accumulate on the insides of the tank as well as on the heating elements. Most manufacturers of tankless water heaters claim that, since tankless units do not store water and only a small amount of water actually remains inside the unit when there is no flow, there is less opportunity for minerals to deposit and collect inside the unit. However, the results of a recent test conducted by Bradford White Corp. found that gas tankless water heaters are more susceptible to lime scale buildup than

[13] Ibid.

[14] In materials posted in their website, S.E.T.S. Systems Inc. (a manufacturer of electric tankless water heaters) acknowledges this limitation. <www.e-tankless.com/products.php>.

[15] U.S. DOE EERE. January 2003.

conventional storage water heaters.[16] Another article published by an electric utility claims that electricity tankless water heaters also have more problems with scaling and residues because the small amount of hot water remaining in the unit constantly causes minerals to boil out and deposit on the heating elements.[17] As such, no conclusion can yet be made about whether tankless units last longer than conventional storage water heaters.

Manufacturers of electric and gas tankless water heaters seem to disagree about which technology has the longest service life. Predictably, a manufacturer that only produces electric tankless water heaters interviewed as part of this study indicated that electric tankless units have longer service life than their gas counterparts. Another manufacturer that only produces gas tankless water heaters claimed exactly the opposite. However, a third manufacturer that produces both tankless technologies indicated that gas tankless units experience less mineral buildup, and they back up this claim by providing a longer warrantee period for gas tankless units.

Energy Savings

When cold water enters the inlet of a conventional storage water heater, the heater operates to raise and maintain the water at a temperature equal to the temperature setting on the tank (usually 120°F to 140°F). Even if no hot water is drawn from the tank, the water heater will operate periodically to maintain the water temperature due to "standby losses." These losses are caused by heat being conducted and radiated from the walls of the tank. For gas-fired units, heat is also lost through the flue exhaust. These standby losses represent 10 percent to 20 percent of a household's annual water heating costs.[18]

The operational efficiency of the heating elements found in tankless water heaters is almost identical to those found in conventional storage water heaters. Therefore, tankless water heaters save energy not by heating water more efficiently than conventional storage water heaters, but by reducing or eliminating standby losses associated with storing hot water in a tank.[19] Also, if installed in point-of-use applications, tankless water heaters reduce or eliminate the losses from "stranded" hot water remaining in the pipes. The exact amount of savings, however, is difficult to quantify, since for conventional storage water heaters, standby losses are dependent upon the storage capacity of the tank, whether the tank is insulated, the length of the home's hot water supply pipe that would be replace by a point-of-use tankless water heater. In addition, there are few published independent test data available on the efficiency performance of tankless water heaters compared to conventional storage water heaters.

While not all manufacturers attempt to estimate the benefits of tankless water heaters, one manufacturer of electric tankless units claims that hot water heating costs will be reduced by 30

---

[16] Bradford White Corp. "Tankless vs. Tank Type Storage Water Heater Efficiency Comparison Testing." *PM Engineer*. January 7, 2005. March 1, 2005. <www.pmengineer.com/CDA/ArticleInformation/features/BNP__Features__Item/ 0,2732,141364,00.html>.

[17] "Thanks, But No Tanks? Tankless Water Heaters Have Limitations." *Cooperative Connections*, November 2004.

[18] U.S. DOE EERE. January 2003.

[19] Tidwell, J. and Clamp, A. September 2004.

to 50 percent while another claims a 60 percent reduction. Another manufacturer's third-party test compared an electric 40-gallon tank water heater to an electric tankless water heater and identified an energy savings of 27 percent.[20] Manufacturers of gas tankless water heaters claim energy savings in the range of 20 to 25 percent.[21]

Energy savings are greater when tankless water heaters replace conventional storage water heaters in settings where there is low hot water use instead of locations where there is high hot water use. This is simply because standby losses are greater when a conventional storage water heater remains idle for long periods of time. The National Association of Home Builders Research Center published a report stating that annual hot water energy savings due to installing an electric tankless water heater are approximately 10 percent for a household that uses large amounts of hot water and approximately 24 percent for a household that uses relatively small amounts of hot water.[22]

It is interesting to note that, although manufacturers of tankless water heaters often cite the potential to reduce or eliminate standby losses as a selling point, some or possibly all of these savings can also be obtained by installing insulating blankets on conventional storage water heaters and insulation on hot water pipes.

