**Work Paper PGECODHW114**

**Central System natural Gas Boilers—Multifamily**

**Revision # 5**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Central System Natural Gas Boilers Multifamily**

**Measure Codes H150, H719, H720, H244, H247**

***(H244 and H247 are San Francisco Energy Watch measure codes)***

# At-a-Glance Summary

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Applicable Measure Codes:** | **H150** | **H719** | **H247** | **H720** | **H244** |
| **Measure Description:** | Central System Storage Type Natural Gas Water Heater | Domestic Hot Water Boiler TE ≥ 84% and input rating > 75kBtuh | Domestic Hot Water Boiler TE ≥ 84% and input rating > 75kBtuh. San Francisco Energy Watch measure (SFEW) | Space Heating Hot Water boiler < 300 MBtuh AFUE.  >300MBtuh TE > 84% | Space Heating Hot Water boiler < 300 MBtuh AFUE.  >300MBtuh TE > 84%  San Francisco Energy Watch measure (SFEW) |
| **Energy Impact Common Units:** | Annual therms saved per installation of high efficiency boiler. | Annual therms saved per dwelling supplied from the high efficiency boiler. | Annual therms saved per dwelling supplied from the high efficiency boiler. | Annual therms saved per dwelling supplied from the high efficiency boiler. | Annual therms saved per dwelling heated by the high efficiency boiler. |
| **Base Case Description:** | Source: CA Title 20 Regulations: **80% Thermal Efficiency** (Table F-3) | Source: CA Title 20 Regulations: Water heating boiler with **TE efficiency of 80%.**  Source: DEER, D13v1.0, DEER2014 | Source: CA Title 20 Regulations: **80% Thermal Efficiency or AFUE.** (Table E-3) | Source: CA Title 20 Regulations: Space heating water boiler with **thermal efficiency of 80%.**  Source: DEER, D13v1.0, DEER2014 | Source: CA Title 20 Regulations: Space heating water boiler with **Thermal efficiency of 80%.** |
| **Base Case Energy Consumption:** | Source: PG&E Calculations  The energy consumption for the base case measure is 3,520 therms/yr. | DEER does not provide values for base case or measure energy consumption, only savings. PG&E Calculations 3520 therms/yr | Source: California Statewide Residential Appliance Saturation Study. 176 therms/yr/dwelling. | DEER does not provide values for base case or measure energy consumption, only savings. PG&E Calculations 1080 therms per year | Source: California Statewide Residential Appliance Saturation Study. 36 therms/yr/dwelling. |
| **Measure Energy Consumption:** | Source: PG&E Calculations  The energy consumption for the energy efficient measure is 3,393 th/yr. | Source: PG&E Calculations The energy consumption for the measure is 3,313 therms/yr. | Source: PG&E Calculations The energy consumption for the measure is 166 therms/yr/dwelling. | Source: PG&E Calculations The energy consumption for the measure is 1,019 therms/yr. | Source: PG&E Calculations The energy consumption for the measure is 34therms/yr/dwelling. |
| **Energy Savings**  **(Base Case – Measure):** | Source: PG&E Calculations  127 therms/yr. | Source: PG&E calculations: 207 therms/yr | Source: PG&E Calculations 10 therms/yr/dwelling unit. | Source: PG&E Calculations 61 therms/yr | PG&E Calculations  2 therms/ yr/dwelling unit |
| **Costs Common Units:** | $ per boiler installation. | $ per boiler installation. | $ per household served by boiler. | $ per boiler installation. | $ per household served by boiler. |
| **Base Case Equipment Cost ($/unit):** | Source: 2008 DEER Cost Values and Summary Documentation , PG&E Calculations  $4,073/boiler installation | Source: DEER 2008 Cost Values and Summary Documentation  $2846/boiler installation | Source: 2008 DEER Cost Values and Summary Documentation  $2,846/boiler installation | Source: DEER 2008 Cost Values and Summary Documentation  $3006/boiler installation | Source: 2008 DEER Cost Values and Summary Documentation  $3,006/boiler installation |
