**Work Paper PGECODHW104**

**Gas Water Heater**

**Revision # 4**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Gas Storage Water Heater**

**>0.67 EF<75 kBtu/h input, Condensing Instantaneous (tankless) >0.85 EF**

**Measure Codes: HA 58 (> 0.67EF)**

**HA 59 (condensing instantaneous)**

# At-a-Glance Summary

|  |  |  |
| --- | --- | --- |
| **Applicable Measure Codes:** | HA58 | HA59 |
| **Measure Description:** | Gas Storage Water Heater  HA58: EF >0,67 | Residential Condensing Tankless Water Heater, EF>0.85  For Multi Family, Mobile Homes and Residential Single Family |
| **Energy Impact Common Units:** | Per water heater | Per water heater |
| **Base Case Description:** | Source:  DEER 2014 Gas Storage Water Heater Average EF 0.57 | Source: PG&E Calculations  Gas Storage Water Heater,  EF = 0.61 |
| **Base Case Energy Consumption:** | Source:  DEER 2014  N/A for DEER Measures | Source: PG&E Calculations  SFm=242.5 therm  MFm=147.6 therm  DMo=147.6 therm |
| **Measure Energy Consumption:** | Source: DEER 2014  N/A for DEER Measures | Source: PG&E Calculations  SFm=159.0 therm  MFm=96.8 therm  DMo=96.8 therm |
| **Energy Savings**  **(Measure Case--Base Case):** | Source: DEER 2014  Average Savings =43.9 therm | Source: PG&E Calculations  SFm=83.5 therm  MFm=50.8 therm  DMo=50.8 therm |
| **Costs Common Units:** | Per water heater | Per water heater |
| **Base Case Equipment Cost ($/unit):** | Source: DEER2014  Average Cost = $474.33 | Source: DEER2011  Average Cost = $427.98 |
| **Measure Equipment Cost ($/unit):** | Source: DEER 2014 Average Cost = $598.46 | Source: Market Survey, PG&E Calculations  Average Cost = $2,235.78 |
| **Gross Measure Cost** | $124.14 | $1807,80 |
| **Measure Incremental Cost ($/unit):** | Average IMC = $124.14 | Average IMC = $1,807.80 |
| **Effective Useful Life (years):** | Source: DEER2014  11 years | Source: DEER2014  20 years |
| **Measure Application Type:** | ROB. NC | ROB, NC |
| **Net-to-Gross Ratios:** | Source:  EF > 0.67 DEER2014  NTG = 0.55 | Source: DEER2014  Default < 2 yrs NTG = 0.70 |
| **Important Comments:** |  | |

# Work Paper Approvals

The following Manager(s) approved this workpaper through the PG&E Electronic Data Routing System under Routing Requisition # \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |
| --- |
|  |
| **Grant Brohard**  Manager, Technical Product Support |
| **Carolyn Weiner**  Manager, Appliance Products |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision #** | **Revision Date** | **Section-by-Section Description of Revisions** | **Author (Company)** |
| **Revision 1** | **03.10.2009** | **Natural Gas Storage Water Heater PGECODHW104** | **Charlene Spoor PG&E** | |
| **Revision 2** | **11.30.2009** | **Update measure codes and tiers per DEER 08** | **CLCI PG&E** | |
| **Revision 3** | **06.20.2012**  **8/22/2012** | **- Updated savings, costs, NTG, and EUL to match DEER2011.**  **- Removed measures H671 – H685.**  **- Added all commercial building types, climate zones, and building vintages to H722 and H721.**  **- Added energy savings, costs, EUL, and NTG for Residential Condensing Tankless Water Heater w/ EF>0.85 Added > 0.67 EF**  **Updated BLD ALL with ANY** | **David Gilliland,**  **kW Engineering**  **Charlene Spoor, PG&E**  **Charlene Spoor (PG&E)** | |
| **Revision 4** | **05/28/2014** | **Changed to new template and DEER 2014 references** | **Charlene Spoor (PG&E clci)** |

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# Section 1. General Measure & Baseline Data

## 1.1 Product Measure Description & Background

This work paper documents the rationale for the savings methodologies and assumptions for a high efficiency natural gas storage water heater and for a condensing tankless water heater as part of Pacific Gas and Electric Company’s Customer Energy Efficiency Program. PG&E offers incentives to residential and commercial customers for installing qualifying equipment.

***Catalog Description******[[1]](#endnote-1):***

**HA58**: Encourages residential and commercial customers to upgrade to a high-efficiency natural gas storage water heater with an EF of 0.67 or greater.

**HA59:** This measure encourages customers to upgrade to high-efficiency condensing tankless water heaters with a minimum EF of 0.85.

