ENERGY STAR® Residential Water Heaters: Draft Criteria Analysis

Water heating represents between thirteen and seventeen percent of national residential energy consumption, making it the third largest energy end use in homes, behind heating and cooling and kitchen appliances. As homes become more energy efficient, the percentage of energy used for water heating steadily increases. This is attributed to limited energy efficiency potential in the common conventional water heating technologies as well as ineffective deployment of advanced water heating technologies. Water heating is the only major residential energy end use that ENERGY STAR does not address.

Developing ENERGY STAR criteria is critical to expand the value of the ENERGY STAR brand and its continued relevance in the marketplace. When developing ENERGY STAR criteria, the Department of Energy considers and balances a varied set of objectives, ensuring that the established criteria:

- Provide meaningful differentiation between ENERGY STAR qualified products and those that just meet the Federal standard.
- Will result in significant energy savings, both for consumers and the nation as a whole.
- Are cost-effective for consumers as well as manufacturers.
- Provide ample consumer choice, both in terms of number of models and a wide range of manufacturers.
- Do not compromise functionality or performance of the qualified product.
- Do not rely on proprietary technologies of one or a small set of manufacturers.

Almost all water heaters sold in the U.S. are traditional storage units with nearly an even split between gas and electric. Of the 9.8 million water heater shipments in the U.S. in 2006, 4.8 million were conventional electric-resistance and 4.7 million were conventional gas storage. Advanced water heating technologies constitute a very small portion of the market. Of the advanced technologies, gas tankless water heaters have the largest number of shipments at 254,600 in 2006, which represents 2.6% of the market. Small manufacturers with limited production capacity are the predominant producers of solar and heat pump water heaters. Solar water heater shipments amount to an estimated 2,430 units per year, while heat pump water heater shipments amount to less than an estimated 2,000 units per year. Currently, gas-condensing and advanced non-condensing water heaters are not in the residential market.

Historically, a number of barriers have prevented widespread success of advanced water heating technologies, with most of them related to one another. The most significant barrier is the nature of water heater replacement. Two-thirds of consumers replace their water heaters due to sudden failure of their existing model. Of those replacements, 60% are emergency replacements.[1] When a water heater fails suddenly, most consumers have their water heater replaced with the cheapest, most readily available and easily installed model from their plumber or contractor. These circumstances do not encourage consumers to make the extra effort to track down hard-to-find advanced technologies or evaluate lifetime cost savings.

[1] KEMA Inc. "Assessment of the Residential Water Heater Market in the Northwest" December 2005 prepared for the Northwest Energy Efficiency Alliance

High first cost has made consumers reluctant to invest in historically non-brand name products that are considerably more expensive than their conventional brand-name counterparts. Product performance has often been inconsistent, giving advanced water heating technologies a poor reputation. Limited availability and a lack of trained installers have meant consumers often must go to great lengths to acquire advanced water heating technologies and have them installed. An overall lack of consumer awareness and interest in advanced water heating technologies has led to misconceptions from those unwilling to invest in them and poor maintenance habits by those who have invested in them. The proliferation of the advanced technologies would benefit considerably from an organized, nationwide approach to deploy these technologies and transform the market.

ENERGY STAR can assist in the deployment of advanced water heating technologies to the residential market. High first cost, poor product performance, limited availability and the lack of consumer interest have been attributed, in part, to a lack of production and promotion from major manufacturers. Major manufacturers have claimed there is not enough consumer demand to warrant producing these products. ENERGY STAR can serve as an end goal for industry and a catalyst for consumer demand. Consumers recognize the ENERGY STAR label as delivering the same or better performance as conventional products while using less energy and thus saving money. The label carries legitimacy and a sense of reassurance for consumers. ENERGY STAR can collaborate with its partners to develop consumer demand, contractor expertise, consumer education, and encourage product availability.

Water Heater Technologies

Conventional Technologies

Electric-Resistance Storage Water Heaters

Conventional electric-resistance water heaters have a glass-lined steel tank and foam insulation along with two electric heating elements located near the base and top of the tank. Cold water enters the base of the tank where it is heated by an electric heating element. The hot water rises to the top of the tank where it is drawn for consumption. When hot water consumption is high, an additional heating element located near the top of the tank is turned on to provide additional heat to the water before it exits the water heater.