| **Measure Equipment Cost ($/unit):** | Source: 2008 DEER Cost Values and Summary Documentation  $4,282/boiler installation | Source: DEER 2008 Cost Values and Summary Documentation  $3000/boiler installation | Source: 2008 DEER Cost Values and Summary Documentation , PG&E Calculations  $3,000/boiler installation | Source: DEER 2008 Cost Values and Summary Documentation  $3555/boiler installation | Source: 2008 DEER Cost Values and Summary Documentation , PG&E Calculations  $3,555/boiler installation |
| **Gross Measure Cost ($/unit)** | Source: 2008 DEER Cost Values and Summary Documentation  $4,282/boiler installation | Source: DEER 2008 Cost Values and Summary Documentation  $3000/boiler installation | Source: 2008 DEER Cost Values and Summary Documentation , PG&E Calculations  $3,000/boiler installation | Source: DEER 2008 Cost Values and Summary Documentation  $3555/boiler installation | Source: 2008 DEER Cost Values and Summary Documentation , PG&E Calculations  $3,555/boiler installation |
| **Measure Incremental Cost ($/unit):** | Source: 2008 DEER Cost Values and Summary Documentation  ROB - $209/boiler installation | Source: DEER 2008 Cost Values and Summary Documentation  ROB - **$1**54/boiler installation | Source: 2008 DEER Cost Values and Summary Documentation  ROB - $154/boiler installation | Source: DEER 2008  ROB - **$**549/boiler installation | Source: 2008 DEER Cost Values and Summary Documentation  ROB - $549/boiler installation |
| **Effective Useful Life (years):** | Source: DEER 2014 EUL/RUL Values and Summary Documentation:  11 years Storage Water Heater | Source: DEER 2014 EUL/RUL Values and Summary Documentation  EUL: 15 yrs Com Water Heating Equipment | Source: DEER 2014 EUL/RUL Values and Summary Documentation  EUL: 15 yrs Com Water Heating Equipment | Source: DEER 2014 EUL/RUL Values and Summary Documentation  EUL: 15 yrs Com Water Heating Equipment | Source: DEER 2014 EUL/RUL Values and Summary Documentation  EUL: 15 yrs Com Water Heating Equipment |
| **Measure Application Type:** | ROB and New | ROB and New | ROB and New | ROB and New | Rob and New |
| **Net-to-Gross Ratios:** | 0.55 DEER 2014 Res Default > 2 yrs | 0.55 DEER 2014 Res Default > 2 yrs | 0.55 DEER 2014 Res Default > 2 yrs  Res Default DI 0.85 | 0.55 DEER 2014 Res Default > 2 yrs | 0.55 DEER 2014 Res Default > 2 yrs  Res Default DI 0.85 |
| **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 0** | **May 2008** | **PGECODHW114R0 Central System Boilers and Water Heaters for Space Heating** | **Adam Fernandez (PG&E)** |
| **Revision 1** | **April 2010** | **Change in calculation methodology: Therms/dwelling was changed to reflect values in RASS. Baseline efficiency values follow Title 20 requirements. Measure efficiencies are taken from DEER 2005, as they provide a consistent standard for our programs.** | **Edwin Huestis (PG&E)** |
| **Revision 2** | **May 2010** | **Calculation methodology errors addressed** | **Edwin Huestis (PG&E)** |
| **Revision 3** | **August 2010** | **Removed H149 from workpaper and replaced with H719 and H720. H150 remains in the workpaper.** | **Edwin Huestis (PG&E)** |
| **Revision 4** | **June 2012**  **August 22, 2012** | **Updated for DEER 2011. Merged San Francisco Energy Watch Measures**  **Updated BLD to Any and CZ to Z** | **Justin Westmoreland (PG&E)**  **Charlene Spoor (PG&E)** |
| **Revision 5** | **May 30, 2014** | **revised EUL/NTG per DEER 2014** | **Charlene Spoor (PG&E)** |

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# Section 1. General Measure & Baseline Data

