ENERGY STAR® Residential Water Heaters: Final 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. Water heating is the only major residential energy end use that ENERGY STAR has not addressed.

Developing ENERGY STAR criteria is essential to expand the value of the ENERGY STAR brand and its continued relevance in the marketplace. ENERGY STAR is a critical driver of technology in the market. When developing ENERGY STAR criteria, the Department of Energy (DOE) 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 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.

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. Gas tankless water heaters accounted for 254,600 shipments, representing 2.6% of the market. Currently, 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 8,500 units per year, while heat pump water heater shipments amount to less than 2,000 units per year. Currently, residential gas-condensing water heaters are not in the market.

ENERGY STAR can assist in the deployment of highly efficient 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 claim 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

Electric, gas and solar water heaters are each categorically unique in relation to the efficiency they can achieve heating water. Since each 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. DOE is intent on establishing a program that does not favor one energy source over another.

The energy consumption and savings calculations are based on the DOE test procedure,[1] which accounts for standby energy as well as energy consumed from additional sources. All figures for the technology profiles are in Tables 1 and 2 on pages nine and ten. For reference, the DOE residential product classes are included on page eleven.

Electric-Resistance Storage and Tankless Water Heaters

The individual energy savings of both electric-resistance storage and tankless water heaters are low. Typical fifty-gallon electric-resistance storage 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 storage water heater with an Energy Factor of 0.95 would consume 4,622 kilowatt-hours per year (see Table 1 on page nine for figures). This is a savings of 4.8% in comparison to the typical fifty-gallon electric-resistance storage water heater with an Energy Factor of 0.904 at the Federal standard.

Typical electric-resistance tankless water heaters have Energy Factors that range from 0.96 to 0.99. Using the DOE test procedure for calculations, an electric-resistance tankless water heater with an Energy Factor of 0.99 would consume 4,435 kilowatt-hours per year. This is a savings of 8.7% in comparison to the typical fifty-gallon electric-resistance storage water heater with an Energy Factor of 0.904 at the Federal standard.

Both electric-resistance storage and tankless water heaters present limited individual energy savings potential. Energy Factor is the ratio of useful energy output to the total amount of energy delivered to the water heater. The perfect electric-resistance water heater could not exceed an Energy Factor of 1.0 due to this technology's physical limitations. The best electric-resistance storage water heaters achieve an Energy Factor of 0.95 and the best electric-resistance tankless water heaters achieve an Energy Factor of 0.99. This technology has little to no room for improving its current energy savings.

A savings of 4.8% and 8.7% is not significant and does not offer meaningful differentiation in accordance with the ENERGY STAR guiding principles. In addition, electric resistance technology has nearly maximized its energy savings potential. Given current and potential energy savings, electric resistance water heating technology is not under consideration for ENERGY STAR.

DOE has taken into account stakeholder feedback and comments supporting the exclusion of electric resistance water heaters in the program. Stakeholders have indicated the primary reason for exclusion is insignificant energy savings. In addition, stakeholders have suggested that electric resistance technology is highly inefficient over the full fuel cycle and it potentially increases total energy consumption and emissions.

[1] Title 10, Code of Federal Regulations, Chapter 11, Part 430, Subpart B, Appendix E

High-Efficiency and High-Performance 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 the combustion products ascend through a flue in the center of the tank. Heat from the burner and the 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. Currently, high-performance gas storage water heaters require the use a power vent to assist the venting of combustion gases in order to achieve a greater Energy Factor.

Stakeholders have indicated the water heater industry is not well adjusted enough at this point for the establishment of a high minimum Energy Factor requirement. Such an ambitious requirement would commit the program to including only high-performance gas storage water heaters at its onset. Because of the current requirement for a power vent, there will be an increase in installation costs for a direct retrofit. Stakeholder comments and feedback have indicated manufacturers are in the process of designing competitively priced high-performance gas storage models not requiring a power vent. However, these models are still in development and may take additional time before reaching the market.