***Program Restrictions and Guidelines***

***Terms and Conditions:***

**HA58:** The qualifying natural gas storage water heater must have natural gas distributed to the installation address by PG&E. “Instantaneous” and “tankless” water heaters do not qualify. The installed high efficiency natural gas storage water heaters must have an EF greater than or equal to 0.67.

**HA59:** The qualifying natural gas condensing tankless water heater must have natural gas distributed to the address by PG&E. The installed water heater must have an EF of 0.85 or greater.

***The rebate is downstream provided to the customer at the time of sale upon receipt of the application and invoice. This is not a Direct Install program.***

***Market Applicability:*** Measures HA58 and HA59 are applicable to all residential and commercial building types of all vintages and climate zones.

The most significant barrier to water heater retrofit is the existing nature of water heater replacement. Two-thirds of consumers replace their water heaters due to the sudden failure of their existing water heater. When a water heater suddenly fails, most consumers purchase replacements that are the cheapest and most readily available model that are also easy to install. These prevailing attitudes do not encourage consumers to make the extra effort to find more advanced, energy-efficient technologies that are now available on the market[[2]](#endnote-2).

***Type of Transaction:*** Due to customers’ reluctance to replace their water heater until it fails and because water heaters are relatively expensive compared to other appliances, offering rebates for early retirement (ER) is not feasible. Therefore, the savings and costs for these measures are calculated assuming replace on burnout (ROB) and new construction (NC) measure types. For these measure types, the baseline energy consumption is determined by applicable codes and industry standards.

## 1.2 Product Technical Description

Conventional natural gas storage water heaters usually consist of a glass-lined steel tank with foam insulation. Located at the base end of the tank is a natural gas burner. Cold water enters the base of the tank and is heated by the burner. The water then rises to the top portion of the tank. This is where the hot water is drawn for consumption.

In general, energy efficient units have a greater amount of insulation and higher efficiency burners. The most efficient natural gas storage water heaters are condensing water heaters. A condensing unit has more heat exchange surface between the hot exhaust gasses and the water being heated. This allows the water to absorb more of the exhaust gas heat, which in turn reduces the temperature of the exhaust gasses and condenses the exhaust by products[[3]](#endnote-3). By using the heat from the exhaust gas, which is wasted by standard tankless models, condensing natural gas tankless water heaters can achieve higher energy factors (EF) than comparably-sized traditional storage-type or instantaneous water heaters.

Tankless natural gas water heaters differ from storage-type water heaters in that they heat incoming water only when there is a demand for hot water, rather than heating and maintaining a constant stored supply of hot water. As a result, an instantaneous water heater for a given application needs a higher kBtu/h input rating than a storage-type natural gas water heater for the same application. Without storage, the instantaneous water heater must have a much higher burner capacity to handle peak demands. So the kBtu/h input rating of a given base case storage-type water heater is much lower than the measure case instantaneous heater.

This measure applies to a specific type of tankless natural gas water heater: condensing tankless water heaters. The condensing models include all of the features of the tankless water heater listed above. Additionally, a condensing unit has more heat exchange surface between the hot exhaust gasses and the water being heated. This allows the water to absorb more of the exhaust gas heat, which in turn reduces the temperature of the exhaust gasses and condenses the exhaust by products. By using the heat from the exhaust gas, which is wasted by standard tankless models, condensing natural gas tankless water heaters can achieve higher energy factors (EF) than comparably-sized traditional storage-type or instantaneous water heaters.

## 1.3 Measure Application Type

The DEER Measure Cost Data Users Guide found on [www.deeresources.com](http://www.deeresources.com) under *DEER2014 Database Format* DEER2014, spreadsheet *SPTdata\_format-V0.97.xls*, defines the terms as follows:

Table 1: Measure Application Type[[4]](#endnote-4)

*Identifies the measure application type in the Measure Implementation table in DEER2014*

|  |  |  |
| --- | --- | --- |
| **Code** | **Description** | **Comment** |
| ROB | Replace on Burnout | *measure applied when existing equipment fails or maintenance requires replacement* |
| NC | New Construction | *measure applied during construction design phase as an alternative to a code-compliant standard design* |

Measures HA58 and HA59 are applicable to both residential and commercial installations. The savings for all measures are calculated assuming that the installation is either a replace-on-burnout (ROB) or new construction (NC) measure.

## 1.4 Product Base Case and Measure Case Data

### 1.4.1 DEER Base Case and Measure Case Information

The DEER2014 data includes gas energy savings, equipment unit costs, and equipment incremental costs, which were averaged and normalized in order to fit the catalog requirements of measures HA58. The DEER2014 data also includes equipment useful life, and net to gross ratio which are applicable to all measures in this paper, including the condensing instantaneous-type water heater HA59.