## 1.1 Product Measure Description & Background

***Catalog Description –***

***H150 Storage Type Water Heater 80 gallons or greater***

***H719 Small Water Boiler for Water Heating***

***H247 Small Water Boiler for Water Heating (San Francisco Energy Watch measure)***

***H720 Medium Water Boiler for Space Heating***

***H244 Medium Water Boiler for Space Heating***

Additional tiered measures are described and available under PGECOHVC101 R3

***Program Restrictions and Guidelines***

This workpaper documents the rationale for the savings methodologies and assumptions for Domestic Water Heating and Space Heating Boilers, as listed in the Multifamily Properties Rebate Catalog. The Multifamily Properties Program Catalog is part of Pacific Gas and Electric Company’s Customer Energy Efficiency Program. PG&E offers incentives to mutifamily customers for installing qualifying, high-efficiency equipment.

***Terms and Conditions:*** Requirements from Boilers and Water Heating Catalog:

* H150, H719 and H247must be used for hot water only, space heating boilers do not apply.
* H720 and H244 must be used for space heating to induce human comfort, as defined by the California Energy Commission Title 20 and 24 standards.
* Must meet efficiency requirements based on input ratings and types shown in the *Multifamily Properties Rebate Catalog*.
* Must include a manufacturer’s specification sheet documenting the boiler type, input rating and efficiency rating with the incentive application.
* Installation address must have a commercial or multifamily natural gas account with PG&E.

***The rebate is downstream and is provided to the contractor or customer at the time of installation upon receipt of sales data and application. H150, H719, H720 are not direct install programs. This workpaper covers H247 and H244 which are part of the San Francisco Energy Watch direct install program.***

***Market Applicability:*** These measures are is applicable to any small or medium commercial storage water heater or boiler used for water heating or space heating, as specified below, and not applicable to boilers used for process end uses, pools, or spas. Applicable business types include Multifamily facilities.

* Measure Code H150:
* This measure is applicable to any small or large multifamily property application used for domestic hot water and is not applicable to water heaters used for process end uses, space heating, pools, or spas. Water heater must have a storage capacity must be ≥ 80 gallons and must provide hot water to a building complex of 2 or more dwelling units to qualify.
* Measure Code H719, H247:
* These measures are applicable to any multifamily property application used for domestic hot water and not applicable to boilers used for space heating, process end uses, pools, or spas. Boiler must be >75MBtuh. A boiler with rated input ≤ 300-MBtuh serving a multifamily dwelling of more than 20 units does not qualify for a rebate. Measure H247 is only eligible through the San Francisco Energy Watch Program.

Measure Code H720, H244:

* These measures are applicable to any multifamily property application used for space heating or domestic hot water and not applicable to boilers used for process end uses, pools, or spas. Measure H244 is only eligible through the San Francisco energy watch.

**Table 1 Qualification requirements for Central System Space and Water Heaters**

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Code** | **Type** | **Size or Input Rating** | **Required Efficiency** |
| **H150** | Storage Type Hot Water | 80 Gallons | Thermal Efficiency ≥ 82% |
| **H719 & H247** | Domestic Hot Water | > 75 MBtuh | Thermal Efficiency ≥ 84% |
| **H720 & H244** | Space Heating Hot Water | < 300 MBtuh  ≥ 300 MBtuh | AFUE ≥ 82%  Thermal Efficiency ≥ 84% |

## 1.2 Product Technical Description

Space heating boilers are pressure vessels that transfer heat to water for use primarily in space heating applications. Boilers heat water using a heat exchanger that works like an instantaneous water heater or by the addition of a separate tank with an internal heat exchanger that is connected to the boiler. Energy efficient units often feature high-efficiency and/or low NOx burners, and typically have features such as forced air burners, relatively large heat exchange surfaces, and/or utilize heat recovery from stack gases.

High-efficiency gas-fired boilers, typically rated above 90% thermal efficiency, are commonly known as “condensing” boilers. Condensing boilers are equipped with larger heat exchangers that are able to recuperate additional thermal energy from the flue gas – compared to their non-condensing counterparts. They are known as condensing boilers because the additional heat recuperation results a lower flue gas temperature and water vapor condensing out of the flue gas.