DOE holds the disposition that ENERGY STAR should act as a driver of the market and is willing to give manufacturers additional time to develop high-performance gas storage water heaters that are better equipped to meet consumer needs. Gas storage technology has a considerable amount of room to improve its energy savings potential. Manufacturers are optimistic high-performance gas water heaters can act as a bridge to advanced non-condensing or near-condensing gas storage water heating technologies.

ENERGY STAR can prepare market channels for high-performance gas water heaters by establishing an Energy Factor requirement of 0.62 for high-efficiency gas storage water heaters for a limited timeframe. Distributors, installers and consumers will become acquainted with the ENERGY STAR label, thus creating the foundation for ENERGY STAR to gain acceptance and appreciation in the water heater market infrastructure. In addition, a minimum Energy Factor requirement of 0.62 conforms to the Consortium of Energy Efficiency's (CEE) Tier Zero level. DOE looks forward to collaborating with CEE to achieve long-term market transformation.

However, DOE is intent on establishing an ambitious deadline for the qualifying criteria to ascend to the high-performance gas storage level. DOE will accede with manufacturers' requests to implement a minimum Energy Factor requirement for the inclusion of high-efficiency gas storage water heaters at the program's onset. However, by setting a hard deadline now, DOE is obligating manufacturers to fulfill the market niche for high-performance gas storage water heaters in the near term.

DOE will include high-efficiency gas storage water heaters with a minimum Energy Factor of 0.62 at the onset of the program for a limited timeframe. On September 1, 2010, the minimum Energy Factor will increase to 0.67 for qualification.

Criteria
DOE is including residential high-efficiency gas (natural gas and propane) storage water heaters in the program. The final criteria are:

- A minimum Energy Factor of 0.62 to sunset August 31, 2010.
- A minimum First-Hour Rating requirement of 67 gallons-per-hour. This is to ensure models earning the label provide sufficient hot water delivery.
- A minimum six-year limited warranty on the sealed system. This is to ensure models earning the label are reliable and perform properly.
- Compliance with ANSI Z21.10.1/CSA 4.1.

Savings and Payback
Using the DOE test procedure for calculations, a fifty-gallon gas storage water heater with a 0.62 Energy Factor would consume an estimated 242 therms per year. This is a savings of 7.3%, or 19 therms, in comparison to the typical conventional gas water heater. The annual energy savings equal $26 using the national average gas rate. The monetary savings will pay for the price premium in 2.5 years.

Using the DOE test procedure for calculations, a fifty-gallon gas storage water heater with a 0.67 Energy Factor would consume an estimated 224 therms per year. This is a savings of 14%, or 37 therms, in comparison to the typical conventional gas water heater. The annual energy savings equal $51 using the national average gas rate. The monetary savings will pay for the price premium in eight years, given the estimated price premium in the market in response to an ENERGY STAR label. Manufacturers are designing competitively priced high-performance gas storage water heaters with a category-one vent and material alterations to decrease first cost as an ENERGY STAR label would open these models to a wider consumer segment. The price premium should also decrease with economies of scale in time.

Market Share
High-efficiency gas storage water heaters account for an estimated 350,000 residential sales per year. [2] The number of high-efficiency gas storage water heaters available on the market is sufficient, although lower in comparison to the typical conventional gas storage water heaters at the Federal standard. If just 15% of the nation's 4.7 million gas water heater shipments were high-efficiency gas storage water heaters with an Energy Factor of 0.62 instead of conventional models with an Energy Factor at the Federal standard, the aggregate energy savings would amount to 13.4 million therms per year.