Improving energy efficiency of electric resistance water heaters in the residential market is limited. Typical fifty-gallon electric resistance water heaters have Energy Factors that range from 0.904 to 0.95. Using the DOE test procedure for calculations, a fifty-gallon electric resistance water heater with an Energy Factor of 0.95 would consume 4,622 kilowatt-hours per year (see Table 1 on page ten for calculations). This is a savings of 4.8% in comparison to the typical fifty-gallon electric resistance water heater with an Energy Factor of 0.904 at the Federal standard. Given current and potential energy savings, electric resistance water heating technology is nearly maximized and not under consideration for ENERGY STAR.

Gas Storage Water Heaters

Conventional gas storage water heaters have a center-flue design, a glass-lined steel tank and foam insulation along with an atmospheric burner at the base of the tank. Cold water enters the bottom of the insulated tank in close proximity to the gas burner. Gas is combusted in the burner and its

combustion products ascend through a flue in the center of the tank. Heat from the burner and its combustion products are passed onto the flue and base plate, where it transfers to the water in the tank. The water is heated and rises to the top of the tank where it is drawn for consumption.

Energy efficiency improvements for conventional gas storage water heaters are limited. Fifty-gallon gas storage water heaters have Energy Factors that range from 0.58 to 0.67. However, the majority of models available on the market as well as product sales fall in the 0.58 to 0.62 range. Using the DOE test procedure for calculations, a fifty-gallon gas storage water heater with an Energy Factor of 0.62 would consume 242 therms per year (see Table 2 on page eleven for calculations). This is a savings of 7.3% in comparison to the typical conventional gas storage water heater with an Energy Factor of 0.58 at the Federal standard. Given current and potential energy savings, conventional gas storage water heating technology is nearly maximized and is not under consideration for ENERGY STAR.

Advanced Technologies

Advanced water heating technologies vary in the technological characteristics they employ to heat water. Electric, gas and solar water heaters are each categorically unique in relation to the efficiency they can achieve heating water. Since each advanced technology is inherently different than another, each technology will have its criteria based on its own merits. Certain technologies will have criteria that are exclusive. The Department is intent on establishing a fuel neutral program that does not favor one energy source over another. All calculations and figures for the technology profiles are in Tables 1 and 2 on pages ten and eleven.

Whole-Home Tankless Water Heaters

Gas tankless water heater technology uses a similar concept as conventional water heater technology to heat water, but without a storage tank. Cold water enters the base of the heater where a flow sensor is triggered when the unit's minimum water draw is met, activating the gas burner. The burner immediately fires and begins to heat a heat exchanger. The cold water encircles the heat exchanger. The heat exchanger becomes hot; the water reaches its set point temperature, and then exits the unit.

Draft Criteria

ENERGY STAR is considering whole-home gas tankless water heaters for inclusion in the program. The proposed criteria are:

- A minimum Energy Factor of 0.80.
- A minimum gallons-per-minute (gpm) requirement of 3.5 gpm at a 77°F rise. This is to ensure models earning the label provide sufficient water delivery.
- A minimum ten-year warranty. This is to ensure models earning the label are reliable and perform properly.

Savings and Payback

Using the DOE test procedure for calculations, a whole-home gas tankless water heater with a 0.80 Energy Factor would consume 187 therms per year. This is a savings of nearly 30%, or 74 therms, in comparison to the typical gas storage water heater. The annual energy savings equal $102 using the national average gas rate. The monetary savings will pay for the price premium in 6-16 years, depending on installed cost. Installing whole-home gas tankless water heaters in new construction is the more cost effective option. Gas tankless water heaters require larger gas lines to achieve delivery for whole-home performance. Replacing gas lines is generally expensive. A Federal tax credit is

currently available that can offset 10% of the installed cost of a tankless water heater with an Energy Factor of 0.80 or greater. When taking the tax credit into account, the monetary savings will pay for the price premium in 3.5-13.5 years.

Market Share
Gas tankless water heaters currently account for 254,600 sales per year. Manufacturers can produce models that meet or exceed a 0.8 Energy Factor with a 3.5-gpm flow at a 77°F rise. If 10% of the nation's 4.7 million gas water heater shipments were whole-home gas tankless water heaters with a 0.80 Energy Factor instead of conventional models with an Energy Factor at the Federal standard, the aggregate energy savings would amount to nearly 34.8 million therms per year.

