**Work Paper WPSDGENRWH1207**

**Revision 1**

**San Diego Gas & Electric**

**Energy Efficiency Engineering**

**Commercial Hot Water Boilers**

### Core Measure Summary Table

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| General Measure Information | | | | | | | | | | | | | | | | | | | PT | | 1st Baseline Period | | | | 2nd Baseline Period | | | | TOU |
| Measure Name | PreDesc | StdDesc | Measure RunID | Solution Code | CZ | Building Type | UseCategory | UseSubCategory | TechGroup | TechType | PreTechGroup | PreTechType | StdTechGroup | StdTechType | Load Shape | EUL\_ID | EUL | Unit Definition | Program Type (NEW, ROB, RET) | Applicable Code | Gross Unit Annual Electricity Savings (kWh/unit) | User Entered kW Savings per unit (kW/unit) | Gas Savings (Therms) | 1st Baseline Useful Life | Gross Unit Annual Electricity Savings (kWh/unit) | User Entered kW Savings per unit (kW/unit) | Gas Savings (Therms) | 2nd Baseline Useful Life | % Eligible for TOU AC Adjustment |
| Commercial Hot Water Boiler, ≤200 MBtu/hr (Small / Medium), Tier 1 (≥0.84 EF) |  | Gas Boiler (0.80 EF) | N/A | G-C1 | 8 | Any | SHW | Heating | WaterHtg\_eq | Boiler\_Et |  |  | WaterHtg\_eq | Boiler\_Et | SDG:35-OTI-OtherIndustrial-PROC\_OTH | PrcHt-Blr | 20.0 | Cap-kBTUh | ROB | No | 0.00 | 0.38 | 0.77 | 20.00 |  |  |  |  | 0.00 |
| Commercial Hot Water Boiler, ≤200 MBtu/hr (Small / Medium), Tier 2 (≥0.90 EF) |  | Gas Boiler (0.80 EF) | N/A | G-C1 | 8 | Any | SHW | Heating | WaterHtg\_eq | Boiler\_Et |  |  | WaterHtg\_eq | Boiler\_Et | SDG:35-OTI-OtherIndustrial-PROC\_OTH | PrcHt-Blr | 20.0 | Cap-kBTUh | ROB | No | 0.00 | 0.90 | 1.79 | 20.00 |  |  |  |  | 0.00 |
| Commercial Hot Water Boiler, >200 MBtu/hr (Large), Tier 1 (≥84% TE) |  | Gas Boiler (80% TE) | N/A | G-C1 | 8 | Any | SHW | Heating | WaterHtg\_eq | Boiler\_Et |  |  | WaterHtg\_eq | Boiler\_Et | SDG:35-OTI-OtherIndustrial-PROC\_OTH | PrcHt-Blr | 20.0 | Cap-kBTUh | ROB | No | 0.00 | 0.39 | 0.78 | 20.00 |  |  |  |  | 0.00 |
| Commercial Hot Water Boiler, >200 MBtu/hr (Large), Tier 2 (≥90% TE) |  | Gas Boiler (80% TE) | N/A | G-C1 | 8 | Any | SHW | Heating | WaterHtg\_eq | Boiler\_Et |  |  | WaterHtg\_eq | Boiler\_Et | SDG:35-OTI-OtherIndustrial-PROC\_OTH | PrcHt-Blr | 20.0 | Cap-kBTUh | ROB | No | 0.00 | 0.91 | 1.82 | 20.00 |  |  |  |  | 0.00 |

Note: **For the complete list of Measures, refer to the attached calculation spreadsheet** [[[1]](#endnote-1)]