High-performance gas storage water heaters account for an estimated 10,000 residential sales per year.[3] Currently, the number of high-performance gas storage water heaters available on the market is significantly lower in comparison to the rest of the conventional gas water heater market. However, manufacturer feedback indicates the most significant barrier is market pull, which ENERGY STAR can augment. If just 7.5% of the nation's 4.7 million gas water heater shipments were high-performance gas storage water heaters with an Energy Factor of 0.67 instead of conventional models with an Energy Factor at the Federal standard, the aggregate energy savings would amount to more than 13 million therms per year.

[2] Based on conversations with manufacturers.
[3] Based on conversations with manufacturers.

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 and then exits the unit. Once the heat exchanger becomes hot, the water reaches its set point temperature.

DOE has taken into account stakeholder feedback and comments recommending a decrease in minimum gallons-per-minute (gpm) requirement for whole-home tankless water heaters. Stakeholders stated tankless water heaters with a 3.0 gpm at a 77°F rise are too large for the biggest market segment of tankless water heaters. This segment is primarily one-bathroom and/or two-person households, mainly empty nesters not requiring the type of delivery intended for larger households. Lower occupancy households, such as apartments or condominiums, are pressured towards wasting energy by burning more BTUs than necessary if they use a model with a minimum 3.0 gpm at a 77°F rise. Additionally, apartment and condominium households favor tankless water heaters due to the reduced space these models require.

Criteria
DOE is including residential whole-home gas tankless water heaters in the program.
The final criteria are:

- A minimum Energy Factor of 0.82.
- A minimum gallons-per-minute (gpm) requirement of 2.5 gpm at a 77°F rise. This is to ensure models earning the label provide sufficient hot water delivery.
- A minimum ten-year limited warranty on the heat exchanger and five-year warranty on parts.
- Compliance with ANSI Z21.10.1/CSA 4.1 or ANSI Z21.10.3/CSA 4.3, depending on burner size.

Savings and Payback
Using the DOE test procedure for calculations, a whole-home gas tankless water heater with a 0.82 Energy Factor would consume 183 therms per year. This is a savings of 30%, or 78 therms, in comparison to the typical gas storage water heater. The annual energy savings equal $108 using the national average gas rate. The monetary savings will pay for the price premium in 5.5-15 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.

Market Share
Gas tankless water heaters currently account for 254,600 sales per year. Manufacturers can produce models that meet or exceed a 0.82 Energy Factor with a 2.5-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 0.82 Energy Factor instead of conventional models with an Energy Factor at the Federal standard, the aggregate energy savings would amount to nearly 36.7 million therms per year.

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 into the compressor. The compressor increases the pressure of the refrigerant, raising 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.

Criteria
DOE is including residential drop-in or integrated heat pump water heaters in the program. The final criteria are:

- A minimum Energy Factor of 2.0.
- A minimum First-Hour Rating requirement of 50 gallons-per-hour.
- A minimum six-year limited warranty on the sealed system.
- Compliance with UL 174 and UL 1995.

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.

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 in the process of developing this product in response to the potential impact of an ENERGY STAR label. ENERGY STAR can assist in the development of the heat pump water heater 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.

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.

DOE took into account stakeholder feedback and comments recommending a decrease in the warranty level due to industry practice and current market characteristics. Stakeholders indicated the standard warranty in the solar industry is up to ten years for the solar collector, six years for the storage tank,

two years for the controls and one year for piping and parts.[4] After reviewing stakeholder feedback and analyzing the water heater market DOE has adjusted the minimum warranty.

Criteria
DOE is including residential solar water heaters in the program. The final criteria are:

- A minimum Solar Fraction of 0.50.
- OG-300 certification from the SRCC.
- A minimum ten-year limited warranty for the solar collector, six-year warranty for the storage tank, two-year warranty for the controls and one-year warranty for the piping and parts.