## 1.3 Measure Application Type

The DEER measure application types are defined in the table below:

Table 2 - Measure Application Type[[1]](#endnote-1)

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

|  |  |  |
| --- | --- | --- |
| **Code** | **Description** | **Comment** |
| ER | Early retirement | *measure applied while existing equipment still viable, or retrofit of existing equipment* |
| 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 H150, H719, H720, H247 and H244 are applicable to multifamily residential installations. The savings for all measures are calculated assuming that the installation is replace-on-burnout (ROB).

## 1.4 Product Base Case and Measure Case Data

The DEER measures below include base and measure equipment costs, incremental equipment costs, and equipment useful lives. DEER 2014 does not include savings for H150 Storage Water Heaters > 75MBtuh, > 82% TE. DEER 2014 does not include savings for H719, H720, H247 and H244. Savings are further calculated using CEUS data for average number of units based on size of boiler installations. Calculations are noted in Section 2.3.

## 1.4.1 DEER Base Case and Measure Case Information

* The DEER 2014 data include: gas energy savings, equipment unit costs, equipment incremental costs, equipment useful life, and Net to Gross of the measures.

**Table 3 DEER USE and TECHNOLOGY TABLE H720, H244**

|  |  |  |  |
| --- | --- | --- | --- |
| **Use Category Description** | **Use Category** | **Use Sub Category Description** | **Use Sub Category** |
| HVAC | HVAC | Space heating | SpaceHeat |
| **Technology Groups Description** | **Technology Groups** | **Technology Types Descriptions** | **Technology Types** |
| Space heating equipment, both steam and hot water | SteamHtg\_eg,  WaterHtg\_eq | Boilers with efficiencies rated in AFUE and ET | Boiler\_AF, Boiler\_Et |

**Table 4 DEER USE and Technology Table H150, H719 and H247**

|  |  |  |  |
| --- | --- | --- | --- |
| **Use Category Description** | **Use Category** | **Use Sub Category Description** | **Use Sub Category** |
| Service and Domestic Hot Water | SWH | Water Heating | SHW-Heat |
| **Technology Groups Description** | **Technology Groups** | **Technology Types Descriptions** | **Technology Types** |
| Water Heating Equipment | WaterHtg\_eq | ET rated StoWtrHtr | Stor\_ET |

The data cited by DEER is exactly applicable to measures H150, H719, H720, H244 and H247.

**Hours of Operation**:

* The hours of operation vary by building type and climate zone. The assumed hours are embedded in the prototype building definitions in the DEER runs/calculations. Refer to DEER documentation for further detail regarding the assumed hours of operation.

**Base Case Costs and Measure Case Costs**

There are DEER costs that exactly match catalog measuresH719, H720, H244 and H247. Therefore, we took savings values from the DEER 2008 cost data directly. (DEER 2014 refers to DEER 2008 Data.)

**Table 5 DEER Base Case and Measure Case Costs**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Large Domestic Water Heater** | **Large Storage Water Heater** | **Space Heating Boiler** |
| **Base Equipment Cost** | $2,846/Unit | $4,073/Unit | $3,006/Unit |
|  | **Large Domestic Water Heater** | **Large Storage Water Heater** | **Space Heating Boiler** |
| **Measure Equipment Cost** | $3,000/Unit | $4,282/Unit | $3,555/Unit |

**Net-to-Gross Assumption:**

Table 6 below summarizes all applicable DEER based Net-to-Gross ratios[[2]](#endnote-2) for programs that may be used by these measures.