**HA 58:**

The savings for these measures are based on the average DEER2014 savings for 40-gallon, 50-gallon, and 60-gallon natural gas storage water heaters. The DEER2014 database provides savings values for the following applicable residential storage-type natural gas water heater conversions[[5]](#endnote-5):

Table 2: DEER2014 Baseline and Measure Efficiencies for HA58

|  |  |  |
| --- | --- | --- |
| Water Heater Size (gallons) | Base Case (Code) Energy Factor | Measure Case Energy Factor |
| 40 | 0.59 | HA58: EF > 0.67 |
| 50 | 0.57 | HA58: EF > 0.67 |
| 60 | 0.56 | HA58: EF > 0.67 |

This measure matches PG&E catalog requirements for the baseline and post-retrofit EF levels.

Please refer to Section 2.3 for a discussion of the averaging and normalizing method that we used to determine the gas energy savings for each building type, building vintage, and climate zone.

**HA59:**

* The DEER2014 data does not contain the appropriate information to determine the gas savings or costs of the condensing tankless natural gas water heater measure. Energy savings and costs for this measure were therefore determined using custom calculations. See section 2.3.2 for further details on this measure.

## 1.4.1 DEER Base Case and Measure Case Information

The DEER2014 data include: gas energy savings, equipment unit costs, equipment incremental costs, equipment useful life, Net to Gross and Initial Service Rate of the measures.

* **HA58:**

Table 3: DEER Use and Technology Storage Water Heater



* **HA59:**

Table 4: DEER Use and Technology Condensing Tankless Water Heater



**Therms Savings Assumption (ΔTh) DEER Version and Impact IDs**

**Gas Savings** **(ΔTh): HA58**

* The gas savings for HA58 were downloaded from DEER directly, then averaged and normalized, as explained in section 2.3.1.
* The gas savings for HA59 are in DEER 2014 for Commercial building types only, custom calculations were therefore used for this measure

**EUL Gas Savings** **(ΔTh): Interactive Effect only? DEER Version and Impact IDs**

**Table 5 Gas Savings HA58**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Building type** | **Bldg Vintage** | **Climate Zone** | **Interactive Only?**  **Yes / No** | **Gas Savings Therms** | **Deer units** | **DEER Version** |
| **COM** | **Any** | **All** | **No** | **1.45** | **Cap-kBtuh** | **2014** |
| **RES** | **Any** | **All** | **No** | **43.1** | **Each** | **2014** |
| **Otr** | **Any** | **All** | **No** | **43.18** | **each** | **2014** |
|  |  |  |  |  |  |  |

**Hours of Operation**: *Hours of operation are not listed for water heaters but are assumed to be 24/365 or 8760*

**Base Case Costs and Measure Case Costs**

**Costs DEER Version and Impact Ids**

**Costs, DEER Version and Impact Ids: HA58**

* + The base case and measure case costs were downloaded from DEER2014[[6]](#endnote-6). Costs were not updated in DEER 2014, therefore, he DEER2011 measure cost adjustment factors[[7]](#endnote-7) were applied to the 2008 costs to determine the updated costs. Similar to the gas energy savings approach, the average costs were determined using the weighted average costs of the 40, 50, and 60-gallon sizes in each climate zone. See sections 4.1 and 4.2 for further detail.
* Please refer to Appendix A for a full list of DEER costs.

**Net-to-Gross Assumption:** The table below summarizes all applicable DEER based net-to-gross (NTG) ratios for programs that may be used by this measure[[8]](#endnote-8).

Table 6: DEER2014 Net-to-Gross Ratios

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **DEER Spreadsheet** | |
| Program Approach | NTG | File name |  |
| Default all < 2 yrs | 0.70 | DEER2014V1.01NTGR | HA59 |
| All other EEM with no evaluated NTGR; existing EEM with same delivery mechanism for more than 2 years | 0.55 | DEER2014V1.0NTGR | HA58 |

The NTG Ratios in the table above are appropriate for the measures because:

* For HA58 no other Program Approach fit the measure, and the measure is a new tier but same technology, so the default was used.
* For HA59 no other Program Approach fit the measure, and the measure is a new offering, so the default was used.
* ***The rebate is downstream provided to the customer at the time of sale upon receipt of the application and invoice. This is not a Direct install program.***

**Effective Useful Life / Remaining Useful Life:**

**Effective Useful Life, DEER Version and Impact IDs:**

The effective useful life (EUL) estimates were downloaded directly from DEER2014[[9]](#endnote-9).