Savings and Payback
An OG-300 certified solar water heater with a 0.50 Solar Fraction and a fifty-gallon electric storage auxiliary water heater (with an Energy Factor at the Federal standard) would achieve a Solar Energy Factor of 1.8. Using the DOE test procedure for calculations, the energy consumption for such a solar water heater system, with a 1.8 Solar Energy Factor, would correspond to an estimated 2,429 kilowatt-hours per year. This is a savings of 50%, or 2,428 kilowatt-hours, in comparison to the typical electric resistance water heater. The annual energy savings equal $252 using the national average electric rate. The monetary savings will pay for the price premium in ten years, based on the average installed cost.

An OG-300 certified solar water heater with a 0.50 Solar Fraction and a fifty-gallon gas storage auxiliary water heater (with an Energy Factor at the Federal standard) would achieve a Solar Energy Factor of 1.2. Using the DOE test procedure for calculations, the energy consumption for such a solar water heater system, with a 1.2 Solar Energy Factor, would correspond to an estimated 131 therms per year. This is a savings of 50%, or 130 therms, in comparison to the typical gas storage water heater. The annual energy savings equal $180 using the national average gas rate. The monetary savings will pay for the price premium in 13 years, based on the average installed cost.

Market Share
Solar water heaters account for an estimated 8,500 residential sales per year, with electric storage auxiliary having more prevalence in the market than gas storage. A number of manufacturers can produce OG-300 rated solar water heaters with a Solar Fraction of 0.50 or greater. If just 2.5% 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 291 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 6.1 million therms per year.

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

[4] Based on comments submitted by Florida Solar Energy Research and Education Foundation

storage models, but the combustion gases are vented through coils to supply additional heat to the water that conventional models do not provide.

In the Second Draft Criteria Analysis and Proposal, DOE increased the minimum First-Hour Rating to 67 gallons-per-hour for gas condensing water heaters. This aligns with the National Plumbing Code's suggested First-Hour Rating for gas storage water heaters intended for whole-home purposes.

Criteria
DOE is including residential gas condensing water heaters in the program.
The final criteria are:

- A minimum Energy Factor of 0.80.
- A minimum First-Hour Rating of 67 gallons-per-hour.
- A minimum eight-year warranty on the sealed system.
- Compliance with ANSI Z21.10.1/CSA 4.1.

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 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 $102 using the national average gas. The monetary savings will pay for the price premium in 4-9 years,[5] depending on installed cost.

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.

Summary

DOE is establishing program requirements for residential high-efficiency gas storage, gas condensing, gas tankless, heat pump and solar water heaters for whole home applications, effective January 1, 2009. A moderate displacement of conventional water heaters at the Federal Standard with ENERGY STAR qualified models would achieve cumulative energy savings of 1.6 billion kilowatt-hours and 77.8 million therms per year. These energy savings would equal more than $273 million per year in monetary savings using the national average electric and gas rates. By establishing ENERGY STAR water heater criteria, DOE envisions ENERGY STAR qualified water heating technologies progressing in the market and gaining a nominal market share within five years.

[5] $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

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

Electric Water Heater	Standard	High-Performing	Tankless	HPWH	Solar
Energy Factor	0.904	0.95	0.99	2.0	1.8[6]
Annual Consumption (kWh/yr)[7]	4,857	4,622	4,435	2,195	2,429
Annual Savings (kWh/yr)	None	235	422	2,662	2,428
Annual Cost of Operation ($/yr)	$505	$481	$461	$228	$253
Annual Savings ($/yr)	None	$24	$44	$277	$252
Life Expectancy	13 years[8]	13 years	20 years	10 years[9]	20 years
Lifetime Savings (kWh)	None	3,055	8,440	26,620	48,570
Lifetime Savings ($)	None	$318	$878	$2,768	$5,051
Installed Cost	~$650	~$700	~$1,000-$2,000	~$1,500[10]	~$3,200[11]
Price Premium	NA	~$50	~$350-$1,350	~$850	~$2,550
Payback on Price Premium	NA	~2 years	~8-31 years	~3 years	~10 years
Residential Annual Sales	~4.8 million[12]		~45,000[13]	<2,000[14]	~8,500[15]

