### Storage Water Heater

###### Description

This measure is for upgrading from minimum code to a high efficiency storage-type water heater. Storage water heaters are used to supply hot water for a variety of commercial building types. Storage capacities vary greatly depending on the application. Large consumers of hot water include (but not limited to) industries, hotels/motels and restaurants.

This measure was developed to be applicable to the following program types: TOS.

If applied to other program types, the measure savings should be verified.

###### Definition of Efficient Equipment

The minimum specifications of the high efficiency equipment should be defined by the programs.

###### Definition of Baseline Equipment

The baseline condition is assumed to be a new standard water heater of same type as existing, meeting the Federal Standard for <75,000 Btuh units and IECC 2015 for all others. If existing type is unknown, assume Gas Storage Water Heater.

|  |  |  |
| --- | --- | --- |
| **Equipment Type** | **Sub Category** | **Federal Standard Minimum Efficiency[[1]](#footnote-2)** |
| Gas Storage Water Heaters  ≤ 75,000 Btu/h | ≤55 gallon tanks | 0.675 – (0.0015 \* Rated Storage Volume in Gallons) EF |
| >55 gallon tanks | 0.8012 – (0.00078 \* Rated Storage Volume in Gallons) EF |
| Gas Storage Water Heaters  > 75,000 Btu/h | < 4000 Btu/h/gal | 80% Et  Standby Loss: (Q/800 + 110√V) |
| Electric Water Heaters  ≤ 75,000 Btu/h | ≤55 gallon tanks | 0.96 – (0.0003 \* rated volume in gallons) EF |
| >55 gallon tanks [[2]](#footnote-3) | 2.057 – (0.00113 \* rated volume in gallons) EF |
| Electric Water Heaters  > 75,000 Btu/h | ≤12 kW | 0.97 – (0.00132 \* rated volume in gallons) EF |
| > 12kW | Standby Loss: 0.30 + 27/Vm (%/hr) |

V= Rated volume in gallons, Vm = measured volume in gallons.

###### Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 15 Years[[3]](#footnote-4)

###### Deemed Measure Cost

The full install cost and incremental cost assumptions are provided below. Actual costs should be used where available[[4]](#footnote-5):

| **Equipment Type** | **Category** | **Install Cost** | **Incremental Cost** |
| --- | --- | --- | --- |
| Gas Storage Water Heaters ≤ 75,000 Btu/h, ≤55 Gallons | Baseline | $616 | N/A |
| Efficient | $1,055 | $440 |
| Gas Storage Water Heaters > 75,000 Btu/h | 0.80 Et | $4,886 | N/A |
| 0.83 Et | $5,106 | $220 |
| 0.84 Et | $5,299 | $413 |
| 0.85 Et | $5,415 | $529 |
| 0.86 Et | $5,532 | $646 |
| 0.87 Et | $5,648 | $762 |
| 0.88 Et | $5,765 | $879 |
| 0.89 Et | $5,882 | $996 |
| 0.90 Et | $6,021 | $1,135 |

For electric water heaters the incremental capital cost for this measure is assumed to be[[5]](#footnote-6)

|  |  |
| --- | --- |
| **Tank Size** | **Incremental Cost** |
| 50 gallons | $1050 |
| 80 gallons | $1050 |
| 100 gallons | $1950 |

###### Loadshape

For electric hot water heaters, use Loadshape C02 - Non-Residential Electric DHW.

###### Coincidence Factor

The coincidence factor is assumed to be 0.925 [[6]](#footnote-7).

**Algorithm**

###### Calculation of Savings

###### Electric Energy Savings

Electric energy savings are calculated for electric storage water heaters per the equations given below.

Electric units ≤12 kW:

Where:

Tout = Tank temperature

= 125°F

Tin = Incoming water temperature from well or municiple system

= 54°F[[7]](#footnote-8)

HotWaterUseGallon = Estimated annual hot water consumption (gallons)

= Actual if possible to provide reasonable custom estimate. If not, two methodologies are provided to develop an estimate:

1. Consumption per water heater capacity

= Consumption/cap \* Capacity

Where:

Consumption/cap = Estimate of consumption per gallon of tank capacity, dependent on building type:[[8]](#footnote-9)

| **Building Type** | **Consumption/cap** |
| --- | --- |
| Grocery, Convenience Store, and Restaurant | 803 |
| Lodging, Hospital, and Multifamily | 630 |
| Health Clinic, Church, Warehouse | 433 |
| Education, Office, and Retail | 594 |
| Industrial | 558 |
| Agriculture | 558 |
| Average Non Residential | 558 |