* The EULs for the measures are constant and do not vary by building type, building vintage, or climate zone.
* The EUL for the storage type water heaters in the measure case is 11 years, whereas the EUL for the condensing instantaneous water heaters in the measure case is 20 years.

Table 7: DEER2014 Effective Useful Life

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Building type** | **Bldg Vintage** | **Climate Zone** | **EUL (yrs)** | **RUL (yrs)** | **DEER Version** | **Impact Ids** |
| ALL | ANY | ANY | 20 | N/A | D11 v4.00 | WtrHt-CntLrgInst-Gas HA59 |
| ALL | ANY | ANY | 11 | N/A | D11 v4.00 | NG-WtrHt-SmlStrg-Gas-lte75kBtuh-40G-0p62EF, 50G-0p62EF, 60G-0p62EF HA58 |

**In-service rate/first year installation rate**: *1*

***The rebate is downstream] provided to the customer at the time of sale upon receipt of the application and invoice. This is not a Direct install program.***

## 1.4.2 Codes & Standards Requirements Base Case and Measure Information

***Title 20:*** Department of Energy (DOE) Regulations and California Title 20 require that all small gas storage water heaters (<75 kBtu/h) and small gas-fired instantaneous water heaters (<200 kBtu/h) manufactured on or after the date listed in Table 9 below meet the minimum energy factor (EF) requirement.

Table 8: Gas Fired Storage Water Heater Efficiency Requirements[[10]](#endnote-10)

|  |  |
| --- | --- |
| **Appliance** | **Minimum Energy Factor as of January 20, 2004** |
| Gas-fired storage-type water heaters | 0.67 – (.0019 x Rated Storage  Volume in gallons) |
| Gas-fired instantaneous water heaters | 0.62 - (0.0019 × Rated Storage  Volume in gallons) |

Note the Title 20 definitions of small and large water heaters, as excerpted below:

* “Small water heater" means a water heater that is a gas storage water heater with an

input of 75,000 Btu per hour or less… a gas instantaneous water heater with an input of 200,000 Btu per hour or less,

* “Large water heater” means a water heater that is not a small water heater.[[11]](#endnote-11)

***Title 24:*** These measures do not fall under Title 24 of the California Energy Regulations.

***Federal Standards:*** These measures do not fall under Federal DOE or EPA Energy Regulations.

## 1.4.3 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information

There are no M&V or other studies that apply to these measures. Information on the base and measure cases are found in the other sub-sections of 1.4.

## 1.4.4 Assumptions and Calculations from other sources—Base and Measure Cases

**Energy Savings Assumption (Δtherms):** The energy savings for the Condensing Tankless Natural Gas Water Heater were calculated using the following methodology:

* Much of the data and method for the savings estimates of this measure were derived from the domestic hot water boiler and storage capacity design guidelines in the 2011 ASHRAE Handbook – HVAC Applications, Chapter 50[[12]](#endnote-12). These guidelines are based on a study of hot water peak demand and average demand in typical homes.
* California Energy Commission (CEC) Appliance Databases[[13]](#endnote-13) were used to provide data on code-compliant baseline and measure case water heaters available in the marketplace.
* These domestic water heaters are assumed to be available continuously, or 8,760 hours per year, in all cases.

Table 9: Gas Savings from PG&E Calculations HA59

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Building type** | **Bldg Vintage** | **Climate Zone** | **Interactive Only?**  **Yes / No** | **Gas Savings therms** | **Savings units** | **Reference** |
| SFm | ALL | ALL | No | 83.4 | Each | PG&E Calcs |
| MFm | ALL | ALL | No | 50.8 | Each | PG&E Calcs |
| DMo | ALL | ALL | No | 50.8 | Each | PG&E Calcs |

Please refer to Section 2.3.2 for further discussion of the PG&E calculation method.

***1.4.5 Time-of-Use Adjustment Factor***

We are required by CPUC decision 06-06-063 dated June 29, 2006 to apply time-of-use (TOU) adjustment factors on residential A/C and commercial A/C (packaged and split-system direct-expansion cooling) measures only. Since this is not an A/C measure, the TOU adjustment factor is 0.