[6] Based on the SRCC conversion formula: Solar Fraction = 1 – (Energy Factor/Solar Energy Factor), assuming a 0.9 Energy Factor for the electric auxiliary
[7] Energy consumption estimated using the DOE test procedure. Based on the following formula: (12.03/EF) x 365
[8] Federal Energy Management Program "How to Buy an Energy Efficient Electric Water Heater" September 2004
[9] Oak Ridge National Laboratory "Durability Testing of a Drop-In Heat Pump Water Heater" April 2004
[10] Vermont Energy Investment Corporation "Residential Heat Pump Water Heaters: Energy Efficiency Potential and Industry Status" November 2005
[11] 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.
[12] Gas Appliance Manufacturers Association 2006 Shipments
[13] According to discussions with electric tankless manufacturers, March 2007
[14] Oak Ridge National Lab (ORNL) "The Drop-In Residential Heat Pump Water Heater"
[15] Based on estimate in comments submitted by California Solar Energy Industries Association

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

Gas Water Heater	Standard	High-Efficiency	High-Performance	Tankless	Gas-Condensing	Solar
Energy Factor	0.575	0.62	0.67	0.82	0.8	1.2[16]
Annual Consumption (therm/yr)[17]	261	242	224	183	187	131
Annual Savings (therm/yr)	None	19	37	78	74	130
Annual Cost of Operation ($/yr)	$360	$334	$309	$253	$258	$180
Annual Savings ($/yr)	None	$26	$51	$108	$102	$180
Life Expectancy	13 years[18]	13 years	13 years	20 years[19]	15 years	20 years
Lifetime Savings (therms)	None	247	481	1,560	1,110	2,610
Lifetime Savings ($)	None	$341	$664	$2,153	$1,532	$3,602
Installed Cost	~$865[20]	~$935	~$1,265	~$1,470-$2,500[21]	~$1,300-$1,800[22]	~$3,200
Price Premium	None	~$70	~$400	~$605-$1,635	~$435-$935	~$2,335
Payback on Price Premium	None	~2.5 years	~8 years	~5.5-15 years	~4-9 years	~13 years
Residential Annual Sales	~4.7 million[23]			~254,600[24]	NA	~8,500

[16] Based on the SRCC conversion formula: Solar Fraction = 1 – (Energy Factor/Solar Energy Factor), assuming a 0.6 Energy Factor for the gas auxiliary
[17] Energy consumption estimated using the DOE test procedure. Based on the following formula: (41,045 BTU/EF x 365)/100,000
[18] Federal Energy Management Program "How to Buy an Energy Efficient Gas Water Heater" September 2004
[19] Energy Trust of Oregon "Tankless Gas Water Heaters: Oregon Market Status" December 2005
[20] 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)
[21] 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)
[22] 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
[23] Gas Appliance Manufacturers Association 2006 Shipments
[24] 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.[25]

Residential Water Heater Product Classes[26]		
Storage	**Gas-fired**	A nominal input of 75,000 BTU/hour or less and a rated storage volume from 20 to 100 gallons
	Oil-fired	A nominal input of 105,000 BTU/hour or less and a rated storage volume of 50 gallons or less
	Electric	A nominal input of 40,956 BTU/hour or less and a rated storage volume from 20 to 120 gallons
	Heat Pump	A maximum current rating of 24 amperes, voltage no greater than 250 volts, and a transfer of thermal energy from one temperature to a higher temperature level for the purpose of heating water
	Tabletop	A box enclosure designed to slide into a kitchen countertop space and dimensions of 36 inches high, 25 inches deep and 24 inches wide
Tankless	**Gas-fired**	A nominal input of over 50,000 BTU/hour up to 200,000 BTU/hour and a rated storage volume of 2 gallons or less
	Electric	An input of 12 kilowatts or less

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

[26] Title 10, Code of Federal Regulations, Chapter 11, Part 430, Subpart B, Appendix E.