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FEMP Designated Product Assessment for Commercial Gas Water Heaters

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Proposed Purchasing Specification for FEMP:
Commercial Gas Water Heaters

Proposed Specification for Commercial Gas Water Heaters

LBNL recommends the performance requirement for FEMP-designated commercial water heaters be set at a thermal efficiency of 94%or above. This efficiency level is the top 25% of the efficiency levels for this product type. Products at this thermal efficiency level are available from eleven manufacturers. Shipments to the federal sector in 2009 were estimated to be 34,000.

FEMP Performance Requirement

To determine the recommended efficiency ranges, the performance requirement for FEMP-designated products is generally set at the top 25% for a product type. In addition, products should be available from at least three manufacturers. In the case that three manufacturers cannot meet the 25th percentile efficiency level, the recommended efficiency level is the best efficiency that can be met or exceeded by three manufacturers. Additionally, all recommended efficiency levels must meet or exceed the minimum levels specified in EPAct for that product.[1] The best available efficiency level represents the single most efficient commercial water heater.

Definition of Product

Commercial gas water heaters are defined by the CFR as being storage water heaters, instantaneous water heaters, or hot water supply boilers.

Storage water heater means a water heater that heats and stores water within the appliance at a thermostatically controlled temperature for delivery on demand. The term ‘‘instantaneous water heater’’ means a water heater that has an input rating of at least 4000 Btu per hour per gallon of stored water.[2] Hot water supply boiler means a packaged boiler that has an input rating from 300,000 Btu/hr to 12,500,000 Btu/hr (and at least 4,000 Btu/hr per gallon of stored water), and is intended for heating potable water.[3,4]

This proposed purchasing specification is only for gas-fired products. Electric resistance and heat pump water heaters are not covered. Neither are oil-fired water heaters.

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[1] 10 CFR 431.110 Energy conservation standards and their effective dates.
[2] 42 U.S.C. 6311
[3] 10 CFR431.102 Definitions concerning commercial water heaters, hot water supply boilers, and unfired hot water storage tanks.
[4] Packaged boiler means a boiler that is shipped complete with heating equipment, mechanical draft equipment and automatic controls; usually shipped in one or more sections and does not include a boiler that is custom designed and field constructed. If the boiler is shipped in more than one section, the sections may be produced by more than one manufacturer, and may be originated or shipped at different times and from more than one location

Table 1 displays the information in another format for easy comparison.

Definitions of Commercial Water Heaters				
Appliance	***Definition***	***Input (BTUH)***	***Size (Volume)***	***Input to Volume Ratio***
Gas storage water heaters	a water heater that heats and stores water within the appliance at a thermostatically-controlled temperature for delivery on demand.	> 75,000	any	< 4,000 Btu/hr/gal
Gas instantaneous water heaters	a water heater that has an input rating of at least 4,000 Btu per hour per gallon of stored water.	>200,000	< 10 gal	≥4,000 Btu/hr/gal
			≥10 gal	
Gas hot water supply boilers	a packaged boiler that is industrial equipment and that is suitable for heating potable water.	≥300,000 & <12,500,000	< 10 gal	≥4,000 Btu/hr/gal
			≥10 gal	

Efficiency Metric

The efficiency metric for commercial gas water heaters is thermal efficiency. Thermal efficiency is the ratio of the heat transferred to the water flowing through the water heater to the amount of energy consumed by the water heater as measured during the thermal efficiency test procedure.[5] The test procedure to use for rating gas-fired storage and instantaneous water heaters and hot water supply boilers is ANSI Z21.10.3–1998.[6] [7]

Note the CFR references a specific year of ANSI. ANSI standards are updated every 5 years. The standard being referenced is now 13 years out of date.

Performance Standard

The minimum thermal efficiency for all gas-fired storage and instantaneous water heaters and hot water supply boilers is 80%. The maximum standby loss is specified using a formula that accounts for rated volume and nameplate input rate.[8] There is no maximum standby loss specified for gas-fired instantaneous water heaters and hot water supply boilers sized less than 10 gallons.

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[5] 10CFR431.102 Definitions concerning commercial water heaters, hot water supply boilers, and unfired hot water storage tanks.

[6] 10CFR431.105 Materials incorporated by reference.

[7] 10CFR431.106 Uniform test method for the measurement of energy efficiency of commercial water heaters and hot water supply boilers (other than commercial heat pump water heaters).

[8] 10CFR431.110 Energy conservation standards and their effective dates.

Range of Efficiencies

The range of efficiencies for commercial water heaters was determined by examining the entries for large gas water heaters in the California Energy Commission (CEC) Appliance Database.[9] This data set lists 2,670 models added since January 1, 2000 with inputs ranging from 75,000 BTU/hr up to 8 million BTU/hr and measured volumes up to 4,500 gallons.