### Costing and NTG Summary Table

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| General Measure Information | | | | PT | | NTG | | | IR | 1st Baseline Period | 2nd Baseline Period | IMC | DIM |
| Measure Name | Solution Code | CZ | Unit Definition | Program Type (NEW, ROB, RET) | Applicable Code | NTG Non-Res. | NTG Res. | NTG Multi Family | Installation Rate | Gross Measure Cost per unit | Gross Measure Cost per unit | Incremental Measure Cost per unit | Delivery & Incentive Method |
| Commercial Hot Water Boiler, ≤200 MBtu/hr (Small / Medium), Tier 1 (≥0.84 EF) | G-C1 | 8 | Cap-kBTUh | ROB | No | 0.6 |  |  | 1.00 | 6.06 |  | 1.64 | Financial Support / Down-Stream Incentive - Deemed |
| Commercial Hot Water Boiler, ≤200 MBtu/hr (Small / Medium), Tier 2 (≥0.90 EF) | G-C1 | 8 | Cap-kBTUh | ROB | No | 0.7 |  |  | 1.00 | 8.13 |  | 3.71 | Financial Support / Down-Stream Incentive - Deemed |
| Commercial Hot Water Boiler, >200 MBtu/hr (Large), Tier 1 (≥84% TE) | G-C1 | 8 | Cap-kBTUh | ROB | No | 0.6 |  |  | 1.00 | 13.54 |  | 4.48 | Financial Support / Down-Stream Incentive - Deemed |
| Commercial Hot Water Boiler, >200 MBtu/hr (Large), Tier 2 (≥90% TE) | G-C1 | 8 | Cap-kBTUh | ROB | No | 0.7 |  |  | 1.00 | 20.48 |  | 11.42 | Financial Support / Down-Stream Incentive - Deemed |

Note: **For the complete list of Measures, refer to the attached calculation spreadsheet** [A]

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision # | MM/DD/YY | Author/Affiliation | Summary of Changes |
| 0 | 06/15/2012 | Kelvin Valenzuela / SDGE | Adopted WPSCGNRWH120206C\_Rev3\_Comm Blr-May 22.docx, updated May 18, 2012. |
| 1 | 06/24/2014 | Judelson Enriquez / RMS Energy Consulting, LLC | 1. Updated to new workpaper format and adopted revisions made in WPSCGNRWH120206C\_Rev4\_Comm\_Blr-May29.docx, updated May 29,2014.  2. Savings and costs updated by SCG.  3. Generated calculation spreadsheet based on IOU statewide Calculation Template output. |

# Section 1. General Measure & Baseline Data

## 1.1 Measure & Delivery Description

### 1.1a Measure Description

This work paper documents the rationale for the commercial boiler measure as listed in SDG&E’s Energy Efficiency Business Rebates Natural Gas Catalog [[[2]](#endnote-2)].

1. Measure Description
2. Commercial hot water boilers are pressure vessels that transfer heat to water. In most boilers, a heat exchanger separates the combustion products from the water. Boilers can be configured as an integrated packaged boiler, or, in some cases, the boiler (which may resemble an instantaneous water heater) may be connected to a separate tank that contains an internal heat exchanger. Energy efficient units may have one or more of the following features: high efficiency/low NOx burners, power burners, water tubes, relatively large heat exchanger surfaces, and flue exhaust heat recovery systems.
3. Due to the relatively larger burner size, these water-heating devices are capable of providing hot water on a continuous basis. They have relatively high energy efficiency levels because standby losses from storage tanks are essentially eliminated.
4. The California Titles 20 and 24 standards define an instantaneous water heater to mean “a water heater that has an input rating of at least 4,000 Btu per hour per gallon of stored water” [[[3]](#endnote-3),[[4]](#endnote-4)]. Commercial domestic hot water boilers are included under this definition.
5. Hot water boilers are most efficient in combination with a large hot water storage tank or in point-of-use applications with no circulation loop. They are very inefficient in applications without a storage tank on a circulation loop due to the temperature loss in the circulation system, which causes the instantaneous water heater to run without water demand. They are problematic in central systems with circulation loops, which have long pipe runs from the water heater to the faucet.
6. The 2006 Commercial Boiler Workpaper includes a more detailed technology description in its Appendix A [[[5]](#endnote-5)].

Table 1 Measure Summary Table

|  |  |  |
| --- | --- | --- |
| Product Code | Measure name | Unit Definition |
| G-C1 | Commercial Boiler | MBtuh |

### 1.1b Delivery and Incentive Mechanism

The delivery method for the measure(s) in this workpaper is:

* Down-Stream Incentive – Deemed

However, a midstream point-of-sale rebate or an upstream manufacturer rebate strategy may also be implemented.