Capacity = Capacity of hot water heater in gallons

= Actual[[9]](#footnote-10)

1. Consumption by Facility Size[[10]](#footnote-11)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Building Type** | **Gallons hot water per unit per day** | **Unit** | **Units/1000 ft2** | **Days per year** | **Gallons/1000 ft2 floor area** |
| Small Office | 1 | person | 2.3 | 250 | 575 |
| Large Office | 1 | person | 2.3 | 250 | 575 |
| Fast Food Rest | 0.7 | meal/day | 784.6 | 365 | 200,458 |
| Sit-Down Rest | 2.4 | meal/day | 340 | 365 | 297,840 |
| Retail | 2 | employee | 1 | 365 | 730 |
| Grocery | 2 | employee | 1.1 | 365 | 803 |
| Warehouse | 2 | employee | 0.5 | 250 | 250 |
| Elementary School | 0.6 | person | 9.5 | 200 | 1,140 |
| Jr High/High School | 1.8 | person | 9.5 | 200 | 3,420 |
| Health | 90 | patient | 3.8 | 365 | 124,830 |
| Motel | 20 | room | 5 | 365 | 36,500 |
| Hotel | 14 | room | 2.2 | 365 | 11,242 |
| Other | 1 | employee | 0.7 | 250 | 175 |

γWater = Specific weight capacity of water (lb/gal)

= 8.33 lbs/gal

1 = Specific heat of water (Btu/lb.°F)

EFelecbase = Rated efficiency of baseline water heater expressed as Energy Factor (EF);

|  |  |  |
| --- | --- | --- |
| **Equipment Type** | **Sub Category** | **Federal Standard Minimum Efficiency[[11]](#footnote-12)** |
| Electric Water Heaters  ≤ 75,000 Btu/h | ≤55 gallon tanks | 0.96 – (0.0003 \* rated volume in gallons) EF |
| >55 gallon tanks [[12]](#footnote-13) | 2.057 – (0.00113 \* rated volume in gallons) EF |
| Electric Water Heaters  > 75,000 Btu/h | ≤12 kW | 0.97 – (0.00132 \* rated volume in gallons) EF |
| > 12kW | N/A  (For >12 kW Units see below) |

EFeff = Rated efficiency of efficient water heater expressed as Energy Factor (EF) or Thermal Efficiency (Et)

= Actual

3412 = Converts Btu to kWh

For example, for a 200,000 Btu/h, 150 gallon, 90% Thermal Efficiency storage unit with rated standby loss of 1029 BTU/h installed in a 1500 ft2 restaurant:

ΔkWh = ((125 – 54) \* (297,840 \* 1.5) \* 8.33 \* 1 \* (1/0.8 - 1/0.9))/3412

= 10,756 kWh

Electric units > 12kW:

Tair = Ambient Air Temperature

= 70°F

V = Rated tank volume in gallons

= Actual

SLelecbase = Standby loss of electric baseline unit (%/hr)

= 0.30 + 27/V

SLeff = Nameplate standby loss of new water heater, in BTU/h

8766 = Hours per year

For example, >12kW, 100 gallon storage unit with rated standby loss of 0.5 %/hr:

SLbase = 0.3 + (27 / 100)

= 0.57%/hr

ΔkWh = (((125 – 70) \* 100 \* 8.33 \* 1 \* (0.57- 0.5)) \* 8766)/3412

= 8,239 kWh

###### Summer Coincident Peak Demand Savings

Where:

Hours = Full load hours of water heater

= 6461 [[13]](#footnote-14)

CF = Summer Peak Coincidence Factor for measure

= 0.925 [[14]](#footnote-15)

For example, >12kW, 100 gallon storage unit with rated standby loss of 0.5 %/hr:

ΔkW = 8,239 / 6,461 \* 0.925

= 1.18 kW

###### Natural Gas Energy Savings

Natural gas energy savings are calculated for natural gas storage water heaters per the equations given below.

Where:

100,000 = Converts Btu to Therms

EFgasbase = Rated efficiency of baseline water heater expressed as Energy Factor (EF) or Thermal Efficiency (Et);

|  |  |  |
| --- | --- | --- |
| **Equipment Type** | **Sub Category** | **Federal Standard Minimum Efficiency[[15]](#footnote-16)** |
| Gas Storage Water Heaters  ≤ 75,000 Btu/h | ≤55 gallon tanks | 0.675 – (0.0015 \* Rated Storage Volume in Gallons) EF |
| >55 gallon tanks | 0.8012 – (0.00078 \* Rated Storage Volume in Gallons) EF |
| Gas Storage Water Heaters  > 75,000 Btu/h | < 4000 Btu/h/gal | 80% Et |

**Additional Standby Loss Savings**

Gas Storage Water Heaters >75,000 Btu/h can claim additional savings due to lower standby losses.