The thermal efficiency of commercial water heaters in the directory ranges from a low of 80% to a high of 99%. The top 25% of this range is 94.25%.[10]

There is a widely acknowledged technological break between 85% and 90% thermal efficiency for water heaters and boilers. This depends on whether the water heaters and boilers are efficient enough to condense the water vapor in the combustion products.

See figure 1 for a histogram of the number of models by efficiency level. The double hump distribution of efficiencies is common for gas burning products with both non-condensing and condensing efficiencies. The vertical line shows the number of models with a thermal efficiency of at least 94%.

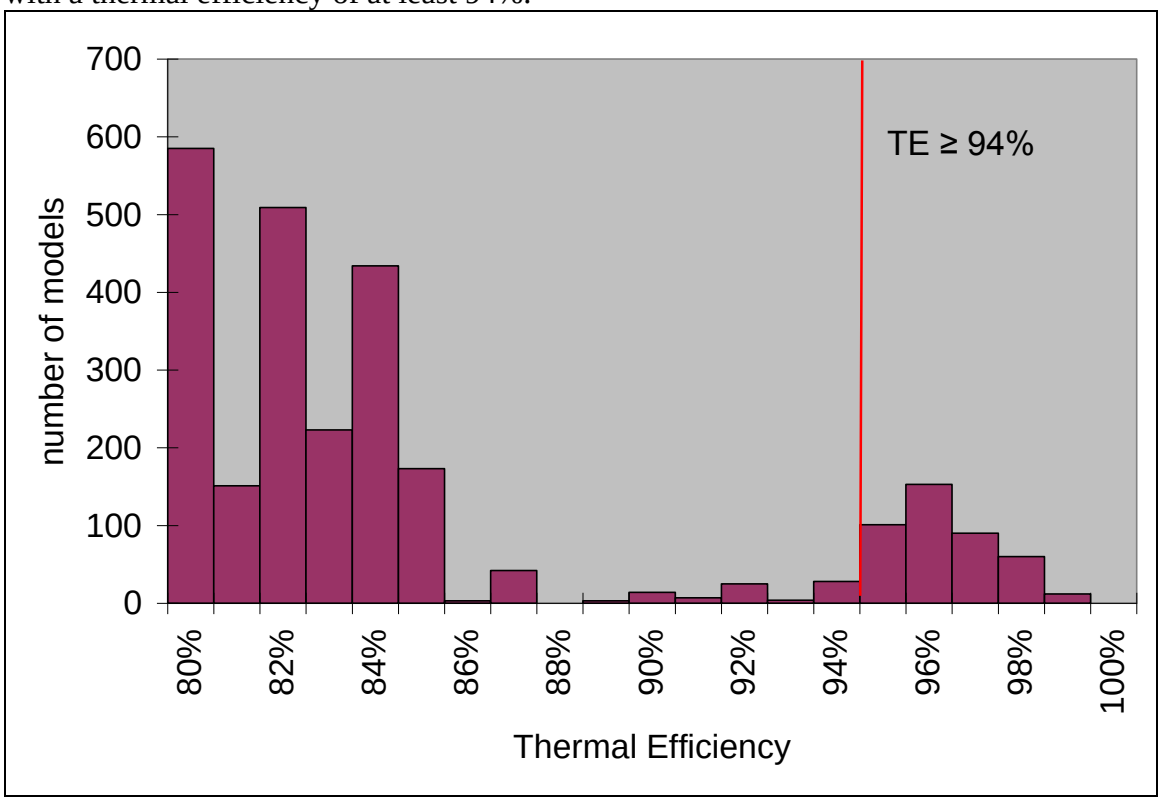

Figure 1 Number of Models by Thermal Efficiency

[9] California Energy Commission Appliance Database's Advanced Search page http://www.appliances.energy.ca.gov/AdvancedSearch.aspx accessed 4/6/2010 8:26AM

[10] 25th percentile efficiency for each product category is calculated as follows: Max efficiency - 0.25*(Max efficiency – Min efficiency), using the efficiency descriptor defined for that product.

Use in the Federal Sector

Commercial water heaters are used in locations with high daily hot water use. Common applications are in food service facilities, laundries, and locations with many showers. Food service facilities, such as cafeterias are common in federal sector and military buildings.

There is no centralized record of annual sales of commercial water heaters to the federal sector. Estimates from industry sources put annual sales to the federal sector at about 34,000 units in 2009.[11]

Number of Manufacturers

There are multiple manufacturers of commercial water heaters that meet the proposed requirement. Based on data about manufacturer certified products in the CEC database, there are eleven manufacturers who offer 376 models with input below 400,000 BTU/hr and thermal efficiencies of at least 94%.