Electric Tankless
Electric tankless water heaters cannot produce the 3.5-gpm (at 77°F rise) requisite for whole-home water heating delivery without exceeding a 12-kW input maximum. Some units can achieve greater than 3-gpm, but require electric service over 100 amps. Many older homes may only have 100 amps of service available, making electric tankless water heater applications inappropriate. Upgrading from 100 amps service to 200 amps costs an estimated $1,000. In addition, a Federal tax credit is not available for electric tankless water heaters to offset some of this cost. The best electric tankless water heaters can only achieve a 0.99 Energy Factor, which is just 9.5% more efficient than the Federal standard. The energy savings do not justify the cost of the retrofit. Electric tankless water heaters are impractical for most homes given the immense electrical requirements and retrofit costs for whole-home service.

Issues/Concerns
There are some potential issues with whole-home gas tankless water heaters. A number of retrofit complications have an adverse impact on consumer demand. Proper venting, gas line replacement and electric wiring are logistical obstacles for a cost effective retrofit, often costing more than the tankless water heater itself. Rebate offers and tax incentives can relieve some of the financial load for consumers. Maintenance becomes an issue for regions with hard water. Scale build up on the heat exchanger decreases performance. Increased water consumption is attributed to the time it takes for the heat exchanger to become hot since consumers typically will run their faucets until hot water is delivered to the tap. Tankless water heaters do not have hot water on standby. Energy savings potential is questionable under real use patterns due the effect of short draws and the time intervals between draws on the heat exchanger. Tankless water heater burners don't fire unless a minimum 0.5-0.8 gpm is reached. There is also concern that consumers tend to consume more water due to the perception of endless hot water.[2]

Heat Pump Water Heaters

Heat pump water heater technology uses a vapor compression refrigeration system to transfer heat from the surrounding air to water stored in a tank. A low-pressure liquid refrigerant is vaporized in the heat pump's evaporator and then is passed onto the compressor. The compressor increases the pressure of the refrigerant, increasing the refrigerant's temperature. Then, the heated refrigerant runs through the condenser coil encircled within the storage tank. The heat is transferred from the refrigerant through the coil to the potable water. Once the refrigerant delivers its heat to the water, it has cooled and condensed, and then passes through an expansion valve where the pressure is reduced and the cycle starts over.

[2] Energy Trust of Oregon "Tankless Gas Water Heaters: Oregon Market Status" December 2005

Draft Criteria
ENERGY STAR is considering drop-in heat pump water heaters for inclusion in the program. The proposed criteria are:

- A minimum Energy Factor of 2.0.
- A minimum First-Hour Rating requirement of 50 gallons-per-hour. This is to ensure models earning the label provide sufficient water delivery.
- A minimum six-year warranty.

Savings and Payback
Using the DOE test procedure for calculations, a fifty-gallon heat pump water heater with a 2.0 Energy Factor would consume an estimated 2,195 kilowatt-hours per year. This is a savings of nearly 55%, or 2,662 kilowatt-hours, in comparison to the typical electric resistance water heater. The annual energy savings equal $277 using the national average electric rate. The monetary savings will pay for the price premium in three years, which is just over a third of the ten-year life of a heat pump water heater. In addition, the monetary savings will pay for the entire installed cost of the water heater in 5.5 years. By the end of its lifetime, a heat pump water heater will net a savings of more than $1,250. A federal tax credit is currently available that can offset 10% of the installed cost of a heat pump water heater with an Energy Factor of 2.0 or greater. When taking the tax credit into account, the monetary savings will pay for the price premium in 2.5 years.

Market Share
Heat pump water heaters account for less than 2,000 residential sales per year. Only small manufacturers with limited capacity are currently producing heat pump water heaters. Major manufacturers have indicated they are interested in developing this product if a market can emerge and compete. ENERGY STAR can assist in the development of this market with the collaboration of its partners. If just 10% of the nation's 4.8 million electric water heater shipments were heat pump water heaters with an Energy Factor of 2.0 instead of conventional models with an Energy Factor at the federal standard, the aggregate energy savings would amount to nearly 1.3 billion kilowatt-hours per year.

Issues/Concerns
There are some potential issues with heat pump water heaters. The lack of product availability is the most significant barrier. Questionable performance and reliability have historically been associated with heat pump water heaters. A minimum warranty should offer recourse if product performance or reliability becomes an issue for consumers. Water heater contractors have been reluctant to stock heat pump water heaters in their inventory, making availability an issue. They also tend to have little to no expertise in maintaining heat pump technology since many are exclusively plumbers. Organized training sessions and contractor-driven educational materials are two ways to address this issue.