***1.5 Summary of Inputs for Savings Calculations***

The following table provides references to sections that document the inputs for calculation: The following table provides references to sections that document the inputs for calculation:

Table 10: HA58 Savings Calculation Summary

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Input Variable** | **Variations** | **Base Case 1 Average Value** | **Base Case 2 Average Value** | **Average Savings/Costs** | **Measure Case Average Value** | **Reference Section** |
| **Electric Savings** | N/A | N/A | N/A | N/A | N/A | *Section 2.1* |
| **Gas Savings** | CZ, BT, BV | N/A | N/A | 44 | N/A | *Section 2.3.1* |
| **Hours of operation** | N/A | 8,760 | N/A | N/A | 8,760 | *Section 1.4.4* |
| **Full Cost** | ROB, NC | $474 | N/A | N/A | $598 | *Sections 4.1, 4.2* |
| **Incremental Cost** | ROB, NC | N/A | N/A | $124 | N/A | *Section 4.3.2* |
| **EUL /RUL** | ROB, NC | 11 | N/A | N/A | 11 | *Section 1.4.1* |
| **NTG** | One | N/A | N/A | N/A | 0.55 | *Section 1.4.1* |
| **ISR** | No | N/A | N/A | N/A | N/A | *N/A* |
| **TOU Factor** | A/C projects only | N/A | N/A | N/A | N/A | *Section 1.4.5* |

Table 11: HA59 Savings Calculation Summary

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Input Variable** | **Variations** | **Base Case 1 Average Value** | **Base Case 2 Average Value** | **Average Savings/Costs** | **Measure Case Average Value** | **Reference Section** |
| **Electric Savings** | N/A | N/A | N/A | N/A | N/A | *Section 2.1* |
| **Gas Savings** | BT | N/A | N/A | 61.67 | N/A | *Section 2.3.2* |
| **Hours of operation** | N/A | 8,760 | N/A | N/A | 8,760 | *Section 1.4.4* |
| **Full Cost** | ROB, NC | $428 | N/A | N/A | $2,236 | *Sections 4.1, 4.2* |
| **Incremental Cost** | ROB, NC | N/A | N/A | $1,808 | N/A | *Section 4.3.2* |
| **EUL /RUL** | ROB, NC | 11 | N/A | N/A | 20 | *Section 1.4.1* |
| **NTG** | One | N/A | N/A | N/A | 0.70 | *Section 1.4.1* |
| **ISR** | No | N/A | N/A | N/A | N/A | *N/A* |
| **TOU Factor** | A/C projects only | N/A | N/A | N/A | N/A | *Section 1.4.5* |

# Section 2. Calculation Methods

Table 12 Baseline by Measure Application Type

|  |  |  |  |
| --- | --- | --- | --- |
| ****Measure Application Type**** | ****Measure Life Basis**** | ****First Baseline Period: Energy Savings Baseline**** | ****Second Baseline Period: Energy Savings Baseline**** |
| ***ER* (early retirement)** | **EUL** | Customer Average Baseline | Code Baseline |
| ***ROB* (replace-on-burnout)** | **EUL** | Code Baseline | N/A |
| ***NC* (new construction)** | **RUL/EUL-RUL** | Code Baseline | N/A |

Notes:

* For ROB measures, First Baseline is the baseline for the full EUL. There is no second baseline.
* For ER measures, First Baseline Period is the period for the RUL(remaining useful life),defined by the CPUC as RUL=1/3 EUL. Second baseline period for ER is Code baseline for the period EUL-RUL.

## 2.1 Electric Energy Savings Estimation Methodologies

* There were no electric energy savings associated with these measures.

## 2.2. Demand Reduction Estimation Methodologies

* There is no anticipated demand reduction associated with this measure

## 2.3. Gas Energy Savings Estimation Methodologies

**Annual Gas Savings:**

EUL **Energy Savings [therms/unit] = Annual Code/Industry std. Base Gas Usage – Annual Energy Efficient Gas Usage**

The annual gas savings were determined using two distinct calculation methods – one for the gas storage water heater measures, and one for the instantaneous water heater measure.

### 2.3.1. Gas Storage Measures (HA58):

The natural gas energy savings for these measures use DEER2014 data. DEER2014 now includes savings for single family homes (SFm), multi-family homes (MFm), and mobile homes (DMo), as well as for all commercial building types. Savings vary by climate zone and building vintage in addition to building type. The DEER2014 data had to be averaged and normalized in order to properly fit the catalog description. For all building types, the data was averaged using the following approach:

Averaging DEER Data:

The catalog requirements for HA58 specify required energy factors (>0.67). The DEER2014 data for 40-gallon, 50-gallon, and 60-gallon water heaters was averaged for each building vintage, building type, and climate zone in order to determine the average savings for the eligible water heater sizes. Based on the CEC Appliance Database, however, there are significantly more 40-gallon and 50-gallon water heaters than 60-gallon water heaters on the market, so the savings for the 60-gallon units should be weighted less heavily than for the other sizes13. We therefore applied a weighted average to the DEER2014 energy savings based on the number of water heaters of each size listed on the CEC database. As shown in Table 13, below, the weighting factors for the 40, 50, and 60-gallon water heaters are 50.1%, 47.5%, and 2.4% respectively.