Energy Efficiency

The energy efficiency of water heaters is described in terms of its "energy factor" (EF). The energy factor is basically a measure of the portion of input energy (gas or electricity) that is transferred to the hot water. The higher the energy factor value, the more efficient the water heater. As such, the energy factor is mainly a function of the efficiency of the heating element and heat losses from the water heater. Conventional gas-fired storage water heaters have energy factors between 0.50 to around 0.70, while electric models range from 0.75 to 0.95. Gas-fired water heaters generally have a lower energy factor than electric models because a significant amount of energy is lost through the flue exhaust. Heat loss (including standby losses) from the storage tank is another major factor that determines the energy factor of gas and electric conventional storage water heaters.

Since tankless water heaters can significantly reduce standby losses, the energy factor of these units is higher than that of conventional storage water heaters. According to product specifications posted on manufacturers' websites, gas tankless water heaters have energy factors in the range of 0.69 to 0.85, while electric tankless water heaters have energy factors in the range of 0.98 to 0.99.

[20] Published data from Microtherm, Inc., including: *SEISCO Microtherm, Inc. Addresses Electrical Demand and Other Major Issues*, April, 1999.

[21] Manufacturers' published data, advertisement, or web pages were used for referencing savings estimates.

[22] NAHB Research Center, Inc. 2002.

Financial Issues

The three most important financial issues concerning electric tankless water heaters and their two alternatives are:

- Initial costs,
- Installation costs, and
- Operation costs.

Initial Costs

It can be said that tankless water heaters generally have a higher initial cost than conventional storage water heaters. This is especially true if more than one tankless unit is to be installed. However, retail prices of tankless water heaters are driven by the capacity of the unit and cover a wide range, depending upon the brand.

Small-capacity models are available at prices comparable to conventional storage water heaters. In the review of retail prices conducted as part of this study, it was found that small electric tankless water heaters (maximum of 1 to 2 gpm) are available for as low as $200 per unit, while larger units (maximum of 3 to 4 gpm) are available for $625 to $800. Gas tankless water heaters (maximum of 3 to 5 gpm) are available for $550 to $1,000 per unit. In contrast, conventional storage water heaters cost in the range of $250 to $500 for electric and $375 to $750 for gas-fired versions.[23] One manufacturer of electric tankless water heaters interviewed as part of this study indicated that, with all other things being equal, there should be no cost difference between an electric and a gas tankless water heater having the same capacity.

Installation Costs

Installation costs for conventional gas-fired storage water heaters are in the range of $300 to $850. In contrast, there is anecdotal evidence suggesting that installation costs for tankless water heaters would be in the range of $250 to $450 for electric units and $350 to $700 for gas-fired units, not including any additional costs for electric or gas service upgrades.[24]

More often than not, installing tankless water heaters in an existing home will require an upgrade to the existing electric or gas service. Some anecdotal evidence can be found regarding the costs of these upgrades. For instance, one owner paid over $1,500 for the gas service upgrade needed for installing a gas tankless water heater in this home.[25] Since the total cost of the service upgrade depends on the specific conditions of the home, it is difficult to specify how much an electric service upgrade will cost. However, it would not be unrealistic to estimate the cost to also be $1,500 or higher.

---

[23] RSMeans. *Building Construction Cost Data, 62nd Annual Edition*. 2004.

[24] Seitz, D. 2001, and Bradford White Corp. January 2005.

[25] Seitz, D. 2001.

In some cases, the homeowner may also have to pay for heavier wiring between the distribution transformer in the neighborhood and the home's electric meter. One manufacturer interviewed as part of this study recounted an experience involving one of their commercial customers that installed several large electric tankless water heaters. The tankless units required an upgrade of the commercial facility's electric service to 800 amps, and the local electric utility charged $32,000 for upgrading the power lines between the distribution transformer and the facility.