Where:

SLgasbase = Standby loss of gas baseline unit (Btu/h)

Q =Nameplate input rating in Btu/h

V = Rated volume in gallons

SLeff = Nameplate standby loss of new water heater, in Btu/h

8766 = Hours per year

For example, for a 200,000 Btu/h, 150 gallon, 90% Thermal Efficiency storage unit with rated standby loss of 1029 BTU/h installed in a 1500 ft2 restaurant:

ΔTherms = ((125 – 54) \* (297,840 \* 1.5) \* 8.33 \* 1 \* (1/0.8 - 1/0.9))/100,000

= 367.0 Therms

ΔThermsStandby = (((200000/800 + 110 \* √150) – 1079) \* 8766)/100,000

= 49.8 Therms

ΔThermsTotal = 367.0 + 49.8

= 416.8 Therms

###### Water Impact Descriptions and Calculation

N/A

###### Deemed O&M Cost Adjustment Calculation

N/A

###### Measure Code: CI-HW\_-STWH-V02-160601

1. ≤75,000 Btu/h Storage Water Heater and <200,000 Btu/h Tankless Water Heater Federal Standard is DOE Standard 10 CFR 430.32(d). All other standards are from 10 CFR 431.110. [↑](#footnote-ref-2)
2. It is assumed that tanks <75,000Btu/h and >55 gallons will not be eligible measures due to the high baseline. [↑](#footnote-ref-3)
3. DEER 08, EUL\_Summary\_10-1-08.xls. [↑](#footnote-ref-4)
4. Cost information is based upon data from “2010-2012 WA017 Ex Ante Measure Cost Study Draft Report”, Itron, February 28, 2014. See “NR HW Heater\_WA017\_MCS Results Matrix - Volume I.xls” for more information. [↑](#footnote-ref-5)
5. Act on Energy Commercial Technical Reference Manual, Table 9.6.1-4 [↑](#footnote-ref-6)
6. Coincidence factor based on Average W in peak period/Max W from Itron eShape data for Missouri, calibrated to Illinois loads, [↑](#footnote-ref-7)
7. US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL [http://www1.eere.energy.gov/buildings/building\_america/analysis\_spreadsheets.html](http://www.energystar.gov/ia/products/appliances/refrig/NAECA_calculation.xls) [↑](#footnote-ref-8)
8. Based on Cadmus analysis. Annual hot water usage in gallons based on CBECS (2003) consumption data of West North Central (removed outliers of 1,000 kBtuh or less) to calculate hot water usage. Annual hot water gallons per tank size gallons based on the tank sizing methodology found in ASHRAE 2011 HVAC Applications. Chapter 50 Service Water Heating. Demand assumptions (gallons per day) for each building type based on ASHRAE Chapter 50 and to LBNL White Paper. LBL-37398 Technology Data Characterizing Water Heating in Commercial Buildings: Application to End Use Forecasting. VEIC consider these relatively conservative estimates and consider this may be a good variable for future evaluation. [↑](#footnote-ref-9)
9. If the replaced unit is a tankless water heater, an estimate will need to be made of the required storage tank for the application. [↑](#footnote-ref-10)
10. Osman Sezgen and Jonathan G. Koomey. Lawrence Berkeley National Laboratory 1995; “Technology Data Characterizing Water Heating in Commercial Buildings: Application to End-Use Forecasting”. December 1995. [↑](#footnote-ref-11)
11. ≤75,000 Btu/h Storage Water Heater and <200,000 Btu/h Tankless Water Heater Federal Standard is DOE Standard 10 CFR 430.32(d). All other standards are from 10 CFR 431.110. [↑](#footnote-ref-12)
12. It is assumed that tanks <75,000Btu/h and >55 gallons will not be eligible measures due to the high baseline. [↑](#footnote-ref-13)
13. Full load hours assumption based on Wh/Max W Ratio from Itron eShape data for Missouri, calibrated to Illinois loads, [↑](#footnote-ref-14)
14. Coincidence factor based on Average W in peak period/Max W from Itron eShape data for Missouri, calibrated to Illinois loads, [↑](#footnote-ref-15)
15. ≤75,000 Btu/h Storage Water Heater and <200,000 Btu/h Tankless Water Heater Federal Standard is DOE Standard 10 CFR 430.32(d). All other standards are from 10 CFR 431.110. [↑](#footnote-ref-16)