Table 6 – DEER Net-to-Gross Ratios

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **DEER Spreadsheet** | |
| Program Approach | NTG | File name |  |
| Res-Default>2yrs | 0.55 | Appendix C - DEER NTG Values |  |
| Res-Default DI | 0.85 | Appendix C DEER NTG Values |  |

The NTG Ratios in Table 6 are appropriate for the measures because:

* Measures are for residential applications (multifamily is considered residential in DEER)
* Equipment has the same delivery mechanism for more than two years

**Effective Useful Life:**

The Effective Useful Life estimates were downloaded from DEER[[3]](#endnote-3). The values match the intended measures for climate zones, building types and vintages. EUL for Boilers is the same as for instantaneous water heaters in DEER.

Table 7 Effective Useful Life

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Building Type** | **Building Vintage** | **Climate Zone** | **EUL (yrs)** | **RUL (yrs)** | **DEER Version** | **EUL Ids** | **Description** |
| ALL | EX | PG&E | 20 | 6.7 | DEER2014 | HVAC-Blr | High Efficiency Boiler |
| ALL | EX | PG&E | 11 | 6.7 | DEER2014 | Str WtrHtr | SHW |

*\*Note: Impact IDs are listed below:*

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

In-service rate was not found in DEER or any supporting documentation. We have therefore assumed that the ISR is 1.0 for all measures based on engineering judgment.

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

***Title 20:*** These measures fall under Title 20 of the California Energy Regulations. Under this regulation, minimum efficiencies are required of boilers, and are listed in Table 8 below.

***Title 24:*** These measures fall under Title 24 of the California Energy Regulations. Title 24 refers to the above Title 20 Appliance Standard, reprinted in Appendix, Section 1.

Title 20 standards are shown below, along with measure efficiencies.

Table 8: Title 20 Standards for Natural Gas Central System Hot Water Boilers and Water Heaters1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Code** | **Type** | **Size or Input Rating** | **Efficiency Requirement** | **DEER Measure Efficiency** |
| **H150** | Storage Type Hot Water | 80 Gallons | Thermal Efficiency ≥ 80% | Thermal Efficiency = 80% |
| **H719 & H247** | Domestic Hot Water | > 75 MBtuh | Thermal Efficiency ≥ 80%1 | Thermal Efficiency = 85%5 |
| **H720 & H244** | Space Heating Hot Water | < 300 MBtuh  ≥ 300 MBtuh | AFUE ≥ 80%1  Thermal Efficiency ≥ 80%1 | AFUE = 84.5%5  Thermal Efficiency = 85%5 |

\*Note: Measure code H244 and H720 can consist of either small or large hot water boilers, depending on demand of the end use. H244 and H720 measure consumption is calculated from an average of measure consumption using AFUE and thermal efficiency measure efficiencies. See the example calculations section for more detail.

The table below lists the 2013 California Title 24 Build Energy Efficiency Standards, Section 110.2, Minimum Efficiency Requirements for Space HeatingBoilers , Table 110.2-K, Gas- and Oil-Fired Boilers, Minimum Efficiency requirements.

**Table 9 California Title 24 Requirements for Space Heating Boilers**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Title 24 Std. Description** | **Base or Measure Case** | **Value** | **Units** | **Code Source or Reference** |
| Boiler, hot water, Gas Fired (< 300 kBTUh) | Base | 82% | AFUE | Table 110.2-K |
| Boiler, hot water, Gas Fired (>= 300 kBTUh, <=2,500 kBTUh) | Base | 80% | Thermal Efficiency | Table 110.2-K |
| Boiler, hot water, Gas Fired (> 2,500 kBTUh) | Base | 82% | Combustion Efficiency | Table 110.2-K |
| Boiler, steam, Gas-Fired (< 300 kBTUh) | Base | 80% | AFUE | Table 110.2-K |
| Boiler, steam, Gas-Fired all except natural draft(>= 300 kBTUh, <=2,500 kBTUh) | Base | 79% | Thermal Efficiency | Table 110.2-K |
| Boiler, steam, Gas-Fired all, except natural draft(>2,500 kBTUh) | Base | 79% | Thermal Efficiency | Table 110.2-K |
| Boiler, steam, Gas-Fired natural draft(>= 300 kBTUh, <=2,500 kBTUh) | Base | 77% | Thermal Efficiency | Table 110.2-K |
| Boiler, steam, Gas-Fired natural draft(>2,500 kBTUh) | Base | 77% | Thermal Efficiency | Table 110.2-K |

The table below shows the difference in energy impacts from 2008 Title 24 to 2013 Title 24[[4]](#endnote-4).