Operation Costs

In the U.S., water heating accounts for approximately 20 percent or more of an average household's annual energy expenditures. The yearly operating costs for conventional electric and gas-fired storage water heaters average approximately $450 and $200 respectively.[26] This suggests that the operation costs for electric tankless water heaters would also be higher than gas tankless units. For the purposes of comparing the operation costs of tankless units to conventional storage water heaters, there has yet to be any independent tests or case studies to address this particular issue.

One test conducted by a manufacturer of conventional storage water heaters (Bradford White Corp.) compared the annual operation costs of gas-fired tankless water heaters and conventional gas-fired storage water heaters. The company found that average annual operation cost for gas tankless units was approximately 8.7 percent lower than that of conventional storage units.

Gas tankless water heaters that have a constantly burning pilot light can offset some of the savings achieved by the reduction of tank standby losses with the energy consumed by the pilot light. Unlike conventional gas-fired storage water heaters, heat produced by the standing pilot light in a gas tankless water heater is not used productively and represents a complete energy loss during idle periods. The exact cost of operating the pilot light will depend on the design of the tankless water heater and the price of gas, but could range from $12 to $20 per year.[27] Fortunately, some models are available that utilize an intermittent ignition device instead of a standing pilot light. This electrical device resembles the spark ignition device in some gas kitchen ranges and ovens, and eliminates the losses associated with a standing pilot light.

Summary of Advantages and Disadvantages of Electric Tankless Water Heaters

Based on the discussion in the previous sections, Table 3-1 provides a summary of the advantages and disadvantages of electric tankless water heaters relative to conventional gas-fired storage water heaters and gas tankless water heaters.

[26] U.S. DOE EERE. January 2003.
[27] Ibid.

Table 3-1
Summary of Advantages and Disadvantages of Electric Tankless Water Heater

Electric Tankless Water Heaters Compared to…			
Conventional Gas-Fired Storage Water Heater		**Gas-Fired Tankless Water Heater**	
Advantages	**Disadvantages**	**Advantages**	**Disadvantages**
• Electric tankless water heaters can potentially reduce standby losses and lower a household's annual water heating energy costs. • Electric tankless water heaters in point-of-use installations provide "instantaneous" hot water, and significantly reduce losses due to hot water "stranded" in the pipes. • If hot water demand is less than the unit's capacity, electric tankless water heaters can potentially provide unlimited quantities of hot water. • Electric tankless water heaters require less physical space to install than storage tank water heaters.	• Storage water heaters can meet the simultaneous hot water demand of the entire house, while electric tankless water heaters usually cannot support simultaneous uses of hot water. • Electric tankless water heaters have a minimum flow rate threshold below which no hot water will be generated. • Unless the electric tankless water heater has modulating temperature control, it may not supply hot water at a constant temperature when the flow rate fluctuates. • More often than not, installation of an electric tankless water heater will require additional costs for upgrading the site's electric service. • If the electric rates include a demand charge, operation costs for an electric tankless water heater can be very expensive.	• Electric tankless water heaters can be installed almost anywhere, whereas gas tankless water heaters require a flue gas vent and access to combustion air, thus limiting the locations where it can be installed. • Electric tankless water heaters generally have a lower minimum flow rate requirement than gas tankless water heaters. As such, electric tankless units can be more easily installed in point-of-use applications. • The technology for modulating temperature control is easier to implement in electric tankless water heaters. • Gas tankless units that have a pilot light can incur an addition operation cost; electric tankless units do not have a pilot light.	• It is often possible to install a larger-capacity gas tankless water heater than an electric tankless water heater, because the electric unit is more likely to be constrained by the site's limited electric current supply. As such, electric tankless units are usually limited to point-of-use applications and not appropriate for whole-house applications. • If the electric rates include a demand charge, then the operation costs for an electric tankless water heater will be much more expensive than that for a gas tankless water heater.

4
BARRIERS TO IMPLEMENTATION

This chapter examines the issues that are potential market barriers and can prohibit increased market penetration of the electric tankless water heater technology.