Solar Water Heaters

Solar water heater technology uses the sun's thermal energy to heat water. Solar water heaters typically are designed to serve as preheaters for conventional storage or tankless water heaters. The sun's rays strike a solar collector, which absorbs the thermal energy and transfers this heat to water in a storage tank or water entering a tankless water heater. Solar water heaters come in a wide variety of designs. The Solar Rating and Certification Corporation (SRCC) applies objective measures to certify solar water heaters.

Draft Criteria
ENERGY STAR is considering solar water heaters for inclusion in the program. The proposed criteria are:

- A minimum Solar Fraction of 0.50.
- OG-300 certification from the SRCC.
- A minimum fifteen-year warranty.

Savings and Payback
An OG-300 certified solar water heater with a 0.50 Solar Fraction and a fifty-gallon electric storage back-up water heater (with an Energy Factor at the Federal standard) would achieve a Solar Energy Factor of 1.8.[3] Using the DOE test procedure for calculations, the energy consumption for a solar water heater with a 1.8 Solar Energy Factor would correspond to an estimated 2,439 kilowatt-hours per year. This is a savings of 50%, or 2,418 kilowatt-hours, in comparison to the typical electric resistance water heater. The annual energy savings equal $251 using the national average electric rate. The monetary savings will pay for the price premium in ten years, based on the average installed cost. A federal tax credit is currently available that can offset 30% of the installed cost of a solar water heater with a Solar Fraction of 0.50 or greater. When taking the tax credit into account, the monetary savings will pay for the price premium in six years.

An OG-300 certified solar water heater with a 0.50 Solar Fraction and a fifty-gallon gas storage back-up water heater (with an Energy Factor at the Federal standard) would achieve a Solar Energy Factor of 1.0. Using the DOE test procedure for calculations, the energy consumption for a solar water heater with a 1.0 Solar Energy Factor would correspond an estimated 150 therms per year. This is a savings of 43%, or 111 therms, in comparison to the typical gas storage water heater. The annual energy savings equal $153 using the national average gas rate. The monetary savings will pay for the price premium in 15 years, based on the average installed cost. The tax credit can offset 30% of the installed cost of a solar water heater with a Solar Fraction of 0.50 or greater. When taking the tax credit into account, the monetary savings will pay for the price premium in nine years.

Market Share
Solar water heaters account for 2,430 residential sales per year. However, there are a number of manufacturers that can produce OG-300 rated solar water heaters with a Solar Fraction of 0.50 or greater. If just 2% of the nation's 4.8 million electric water heater shipments were OG-300 rated solar water heaters with a 0.50 Solar Fraction instead of conventional models with an Energy Factor at the Federal standard, the aggregate energy savings would amount to more than 232 million kilowatt-hours per year. If just 1% of the nation's 4.7 million gas water heater shipments were OG-300 rated solar water heaters with a 0.50 Solar Fraction, the aggregate energy savings would amount to more than 5.2 million therms per year.

Issues/Concerns
There are some potential issues with solar water heaters. Solar water heaters with freeze protection are typically more expensive. The high first cost for solar water heaters suited for northern climates has an adverse impact on consumer demand. Rebate offers and tax incentives can relieve some of the financial load for consumers. An overall lack of trained solar technicians may cause difficulty for consumers in need of system maintenance. Organized training sessions are one way to address this issue. A lack of consumer education on maintenance requirements can lead to poor system

[3] Natural Resources Defense Council "Solar Water Heater Fact Sheet" October 2004.

performance. The distribution of educational materials is one way to make consumers aware of system demands.

Gas Condensing Water Heaters

Gas-condensing water heater technology is similar to conventional gas storage water heater technology with some exceptions. The gas burner is typically encased in the vertical flue towards the middle or top of the water heater tank. Incoming induced air mixes with natural gas for burner combustion. The resulting hot gases travel through a helical heat exchanger coil, where heat is transferred from the gases to the water in the tank. The gases condense as they reach the end of the coil and are drained as slightly acidic water. The ability to capture the heat of condensation of the combustion gases is the major enhancement with gas condensing water heaters. The burner heats the water like typical gas storage models, but the combustion gases are vented through coils to supply additional heat to the water that conventional models do not provide.