**Table 10 Energy Impacts of Codes**



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

The applicable codes and standards for these measures to not dictate associated hours of operation, measure or baseline costs, EUL, NTG, or in-service rate for the equipment involved.

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

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

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

***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:

**Table 11 Summary of Savings Calculations**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Input Variable** | **Variations** | **Measure Case Average Value H719/H247** | **Measure Case Average Value H720/H244** | **Measure Case Average Value H150** | **Reference Section** |
| **Input Variable** | *Variations* | *Base Case 1 Average Value* | *Base Case 2 Average Value* | *Measure Case Average Value* | *Reference Section* |
| **Electric Savings\*** | *Measure* | *N/A* | *N/A* | *N/A* | *1.4.1* |
| **Gas Savings\*** | *Measure* | 207 Th/Yr  10 Th/unit (H247) | *61 Th/Yr*  *2 Th/unit (H244)* | *127 Th/Yr* | *1.4.1* |
| **Hours of operation** | *None* | *8,760* | *8760* | *8760* | *1.4.1* |
| **Full Cost** | *Measure* | $2846 | *$3006* | *$4282* | *1.4.1* |
| **Incremental Cost** | *Measure* | $154 | $549 | *$209* | *1.4.1* |
| **EUL /RUL** | *None* | *20* | *20* | *11* | *1.4.1* |
| **NTG** | *None* | *0.55/0.85* | *0.55/0.85* | *0.55* | *1.4.1* |
| **ISR** | *None* | *1* | *1* | *1* | *1.4.1* |

*\*Note: DEER 2014 database does not include base case or measure values, only energy savings. Values listed represent energy savings.*

# Section 2. Calculation Methods

Table 12 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.

**For the multifamily measures all are determined to be Replace on Burnout.**

## 2.1 Electric Energy Savings Estimation Methodologies

## There are no electric savings associated with this measure.

## 2.2. Demand Reduction Estimation Methodologies

There are no demand savings associated with this measure.

## 2.3. Gas Energy Savings Estimation Methodologies

There are no DEER measures that exactly match catalog measures H719, H720. Therefore, we took savings values from DEER2011 measures directly. Since H247 and H244 are per dwelling unit savings, we used CEUS data and the following calculation.

In the base and measure cases, the heat output of boilers with different efficiencies remains constant while the input gas energy varies. The more efficient measure requires less natural gas usage to achieve a desired heat output.

Annual base gas usage is determined by the product of the number of dwellings and the Unit Energy Consumption (UEC) per dwelling from RASS.4 An assumption is made that the UEC values taken from RASS represent the average therm *input* requirement of a boiler or water heater. It is also assumed that the average efficiency of the boilers and water heaters included in the RASS study are code, 80% AFUE and 80% T.E. The RASS Data used was for a five plus unit apartment. The data was also normalized for the PG&E service territory.

*Annual Gas Savings H150, H719, & H720*

Energy UseB = NoD UEC





Where;

Energy UseB = Annual Baseline Energy Use, therms

Energy UseM = Annual Measure Energy Use, therms

UEC = Unit Energy Consumption per dwelling unit,

(therms/yr/dwelling)(176 for H7194, 36 for H7204,)

NoD = Number of dwellings per installation

(30 for H7207, 20 forH7197)

Base Efficiency = Boiler or Storage Water Heater baseline AFUE/thermal efficiency as shown is Table 3.

Measure Efficiency = Water Heater measure thermal efficiency

**Sample Calculations, H719:**

Energy UseB = 20 dwellings  176 therms/yr/dwelling = 3520 therms/yr

Energy UseM/T.E. = = 3313 therms/yr



**Sample Calculations, H720:**

Energy UseB = 30 dwellings  36 therms/yr/dwelling = 1080 therms/yr

Energy UseM/AFUE = = 1022 therms/yr

Calculate annual measure energy use for a small boiler, rated in AFUE.