Electric Utility Support for the Technology

Given its high power requirements, electric tankless water heaters have received mixed reactions from electric utilities. Some large utilities, such as the Tennessee Valley Authority (TVA), have viewed electric tankless water heaters as a technology that may allow them to gain a more competitive position against natural gas. Gas-fired water heating has been gaining market share in TVA's service territory, and thus promoting electric tankless water heaters could help to increase sales of electricity for the company. TVA's interest in electric tankless water heaters led them to conduct an evaluation of the technology in 1997. TVA monitored and evaluated the performance of an electric tankless water heater installed at a residence, and concluded that the unit operated satisfactorily as the manufacturer's claims.[28]

On the other hand, there is evidence that smaller electric utilities do not support the use of electric tankless water heaters because this technology can potentially increase the cost of wholesale power. Small electric utilities, such as rural electric cooperatives, usually must pay a demand charge to the electricity wholesaler in addition to energy costs. Since the electric tankless water heater's instantaneous demand for electricity can be 30 kW or higher, this technology can significantly increase the system's peak demand as more and more users install the units. Eventually the utility will be forced to pass on the extra costs of purchasing power to consumers, resulting in an increase in retail electricity rates. As such, electric tankless water heaters are likely to be discouraged by electric utilities that are interested in demand reduction.

For example, Sioux Valley Energy and Lake Region Electric in South Dakota do not promote the use of electric tankless water heaters because the demand for hot water usually coincides with the utility's peak demand period in the early morning and early evening hours. Instead, the utilities provide financial incentives to customers that install a conventional storage water heater.[29]

[28] The electric tankless water heater evaluated was Microtherm, Inc.'s SEISCO Model RA-28. This unit was installed in a Chattanooga residence without TVA's involvement or incentives.

[29] "Demand Water Heaters Have Their Limitations," *Cooperative Connections*, October 2004.

Power Quality

When TVA monitored an electric tankless water heater that was installed in 1997, they noted that blinking of the household lights was noticeable to the homeowner as well as to trained observers.[30] The unit was then monitored for harmonic distortion, and the results suggested that the heavy current distortion produced by the electric tankless unit was causing voltage drops. When this problem was reported to the tankless unit's manufacturer (Microtherm, Inc.), the manufacturer produced a modified version of the unit's solid-state controller. When the new controller was installed, TVA noted that blinking of the household lights was reduced to unnoticeable levels. Additional power quality tests did not reveal any problems.

It can be concluded that, although early models of the electric tankless water heater technology had some power quality problems, manufacturers have likely made significant improvements to the technology. Unfortunately, there is no recent test data or case studies available that provide more information on how the latest generation of electric tankless water heaters impact power quality.

Demand Charges

Electric tankless water heaters draw a large amount of electric current and can create a large demand for electricity during peak periods. Residential customers usually do not have to pay a separate demand charge as part of their energy bills, but utilities may still increase electricity rates if residential customers' demand increases (as discussed previously). Commercial and industrial customers, however, often are required to pay a demand charge in addition to energy costs. The operation costs of water heating could rise to infeasible levels for these customers if they install an electric tankless water heater and experience a significant increase in their demand charge.

Cost of Upgrading Electric Service

As discussed in the previous chapter, the cost of upgrading the electric service in order to accommodate an electric tankless water heater can cost thousands of dollars. The electric service upgrade is another cost that must be included when evaluating the costs and benefits of investing in an electric tankless water heater for the purpose of saving energy. For many consumers, the first costs of the tankless unit plus upgrading the building's electric service are too large to remain attractive. In TVA's evaluation, they concluded that the value of the saved energy is low relative to the total costs of installation, and they do not expect electric tankless water heaters to be fully accepted by the mass market due to its long payback.[31]

[30] Tidwell, J. and Clamp, A. September 2004.
[31] Ibid.

Consumers' Unrealistic Expectations

In the review of literature and interviews of manufacturers conducted for this study, a recurring theme that appeared is that consumers often have unrealistic expectations and do not understand the limitations of the tankless water heating system. This is especially true in the case of residential customers. While the potential energy savings may seem attractive, many consumers are disappointed after installing a tankless unit and finding that the limited hot water flow rate is not enough for meeting all of their hot water needs.

Although there is no evidence that this has occurred, the consumers' disappointment can potentially give tankless water heaters a bad reputation. One manufacturer interviewed indicated that this is a major point of concern because consumers are currently driving the market demand for electric tankless water heaters. If consumers should lose confidence in the technology, then manufacturers could see sales plummet.