Draft Criteria
ENERGY STAR is considering residential gas condensing water heaters for inclusion in the program. The proposed criteria are:

- A minimum Energy Factor of 0.80.
- A minimum First-Hour Rating of 50 gallons-per-hour.
- A minimum eight-year warranty.

Savings and Payback
Using the DOE test procedure for calculations, a fifty-gallon gas condensing water heater with an Energy Factor of 0.80 would consume 187 therms and 100 kilowatt-hours per year. This is a savings of nearly 30%, or 74 therms, in comparison to the conventional typical gas storage water heater. The annual energy savings equal $92 using the national average gas and electric rates, accounting for the additional electricity. The monetary savings will pay for the price premium in 5-10 years,[4] depending on installed cost. A federal tax credit is currently available that can offset 10% of the installed cost of a gas-condensing water heater with an Energy Factor of 0.80 or greater. When taking the tax credit into account, the monetary savings will pay for the price premium in 3.5-8 years.

Market Share
Currently, residential gas-condensing water heaters are not available on the market. However, manufacturers have indicated they are interested in developing this product if a market can emerge and compete. ENERGY STAR can assist in the development of this market with the collaboration of its partners. If just 5% of the nation's 4.7 million gas water heater shipments were gas-condensing models with a 0.80 Energy Factor instead of conventional models with an Energy Factor at the Federal standard, the aggregate savings would amount to 17.4 million therms per year.

Issues/Concerns
There are some potential issues with gas condensing water heaters. The lack of product availability is the most significant barrier. Product performance or reliability may be an issue given the infancy of this technology. A minimum warranty should offer recourse if product performance or reliability becomes an issue for consumers. Proper venting, condensate drainage and electric wiring can be

[4] $1,300-$1,800 projected installed cost. Super Efficient Water Heating Appliance Initiative, PIER Draft Final Project Report, March 2007, California Energy Commission (CEC-500-05-010). American Council for an Energy Efficient Economy "Emerging Technology and Practices" 2004

logistical obstacles for a cost effective retrofit. Rebate offers and tax incentives may relieve some of the financial load for consumers.

Advanced Non-Condensing Gas Storage

Advanced non-condensing gas storage water heaters are similar to conventional gas storage water heaters, but with a number of innovations that boost energy efficiency. A powered burner with a draft inducer as well as advanced valves and heat traps improve combustion efficiency and limit standby losses.

Draft Criteria
ENERGY STAR is considering advanced non-condensing gas storage water heaters for inclusion in the program. The proposed criteria are:

- A minimum Energy Factor of 0.70.
- A minimum First-Hour Rating of 50 gallons-per-hour.
- A minimum eight-year warranty.

Savings and Payback
Using the DOE test procedure for calculations, a fifty-gallon advanced non-condensing gas storage water heater with a 0.70 Energy Factor would consume an estimated 214 gas therms and 50 kilowatt-hours per year. This is a savings of 18%, or 47 therms, in comparison to the typical gas storage water heater. The annual energy savings equal $60 using the national average gas and electric rates, accounting for the additional electricity. The monetary savings will pay for the price premium in less than four years,[5] which is less than a third of the product's 13-year life. Since advanced non-condensing gas storage water heaters would provide a direct retrofit for the typical gas storage water heaters, they can make a significant, widespread impact in terms of national cumulative energy savings.

Market Share
Currently, advanced non-condensing gas storage water heaters are not available on the market. However, manufacturers have indicated they are interested in developing this product if a market can emerge and compete. ENERGY STAR can assist in the development of this market with the collaboration of its partners. If just 10% of the nation's 4.7 million gas water heater shipments were advanced non-condensing models with a 0.70 Energy Factor instead of conventional models with an Energy Factor at the Federal standard, the aggregate savings would amount to nearly 22.1 million therms per year.

Issues/Concerns
There are some potential issues with advanced non-condensing gas storage water heaters. The lack of product availability is the most significant barrier. Product performance or reliability may become an issue given the development stage of this technology. A minimum warranty should offer recourse if product performance or reliability becomes an issue for consumers. Proper venting and electric wiring can be logistical obstacles for a cost effective retrofit, depending the circumstances. Rebate offers and tax incentives may relieve some of the financial load for consumers.