* Innovative Design / Mid-Stream Incentive
* Innovative Design / Up-Stream Incentive

The measure install types are:

* Replace on Burnout (ROB) or New Construction (NEW)

### 1.1c Measure Requirements

1. Terms & Conditions
2. This measure is not limited to specific NAICS codes.
3. The rebate applies to gas-for-gas equipment replacements on burnout or to new installations in existing buildings.
4. The rebate does not apply to new construction (NC).
5. Large (>2,000 Btu/hr) commercial hot water boilers and instantaneous water heaters are eligible for either the Energy Efficiency Rebates for Business program or the Energy Efficiency Calculated Incentive Program (EECIP).
6. Only instantaneous water heaters as defined by the California Energy Commission qualify, and they must:
   1. Be used primarily for domestic hot water
   2. Be installed at the point of use or be directly connected to a large hot water storage tank
   3. Never be used to supply hot water to a circulation loop without an intermediary hot water storage tank
7. The manufacturer’s name and equipment model number must be provided.
8. If necessary, customer must provide proof of unit efficiency (e.g., manufacturer’s equipment specification sheet).
9. Market Applicability
   * + 1. This measure is applicable to any commercial domestic (or “service”) hot water application.
       2. This workpaper does not cover water heaters or hot water boilers used for space conditioning, industrial (process) end-use applications, pools, or spas.
       3. Applicable building/business types include (but are not limited to) offices, restaurants, retail establishments, schools, colleges, hotels, motels, and recreational facilities.
       4. Typical NAICS codes include: 111-112, 42, 44-45, 48-49, 51-56, 61-62, 71-72, 81, and 92.
       5. This measure includes replacing an instantaneous water heater or a commercial hot water boiler with a more efficient instantaneous water heater or a commercial hot water boiler of similar rated input.
10. Qualifying Efficiency
11. Test methods for measuring boiler efficiencies are referenced in the California Titles 20 and 24 standards [C,D].
12. Minimum qualifying energy factor (EF) for small (≤200 MBtu/hr) commercial hot water boilers replacing less efficient commercial hot water boilers:
    1. 0.84 for Tier 1 (non-condensing)
    2. 0.90 for Tier 2 (condensing)
13. Minimum qualifying thermal efficiency (TE) for large (>200 MBtu/hr) commercial hot water boilers replacing less efficient commercial hot water boilers:
    1. 84% for Tier 1 (non-condensing)
    2. 90% for Tier 2 (condensing)
14. Tier 2 hot water boilers are condensing and often require flue modifications to handle the condensate. These modifications increase installation costs and may be eligible for a higher rebate amount.