Contractors' Lack of Knowledge

From the viewpoint of the manufacturers interviewed as part of this study, another significant market barrier is that contractors and homebuilders do not actively promote electric tankless water heaters to their customers. These manufacturers believe that the lack of promotion is generally due to the contractors' lack of knowledge about tankless water heaters. All three manufacturers interviewed indicated that they are trying to address this issue by conducting high-powered marketing campaigns aimed at contractors. Their goal is to educate contractors about the merits of the tankless technology, which will help them to introduce the tankless technology to consumers. Contractors will then also be able to help dispel any unrealistic expectations that consumers may have regarding the tankless water heater technology.

5
AVAILABLE MANUFACTURERS AND PRODUCTS

This section provides a survey of the current landscape of manufacturers and their electric tankless water heater products in the U.S. This information is consolidated into Table 5-1 below to provide a convenient reference. It can be observed that most manufacturers have more than one product line, and each product line may contain several models of electric tankless water heaters. The final column in the table contains information concerning the range of hot water flow rates available in each product line (the range given is not the minimum and maximum rated flow rates for any one particular model).

Table 5-1
Manufacturers of Electric Tankless Water Heaters

Company	Product Line	# of models	Voltage	Capacity Range (Gallons per minute)
Advanced Tech Intl., Inc. P.O. Box 833274 Miami, FL 33283 (888) 596-6444 www.waterheater.net	Supreme	2	240V	1.22 gpm - 2.06 gpm
Chronomite Labs 1420 West 240th St. Harbor City, CA 90710 (800) 447-4962 www.chronomite.com	Instant Flow	6	120V/240V	0.23 gpm - 1.22 gpm
	Instant Temp	6	120V/240V	0.22 gpm - 1.22 gpm
Controlled Energy Corp. 340 Mad River Park Waitsfield, VT 05673 (800) 642-3199 www.controlledenergy.com	Powerstream	4	120V/240V	0.71 gpm - 1.62 gpm
	Powerstar	2	240V	1.28 gpm - 3.70 gpm
EEMAX Inc. 353 Christian St. Oxford, CT 06478 (800) 543-6163	Series-Two	2	240V	1.08 gpm - 2.61 gpm
	Flow-Controlled	4	240V	0.42 gpm - 1.30 gpm
Hot Aqua Inc. 141 Calle Iglesia San Clemente, CA 92672 (800) 441-0011	Power Cord	2	120V	0.13 gpm - 0.30 gpm
	Point of Use	3	240V	0.28 gpm - 0.96 gpm

Table 5-1 (Cont.)
Manufacturers of Electric Tankless Water Heaters

Company	Product Line	# of models	Voltage	Capacity Range (Gallons per minute)
Keltech Inc. 729 South Grove St. Delton, MI 49046 (800) 999-4320 www.keltech-inc.com	Acutemp	4	240V/480V	0.75 gpm - 2.44 gpm
Microtherm, Inc. 22 Airtex Houston, TX 77090 (888) 296-9293 www.seisco.net	Point of Use	3	240V	0.68 gpm - 1.92 gpm
	Seisco	3		1.36 gpm - 3.80 gpm
Niagara Industries 4120 NW 28th St. Miami, FL 33142 (305) 876-9010 www.tanklesswaterheater.com	Titan	5	120V/240V	0.27 gpm - 1.90 gpm
S.E.T.S. Systems Inc. 6900 NW 72nd Ave. Miami, FL 33166 (877) 649-8589 www.sets-tankless.com	SETS	5	240V	1.09 gpm - 3.00 gpm
Stiebel Eltron 242 Suffolk St. Holyoke, MA 01040 (800) 582-8423 www.stiebel-eltron-usa.com	Point of Use	4	120V/240V	0.22 gpm - 0.66 gpm
	DHC	2	240V	1.45 gpm - 3.91 gpm
Tankless Hot Water Syst. 111 North 28th Ave. Humboldt, TN 38343 (901) 756-7080 www.tanklesshot.com	Santon	3	120V/240V	0.22 gpm - 1.22 gpm