Table 13: CEC Water Heater Data



Normalizing the Results:

The catalog offerings HA58 and HA59 are normalized per gas storage water heater. In DEER2014, the residential data is already normalized in the same manner, so no adjustment was required. For the commercial building types, however, the DEER2041 energy savings data is normalized per water heater input capacity (kBtu/h). We therefore had to re-normalize the DEER commercial savings to a per water heater basis using the following steps.

1. We determined the total required water heater capacity for each building type (kBtu/h) from the DEER2014 data.
2. We multiplied the total required capacities for each building type (step 1), by the DEER2014 energy savings (listed in therms per kBtu/h) in order to determine the total therms saved for each building type, building vintage, and climate zone.
3. We then used the CEC Appliance Database to determine the average heating capacity (kBtu/h) of each size of eligible water heater (40, 50, and 60 gallons). The average capacities are listed in Table 13 above.
4. By dividing the total required water heater capacity for each building type (step 1) by the average water heater capacity (step 2), we determined how many 40, 50, or 60 gallon water heaters would be required to meet each building’s hot water needs.
5. Finally, we normalized the gas energy savings on a per water heater basis by dividing the total therms saved for each building type (step 2) by the number of required water heaters (step 4).

Example Calculation:

The following is an example of the previously described normalization and averaging methods:

*DEER2014 Energy Impact ID:* NG-WtrHt-SmlStrg-Gas-lte75kBtuh-40G-0p62EF

*DEER2014 Building Type:* Hospital

*DEER2014 Building Vintage:* 1975

*DEER2014 Building Location:* CZ01

*DEER2014 Normalizing Units:* Cap-kBTUh

*DEER2014 AStdWBtherm:* 0.857 (therms/kBtu/h capacity)

*DEER2014 Num Units:* 2530

*Average Heating Capacity of a 40 gallon water heater*: 38.95 kBtu/h (Average of CEC Appliance data).

1. Total required capacity = 2530 kBtu/h (Normalizing Units x Num Units)
2. Total therm savings = 0.857 x 2530 = 2168.21 therms
3. Average heating capacity of a 40-gallon water heater = 38.95 kBtu/h
4. # of 40 gal water heaters required to meet capacity = 2530 / 38.95 = 64.96 water heaters.
5. Savings normalized per water heater = 2168.21 / 64.96 = **33.38 therms/water heater**

By repeating the above calculation for the 50 gallon and 60 gallon water heaters (using the same CZ, BT, and BV), we find the savings to be **38.48 therms/water heater** and **13.28 therms/water heater**, respectively.

The average savings are then calculated using the weighting factors listed in Table 13, above:

|  |  |  |
| --- | --- | --- |
| 40 gallon: | 33.38 therms/water heater \* 0.501 = | 16.72 |
| 50 gallon: | 38.48 therms/water heater \* 0.475 = | 18.28 |
| 60 gallon: | 13.28 therms/water heater \* 0.024 = | 0.32 |
|  | **Total Savings =** | **35.32** |

These normalized and averaged energy savings were calculated for each variation in commercial building type, climate zone, and building vintage.

### 2.3.2. Condensing Tankless Measure (HA59):

DEER2014 does not contain a measure for residential condensing tankless water heaters. We therefore generated custom calculations to determine the savings:

Much of the data and method for the savings estimates of this measure were derived from the domestic hot water boiler and storage capacity design guidelines in the 2011 ASHRAE Handbook – HVAC Applications, Chapter 5012. These guidelines are based on a study of hot water peak and average demand in single family homes and apartments. No data was available for mobile homes. Since no data was available, we estimated the water usage and overall energy savings for mobile homes by using the data from the multi-family residences, as that provided the most conservative savings estimates.

In addition, the California Energy Commission (CEC) Appliance Databases were used extensively to provide data on water heaters available in the marketplace13.

These domestic water heaters are assumed to be available continuously, or 8,760 hours per year, in all cases.

***Sizing Ratio***

An instantaneous water heater for a given application needs a higher kBtu/h input rating than a storage-type water heater for the same application. Without storage, the instantaneous water heater must have a much higher burner capacity to handle peak demands, so the kBtu/h input rating of a given base case storage-type water heater is much lower than the measure case instantaneous heater.

Based on a review of the ASHRAE service water heating sizing recommendations for various residential applications, typical sizing ratios between the base and measure cases were estimated[[14]](#endnote-14). These sizing ratios represent typical relative input ratings for instantaneous-type water heaters vs. storage-type water heaters for the same application. These ratios range from 2.2 to 2.7, and are presented in the following table.