Manufacturer	Number of Models
A O Smith Water Products	2
American Water Heater Co.	238
Bosch Thermotechnology Corp.	2
Bradford-White Corp.	16
Gasmaster Industries, Inc.	2
Heat Cell Technologies, Inc./ECO Heating Systems	10
Heat Transfer Products	87
Lochinvar Corp.	8
PVI	1
Raypak	2
Rinnai	8

Energy Calculation Method

Annual energy use for a commercial water heater is calculated as:

$$Q_{annl} = \frac{DHW \times days \times \rho \times \Delta T \times C_p \times 100000}{Te}$$

where;

Q_{annl} = Annual energy use (therms/year),
DHW = daily hot water use (gallons/day),

[11] personal communication, Charles Adams, AOSmith, March 8 2010.

days = operating days in a year (days/year),
ρ = density of water (pounds/gallon),
ΔT = temperature rise (degrees Fahrenheit),
Cp = specific heat of water (BTUs/(pound- degrees Fahrenheit),
100000 = conversion factor (BTUs/therm) and
Te = thermal efficiency

Commercial water heaters are used in facilities with high daily hot water use. Because of the high daily volume of hot water use, standby losses are not a significant part of annual energy use.

For purposes of this calculation we used a daily hot water quantity of 1,000 gallons with a temperature rise of 80 ^{o}F.

The following values are used for density, specific heat and temperature rise.
ρ = 8.34 (pounds/gallon),
Cp = 1.00 (BTUs/(pound- degrees Fahrenheit),
The density and specific heat for water are at 70 ^{o}F.[12]

The energy costs were calculated for a baseline water heater with a thermal efficiency of 80% and a required model with a thermal efficiency of 94%. The annual energy costs calculated at a federal natural gas price of $.90 per therm are shown below. For comparison the annual energy cost of best available model, with a thermal efficiency of 99%, is also shown.

annual energy cost		
unit	$ per year	efficiency
baseline	$1,876	80%
required	$1,596	94%
best available	$1,516	99%

Lifetime energy costs were calculated by multiplying the annual energy cost by the FEMP uniform present value (UPV) factor for the unit life. The lifetime of a commercial water heater was estimated to be 10 years.[13] There is no available data on lifetimes of commercial water heaters. Warrantees for commercial water heaters range from three to five years. The UPV discount factor for 10 years for United States average commercial price of natural gas using a discount rate of 3.0% is 8.92.[14]

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[12] E.W. Lemmon, M.O. McLinden and D.G. Friend, "Thermophysical Properties of Fluid Systems" in NIST Chemistry WebBook, NIST Standard Reference Database Number 69, Eds. P.J. Linstrom and W.G. Mallard, National Institute of Standards and Technology, Gaithersburg MD, 20899, http://webbook.nist.gov, (retrieved March 18, 2010).
[13] personal communication, Charles Adams, AOSmith, March 8 2010.
[14] A. S. Rushing and B. C. Lippiatt, "Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis – 2009, Annual Supplement to NIST Handbook 135 and NBS Special Publication 709," National Institute of Standards and Technology, May 2009.
http://www1.eere.energy.gov/femp/pdfs/ashb09.pdf Table Ba-5. FEMP UPV* Discount Factors

The lifetime energy savings are calculated as the difference between the lifetime energy cost of the base model and lifetime energy cost of the required model. This is shown in the following table.

lifetime energy costs		
unit	costs	efficiency
baseline	$16,733	80%
required	$14,241	94%
savings	$2,492	

The lifetime energy savings with these assumptions are $2,769.

Incremental Price

An estimate of the incremental price for a commercial water heater of the required efficiency was derived from information taken from the GSA Advantage website.[15] One hundred fifty one commercial gas-fired water heaters were listed for sale on the site. To determine thermal efficiency, model numbers were matched with entries in the CEC database. It was possible to match the model numbers of eighty nine of the commercial water heaters on the GSA Advantage website with model numbers in the CEC database to determine thermal efficiency.

Three sets of condensing and non-condensing water heaters with similar capacities were identified.

Input (BTUH)	Size (Volume)	Thermal Efficiency	Price	Incremental Price
125000	75	80	$4,152	
130000	46	94.9	$4,928	$775
130000	80	92	$5,881	$1,728
156000	82	80	$5,021	
160000	45	94.1	$7,692	$2,670
160000	80	92	$6,064	$1,042
199900	76	80.7	$4,539	
199000	80	91.6	$6,220	$1,681

The average incremental price for a condensing commercial water heater is $1,579. For condensing commercial water heaters with a thermal efficiency greater than 94% the average incremental price is $1,723. This is significantly less than the lifetime energy savings of $2,769.

[15] www.gsaadvantage.gov Advanced Search, Building & Industrial category. Found products for water heater in any product field and gas and commercial and not pkg heat/AC. accessed 3/30/2010