[5] $1,100 projected installed cost. Super Efficient Water Heating Appliance Initiative, PIER Draft Final Project Report, March 2007, California Energy Commission (CEC-500-05-010)

Advanced Storage Water Heaters: Capacity-Based Energy Factor Criteria

The Federal standard for storage water heaters is based on tank capacity. As tank size increases, the Energy Factor to meet the Federal standard decreases. The Department examined whether to implement capacity-based Energy Factor criteria for advanced non-condensing, gas condensing and heat pump water heaters by applying the same proposed percent better for 50-gallon capacity to other capacities, particularly 40 and 60-gallon tank sizes. However, the energy consumption does not vary considerably for 40 and 60-gallon capacities in comparison to 50-gallon capacity. In addition, capacity-based Energy Factor criteria make qualification more complicated than necessary for consumers and manufacturers. ENERGY STAR will therefore not implement capacity-based Energy Factor criteria for advanced storage water heater categories.

Summary

ENERGY STAR is proposing draft criteria for residential gas condensing, gas tankless, advanced non-condensing gas storage, heat pump and solar water heaters for whole home applications. A moderate displacement of conventional water heaters with ENERGY STAR qualified models would achieve cumulative energy savings of nearly 1.5 billion kilowatt-hours and 80 million therms per year. These energy savings would equal more than $260 million in monetary savings using the national average electric and gas rates. By establishing ENERGY STAR water heater criteria, the Department envisions advanced water heating technologies progressing in the market and gaining a nominal market share within five years.

The Department is requesting interested stakeholders to provide comments on the proposed criteria. Please submit comments to both Richard Karney (richard.karney@ee.doe.gov) and Josh Butzbaugh (jbutzbaugh@drintl.com) by May 29, 2007. Comments will be posted as they are received on the Water Heater Criteria Development page (http://www.energystar.gov/waterheaters). ENERGY STAR will hold a stakeholder meeting on June 5, 2007, to discuss the draft criteria, comments received and any issues not raised during the comment period.

Table 1: Energy and Cost Comparison: Electric Water Heating – 50-gallon capacity

Electric Water Heater	Standard	High-Performing	HPWH	Solar
Energy Factor	0.904	0.95	2.0	1.8[6]
Annual Consumption (kWh/yr)[7]	4,857	4,622	2,195	2,439
Annual Savings (kWh/yr)	None	257	2,662	2,418
Annual Cost of Operation ($/yr)	$505	$481	$228	$254[8]
Annual Savings ($/yr)	None	$27	$277	$251
Life Expectancy	12 years[9]	12 years	10 years[10]	20 years
Lifetime Savings (kWh)	None	3,084	26,620	48,360
Lifetime Savings ($)	None	$321	$2,768	$5,029
Installed Cost	~$650	~$700	~$1,500[11]	~$3,200[12]
Price Premium	NA	~$50	~$850	~$2,550
Payback on Price Premium	NA	~2 years	~3 years	~10 years
Tax Credit (See detail below)	None	None	$150	$960
Payback w/ Tax Credit	NA	NA	~2.5 years	~6 years
Residential Annual Sales	~4.8 million[13]		<2,000[14]	2,430[15]

[6] Natural Resources Defense Council "Solar Water Heater Fact Sheet" October 2004. Typical Solar Energy Factor for an electric solar water heater with a 0.5 solar fraction.
[7] Energy consumption estimated using the DOE test procedure. Based on the following formula: (12.03/EF) x 365
[8] SWH annual costs do not include maintenance expenses, which are estimated as $150-$200 every 3-5 years according to discussions at the Water Heater Technologies Meeting (3/22/06)
[9] *Appliance Magazine* "29th Annual Portrait of the U.S. Appliance Industry" September 2006
[10] Oak Ridge National Laboratory "Durability Testing of a Drop-In Heat Pump Water Heater" April 2004
[11] Vermont Energy Investment Corporation "Residential Heat Pump Water Heaters: Energy Efficiency Potential and Industry Status" November 2005
[12] Energy Information Administration "The National Energy Modeling System: An Overview 2003" April 2003. Average cost for a solar water heater. Since most installations are customized, cost is widely variable.
[13] Gas Appliance Manufacturers Association 2006 Shipments
[14] Oak Ridge National Lab (ORNL) "The Drop-In Residential Heat Pump Water Heater"
[15] Energy Information Administration, 2004 Renewable Energy Annual, Tables 38 and 39