Table 14: Instantaneous to Storage-Type Water Heater Sizing Ratios



Small gas storage water heaters (<75 kBtu/h) are appropriate for residential applications. Based on the sizing ratio mentioned above, the appropriate capacity for the measure-case condensing instantaneous water heater is less than 200 kBtu/h (75 kBtu/h x 2.7 = approx. 200 kBtu/h).

***Efficiency*** ***Ratings***

Energy savings for this measure result from the increased efficiency (energy factor) of the condensing tankless water heater compared to a base case Title 20-compliant storage-type water heater. We calculated the measure case and base case energy factors (EF) to be 0.93 and 0.61, respectively, using the California Energy Commission (CEC) Appliance Database above.

The base case efficiency, 0.61 EF, is the average energy factor of all Title 20-compliant natural gas storage-type water heaters with an input rating less than 75 kBtu/h listed in the database.

The measure case efficiency, 0.93 EF, is the average energy factor of all Title 20-compliant instantaneous natural gas water heaters with an input rating less than 200 kBtu/h and with an EF > 0.85, as specified by the catalog offering.

***Energy Savings***

The base case and measure case energy consumption was calculated using the following equation[[15]](#endnote-15):

Annual gas use [therms] = V/yr \* Cp \* dT

100,000 \* EF

where

V/yr = Volume per year [gallons/yr]

Cp = Heat capacity of water [Btu//gal°F]

dT = Temperature increase [°F]

EF = Energy Factor

100,000 = Conversion factor, Btu to therms

The heat capacity of water is 1.0 Btu/lb°F, or 8.34 Btu/gal°F, and the assumed dT is 77°F based on ASHRAE12. Converting to Volume per day, and entering values, the above equation becomes:

Annual gas use [therms] = 365 days/yr \* V/day \* 8.34 Btu/gal°F \* 77°F

100,000 \* EF

Annual gas use [therms] = 2.344 \* V/day

EF

where

V/day = average Volume per day [gallons].

The ‘volume per day’ input comes from the average daily residential water usage in the 2011 ASHRAE Handbook, as referenced above. The energy factor (EF) comes from the California Energy Commission (CEC) Appliance Database, also referenced above.

Using the above equation and the collected data, we determined the savings which are tabulated below.

Table 15: Condensing Tankless Water Heater Savings Calculations



# Section 3. Load Shapes

Load Shapes are an important part of the life-cycle cost analysis of any energy efficiency program portfolio. The net benefits associated with a measure are based on the amount of energy saved and the avoided cost per unit of energy saved. For electricity, the avoided cost varies hourly over an entire year. Thus, the net benefits calculation for a measure requires both the total annual energy savings (kWh) of the measure and the distribution of that savings over the year. The distribution of savings over the year is represented by the measure’s load shape. The measure’s load shape indicates what fraction of annual energy savings occurs in each time period of the year. An hourly load shape indicates what fraction of annual savings occurs for each hour of the year. A Time-of-Use (TOU) load shape indicates what fraction occurs within five or six broad time-of-use periods, typically defined by a specific utility rate tariff. Formally, a load shape is a set of fractions summing to unity, one fraction for each hour or for each TOU period. Multiplying the measure load shape with the hourly avoided cost stream determines the average avoided cost per kWh for use in the life cycle cost analysis that determines a measure’s Total Resource Cost (TRC) benefit.

## 3.1 Base Case Load Shapes

Load shapes are not applicable to gas measures, however, because the price of gas is not dependent on time-of-use.

## 3.2 Measure Load Shapes

Load shapes are not applicable to gas measures, however, because the price of gas is not dependent on time-of-use.

# Section 4. Base Case & Measure Costs

**Table 16 DEER 2014 Measure Application Types**

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Measure Life Basis** | **First Baseline Period Full Measure Cost (RUL)** | **Second Baseline Period Full Measure Cost (EUL – RUL)** |
| ***NC (new construction)*** | EUL | Calculated as Incremental Measure Cost | N/A |
| ***ROB(replace on burnout)*** | EUL | Calculated as Incremental Measure Cost | N/A |
| ***ER (early retirement)*** | RUL/  EUL-RUL | Calculated as Full Gross Measure Cost | Calculated as Negative Full Gross Base Case Cost |

## 4.1 Base Case Costs

The following table is a sample of the base case costs. Please refer to Appendix A for a full list of base costs.