Energy UseM/T.E. = = 1016 therms/yr

Calculate annual measure energy use for a large boiler, rated in thermal efficiency.

Energy UseM **= **

= ****= 1019 therms/yr

Code efficiency ratings for small space heating boilers (< 300 MBtuh) are listed in AFUE while large boilers (≥ 300 MBtuh) are listed in thermal efficiency. Measure code H720 allows both small and large boilers, so average measure consumption is calculated from the measure consumption using each efficiency rating.

****

**Sample Calculations, H150:**

Energy UseB = 20 dwellings  176 therms/yr/dwelling = 3520 therms/yr

Energy UseM/T.E. = = 3393 therms/yr



*Annual Gas Savings H244 & H247*

Energy UseB = UEC





Where;

Energy UseB = Annual Baseline Energy Use, therms

Energy UseM = Annual Measure Energy Use, therms

UEC = Unit Energy Consumption per dwelling unit,

(therms/yr/dwelling)(36 for H2444, 176 for H2474)

Base Efficiency = Boiler or Storage Water Heater baseline AFUE/thermal efficiency as shown is Table 3.

Measure Efficiency = Water Heater measure thermal efficiency

H150 = 82% thermal efficiency

H244/H247 = 84.5% AFUE3/85% thermal efficiency3

H719 = 85% thermal efficiency3

**Sample Calculations, H244:**

Energy UseB = 36 therms/yr/dwelling

Energy UseM/AFUE = = 34.1 therms/yr/dwelling

Calculate annual measure energy use for a small boiler, rated in AFUE.

Energy UseM/T.E. = = 33.9 therms/yr/dwelling

Calculate annual measure energy use for a large boiler, rated in thermal efficiency.

Energy UseM **= **

= ****= 34 therms/yr/dwelling

Code efficiency ratings for small boilers (< 300 MBtuh) are listed in AFUE while large boilers (≥ 300 MBtuh) are listed in thermal efficiency. Measure code H720 allows both small and large boilers, so average measure consumption is calculated from the measure consumption using each efficiency rating.



**Sample Calculations, H247:**

Energy UseB = 176 therms/yr/dwelling

Energy UseM/T.E.= = 166 therms/yr/dwelling

Calculate annual measure energy use for a large boiler, rated in thermal efficiency.



# *Section 3. Load Shapes*

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

# Section 4. Base Case & Measure Costs

## 4.1 Base Case(s) Costs

The following Measure Application Types are appropriate to these measures. The Base Case Costs are:

Table 13 Base Case Costs

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Large Domestic Water Heater** | **Large Storage Water Heater** | **Space Heating Boiler** |
| **Base Equipment Cost** | $2,846/Unit | $4,073/Unit | $3,006/Unit |

There are DEER costs that match catalog measuresH 150**,** H719, H720, H247 and H244. Therefore, we took cost values from the DEER 2008 cost data[[5]](#endnote-5) directly.

**Base Case Costs for H150, H719, H720, H247 and H244:**

The base case costs ($ per kBTUh) for these measures come directly from the 2014 DEER cost data (based on DEER 2008). Material and labor costs are multiplied by a climate multiplier to account for cost variation in each climate zone. Costs can be found in Appendix A

## 4.2 Measure Case Costs

The following Measure Application Types are appropriate to these measures. The Measure Case Costs are:

Table 14 Measure Case Costs

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Large Domestic Water Heater** | **Large Storage Water Heater** | **Space Heating Boiler** |
| **Base Equipment Cost** | $3,000/Unit | $4,282/Unit | $3,555/Unit |

There are DEER costs that match exactly to catalog measures **H150,** H719, H720, H247 and H244. Therefore, we took cost values from the DEER 2008 cost data directly.

**Measure Case Costs for H150, H719, H720, H247 and H244:**

The measure case costs ($ per kBTUh) for these measures come directly from the 2008 DEER cost data. Material and labor costs are multiplied by a climate multiplier to account for cost variation in each climate zone. Costs can be found in Appendix A.