Table 2: Energy and Cost Comparison: Gas Water Heating – 50-gallon capacity

Gas Water Heater	Standard	High-Performing	Advanced Non-Condensing	Tankless	Gas-Condensing	Solar
Energy Factor	0.575	0.62	0.7	0.8	0.8	1.0[16]
Annual Consumption (therm/yr)[17]	261	242	214	187	187	150
Annual Savings (therm/yr)	None	19	47	74	74	111
Annual Cost of Operation ($/yr)	$360	$334	$306[18]	$258	$268[19]	$207
Annual Savings ($/yr)	None	$26	$60	$102	$92	$153
Life Expectancy	9 years[20]	9 years	13 years[21]	20 years[22]	15 years	20 years
Lifetime Savings (therms)	None	171	611	1480	1,110	2,220
Lifetime Savings ($)	None	$234	$776	$2,042	$1,376	$3,064
Installed Cost	~$865[23]	~$930	~$1,100	~$1,470-$2,500[24]	~$1,300-$1,800[25]	~$3,200
Price Premium	None	~$65	~$235	~$605-$1,635	~$435-$935	~$2,335
Payback on Price Premium	None	~2.5 years	~4 years	~6-16 years	~5-10 years	~15 years
Tax Credit (See detail below)	None	None	None	$150-$250	$130-$180	$960
Payback w/ Tax Credit	NA	NA	NA	~4.5-13.5 years	~3.5-8 years	~9 years
Residential Annual Sales	~4.7 million[26]		NA	~254,600[27]	NA	2,430

[16] Natural Resources Defense Council "Solar Water Heater Fact Sheet" October 2004. SEF refers to Solar Energy Factor.
[17] Energy consumption estimated using the DOE test procedure. Based on the following formula: (41,045 BTU/EF x 365)/100,000
[18] Takes into account an additional 50 kWh consumed for running powered burner, igniter and draft inducer
[19] Takes into account an additional 100 kWh consumed for running the blower and igniter
[20] *Appliance Magazine* "29th Annual Portrait of the U.S. Appliance Industry" September 2006
[21] Super Efficient Water Heating Appliance Initiative, PIER Draft Final Project Report, March 2007, California Energy Commission (CEC-500-05-010)
[22] Energy Trust of Oregon "Tankless Gas Water Heaters: Oregon Market Status" December 2005
[23] Based on survey data collected for the Super Efficient Water Heating Appliance Initiative "PIER Draft Final Project Report" March 2007, California Energy Commission (CEC-500-05-010)
[24] Based on information in Energy Trust of Oregon "Tankless Gas Water Heaters: Oregon Market Status" December 2005 and survey data collected for the Super Efficient Water Heating Appliance Initiative "PIER Draft Final Project Report" March 2007, California Energy Commission (CEC-500-05-010)
[25] Based on information in Super Efficient Water Heating Appliance Initiative "PIER Draft Final Project Report" March 2007, California Energy Commission (CEC-500-05-010) and American Council for an Energy Efficient Economy "Emerging Technology and Practices" 2004
[26] Gas Appliance Manufacturers Association 2006 Shipments
[27] Ibid.

Assumptions

Annual energy use is based on the DOE test procedure and calculated assuming an inlet water temperature of 58ºF, a set point of 135ºF, daily hot water demand of 64.3 gallons, and 365 days per year of use. The energy rates are $1.38 per therm for gas and $0.104 per kilowatt-hour for electric, the average 2006 residential rates in the U.S.[28]

Available Tax Credits

Energy Policy Act of 2005; Section 1335, Tax credit amounting to 30% of purchase of qualified solar water heaters.

- Maximum credit of $2,000 per tax year; unused credit may be carried over.
- Must be certified by Solar Rating and Certification Corporation or comparable entity endorsed by the government of the State.
- At least half of energy by must be derived from the sun.
- Credit applies to property installed in primary residence of U.S. and covers both equipment and labor costs associated with installation, piping and wiring.

Energy Policy Act of 2005; Section 1333, Homeowner Tax Credit

- 10% of the amount a taxpayer pays for installation including labor and property (materials/equipment) to make qualified energy efficiency improvements during a taxable year.
- Qualified energy efficient property includes:
    - Electric heat pump water heater (EF $\geq$ 2.0)
    - Natural gas, propane, or oil water heater which has an Energy Factor of at least 0.80
    - The credit cannot exceed $500 in aggregate over the life of the program.

[28] Energy Information Administration (DOE) data; average rates from January 2006 through December 2006