Table 17: Baseline Costs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Measure Code*** | **Measure Application Type** | **Baseline** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Base Case Cost** |
| HA59 | NC, ROB | Title 20 – compliant natural gas storage water heater – Small | $ 428 | N/A | N/A | $ 427.98 |
| HA58 | NC, ROB | Title 20 – compliant natural gas storage water heater – Small | $ 474 | N/A | N/A | $ 474.33 |
| HA58 | NC, ROB | Title 20 – compliant natural gas storage water heater – Small | $ 474 | N/A | N/A | $ 474.33 |

*All costs are noted as $ per measure unit*

DEER 2014 refers to previous cost data. All base case costs are calculated by applying the measure cost adjustment factors in DEER2011 to the base case costs listed in DEER2008, and averaging the savings across the 40, 50, and 60 gallon water heater sizes using the weighting percentages tabulated in Table 13.

## 4.2 Measure Case Costs

The following table is a sample of the measure case costs. Please refer to Appendix A for a full list of measure costs.

Table 18: Measure Case Costs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Measure Code*** | **Measure Application Type** | **Baseline** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Measure Case Cost** |
| HA59 | NC, ROB | Title 20 – compliant natural gas storage water heater - Small | $ 2236 | N/A | N/A | $ 2,235.78 |
| HA58 | NC, ROB | Title 20 – compliant natural gas storage water heater - Small | $ 598 | N/A | N/A | $ 598.46 |
| HA58 | NC, ROB | Title 20 – compliant natural gas storage water heater - Small | $ 598 | N/A | N/A | $ 598.46 |

*All costs are noted as $ per measure unit*

For the DEER measures, measure costs are calculated by applying the measure cost adjustment factors in DEER2011 to the measure costs listed in DEER2008, and averaging the savings across the 40, 50, and 60 gallon water heater sizes using the weighting percentages discussed in Table 15.

For the instantaneous water heater measure, the equipment costs are based on a survey of nine condensing tankless water heaters <200 kBtu/h and > 0.85 EF.

Additionally, since instantaneous water heaters require higher input ratings to serve the same loads as storage-type water heaters, larger natural gas piping is required. The costs for this additional piping were calculated using average instantaneous water heater size for each measure, typical length of new pipe required (based on engineering judgment), Natural Gas Pipe Sizing tables[[16]](#endnote-16) and RS Means 2010 Mechanical Cost Data for schedule 40 steel Gas Service Piping[[17]](#endnote-17). See the following table.

Table 19: Natural Gas Piping Costs



## 4.3 Incremental & Full Measure Costs

Table 20: Cost Definitions by Measure Type

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Gross Measure Cost**  **(RUL Period/First Baseline)** | **Gross Measure Cost**  **(EUL-RUL Period/ Second Baseline)** | **Incremental Measure Cost** |
| ROB | Measure Equipment Cost  – Base Case Equipment Cost | N/A | Measure Equipment Cost  – Base Case Equipment Cost |
| NC | Measure Equipment Cost  – Base Case Equipment Cost | N/A | Measure Equipment Cost  – Base Case Equipment Cost |

### 4.3.1 Gross Measure Cost

Gross Measure Cost is the cost to install an energy efficient measure per the CPUC calculators. This definition implies a different meaning depending on the Measure Application type. Since the approved measures are all NC or ROB, the Gross Measure Cost is the same as the Incremental Measure Cost.

### 4.3.2 Incremental Measure Costs

Incremental Measure Cost is the premium cost to install an energy efficient measure over a standard efficiency measure or code baseline measure. While IMC has a straightforward definition depending on the Measure Application type, the equation does vary.

This Measure Application Types is: **ROB** and **NC** so the Incremental Measure Cost (IMC) is represented by the appropriate equation below:

IMC = (Measure Equipment Cost + Measure Labor Cost) –

(Base Case Equipment Cost + Base Case Labor Cost)

\*Note: Unless stated otherwise the measure case and base case labor costs are typically the same, reducing the equation to the following:

IMC = Measure Equipment Cost – Base Case Equipment Cost

*IMC = $ per (unit) -- $ per (unit) = $ per (unit)*

In this work paper, the measure case and base case labor costs are assumed to be the same for all measures. However, the measure case for condensing instantaneous water heaters requires larger natural gas piping. The additional cost of the larger piping is included in the measure case cost.

Table 21: Summary Table for Section 4

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure ID** | **Measure Application Types** | **Base Case Total Cost** | **Measure Case Total Cost[[18]](#endnote-18)** | **Gross Measure Case Cost** | **Incremental Measure Cost** |
| HA59 | NC, ROB | $ 427.98 | $ 2,235.78 | $ 1,807.80 | $ 1,807.80 |
| HA58 | NC, ROB | $ 474.33 | $ 598.46 | $124.14 | $ 124.14 |
| HA58 | NC, ROB | $ 474.33 | $ 598.46 | $124.14 | $ 124.14 |

(not a summary of all measures, just of the sample measures tabulated in Section 4)

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