## 

## 4.3 Incremental & Full Measure Costs

**Table 15 Incremental and Full Measure Cost Definitions**

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Full Measure Cost**  **(RUL Period/First Baseline)** | **Full Measure Cost**  **(EUL-RUL Period/ Second Baseline)** | **Incremental Measure Cost** |
| ER | Measure Equipment Cost  +Measure Labor Cost | (-1)x(Base Equipment Cost  + Base Labor Cost) | Measure Equipment Cost  – Base Case Equipment 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 Full Measure Cost*

Full 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.

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.

This Measure Application Types is: **ROB,** so the Gross Measure Cost (GMC) is represented by the equation below:

**GMC** = (Measure Equipment Cost + Measure Labor Cost) –

(Base Case Equipment Cost + Base Case Labor Cost)

\*Note: We assume that, unless stated otherwise, the measure case labor and base case labor are assumed to be the same value reducing the equation to the following:

**GMC =** Measure Equipment Cost – Base Case Equipment Cost

**Example:**

GMC = $20.58/kBTUh - $15.39/kBTUh = $ 5.19/kBTUh

## 

## 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,** 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: We assume that, unless stated otherwise, the measure case labor and base case labor are assumed to be the same value reducing the equation to the following:

**IMC =** Measure Equipment Cost – Base Case Equipment Cost

**Example:**

IMC = $20.58/kBTUh - $15.39/kBTUh = $ 5.19/kBTUh

**Table 16 Summary of Cost by Measure**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure ID** | **Measure Application Types** | **Average Base Case Total Cost** | **Average Measure Case Total Cost** | **Average Gross Measure Case Cost** | **Average Incremental Measure Cost** |
| H719 | ROB | $15.39per kBtu | $28.82 | $13.44 | $13.44 |
| H720 | ROB | $9.78per kBtu | $12.66 | $2.89 | $2.89 |
| H244 | ROB | $3,006 per unit | $3,555 | $549 | $549 |
| H247 | ROB | $2,846 per unit | $3,000 | $154 | $154 |
| H150 | ROB | $4073 per unit | $4282 | $209 | $209 |

*All costs are noted as $ per rated kBTUh*

**References**

1. Appendix B – 2014 Database for Energy Efficiency Resources (DEER) Update Study, prepared by Itron Inc., November 2013; D13v1.00 [↑](#endnote-ref-1)
2. Appendix C – DEER NTG Values [↑](#endnote-ref-2)
3. Appendix D – DEER2014 EUL [↑](#endnote-ref-3)
4. Appendix G – DEER2014 Update Documentation [↑](#endnote-ref-4)
5. Appendix H – DEER Measure Cost Summary

   **References from PGECODHW114 R4**

   1. 2010 California Title 20 Appliance Efficiency Regulations, Section 1605.1, Table E-3.
   2. 2010 California Title 20 Appliance Efficiency Regulations, Section 1605.1, Table F-3.

   8. 2011 DEER Database Entries DEER Database for Energy-Efficient Resources; Version 2011 4.01 found at :<http://www.deeresources.com/index.php?option=com_content&view=article&id=68&Itemid=60>

   9. 2009 California Statewide Residential Appliance Saturation Study. Volume 2, Study Results Final Report. October 2010.

   1. 2008 Revised DEER Measure Cost Summary. Revised 06/02/08. Revised DEER Measure Cost Summary (05\_30\_2008) Revised (06\_02\_2008).xls
   2. *DEER2011\_NTGR\_2012-05-16.xls* from DEER Database for Energy-Efficient Resources; Version 2011 4.01 found at :<http://www.deeresources.com/index.php?option=com_content&view=article&id=68&Itemid=60> Under: DEER2011 Update Documentation linked at: [DEER2011 Update Net-To-Gross table](http://www.deeresources.com/DEER2011/download/DEER2011_NTGR_2012-05-16.xls) Cells: (U54)

   [↑](#endnote-ref-5)