## 1.2 DEER Differences Analysis

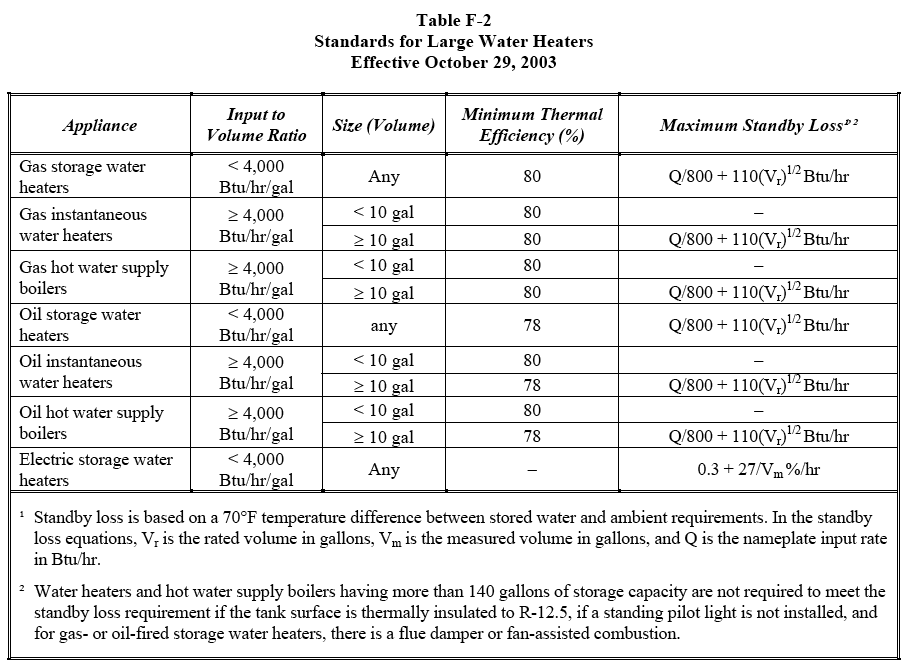
1. Measure Efficiency
   1. The 2014 Database for Energy-Efficient Resources (DEER) [[[6]](#endnote-6)] does not cover high efficiency commercial domestic hot water boilers being used to replace less efficient commercial domestic hot water boilers. Therefore, the instantaneous water heater cases in the DEER 2014 database were adapted for this purpose.
      1. The medium (76-200 MBtu/hr) instantaneous water heater qualifying thermal efficiency from DEER 2014 is converted to an energy factor (EF) to be consistent with Titles 20 and 24 for small (≤200 MBtu/hr) instantaneous hot water boilers. Since the rated volume of a commercial hot water boiler is negligible, the energy factor is assumed equal to the thermal efficiency. Also, the three DEER tiers for medium instantaneous water heater TE (80%, 85%, and 90%) are reduced to two tiers for commercial boiler EF.
      2. The large (>200 MBtu/hr) instantaneous water heater qualifying thermal efficiency from DEER 2014 is used for large commercial boilers, except that the three DEER tiers for instantaneous water heater thermal efficiency have been reduced to two tiers for large commercial boilers.
   2. The following measure efficiencies are adopted after consideration of the California Titles 20 and 24 standards, and the high-efficiency instantaneous water heaters listed in the California Energy Commission Energy Efficiency Appliance Database [[[7]](#endnote-7)]:
      1. Small (≤200 MBtu/hr) Tier 1 hot water boiler – since almost 60% of the models in the CEC Appliance Efficiency Database have EF at or below 0.82, the qualifying EF is set to 0.84.
      2. Small (≤200 MBtu/hr) Tier 2 hot water boiler – the qualifying EF is set to the standard Tier 2 value of 0.90 to be consistent across all types of boiler and water heaters (90% efficiency can only be achieved with condensing boilers).
      3. Large (>200 MBtu/hr) Tier 1 hot water boiler – since the Titles 20 and 24 standard is 80% thermal efficiency, the qualifying TE is set to 84% because there is a good selection of boilers with TE between 84% and 87%.
      4. Large (>200 MBtu/hr) Tier 2 hot water boiler – the qualifying TE is set to the standard Tier 2 value of 90% to be consistent across all types of boiler and water heaters.
2. Baseline Efficiency
   1. The 2014 Database for Energy-Efficient Resources (DEER) does not cover high efficiency commercial domestic hot water boilers being used to replace less efficient commercial domestic hot water boilers. However, the instantaneous water heater data in the DEER 2014 database are adapted for this purpose. The following baseline standards are adopted after consideration of the California Titles 20 and 24 standards, and the high-efficiency instantaneous water heaters listed in the California Energy Commission Energy Efficiency Appliance Database:
      1. Small (≤200 MBtu/hr) hot water boiler – Titles 20 and 24 allows an EF of 0.62, but about more than half of the models in the CEC Appliance Efficiency Database have an EF between 0.79 and 0.82 with 28% alone being 0.80, so an average EF of 0.80 is used for energy savings calculations.
      2. Large (>200 MBtu/hr) hot water boiler – the Titles 20 and 24 standard value of 80% TE is used in this workpaper.

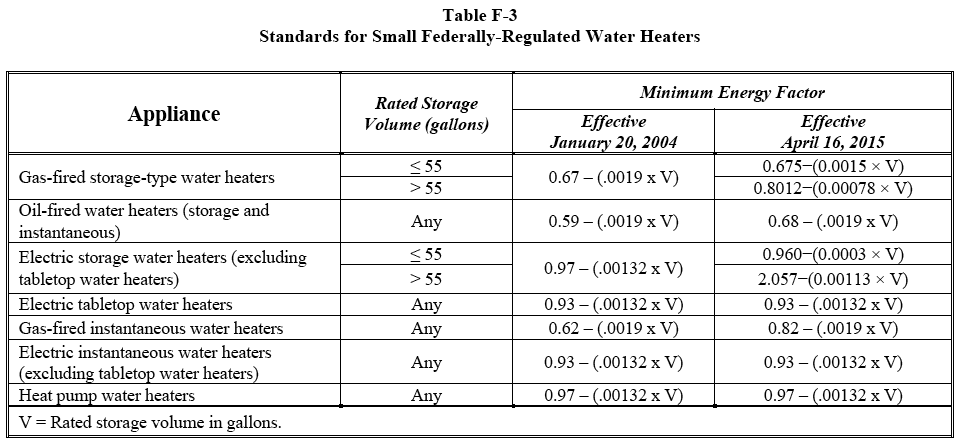
Table 2 DEER Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Modified DEER Methodology | Yes |
| Scaled DEER Measure | No |
| DEER Building Prototypes Used | Yes |
| Deviation from DEER | • Modified DEER three tiers to two tiers  • Set measure efficiency to match Title 20 and 24 and Code of Federal Regulations standards  • DEER does not contain cost data for measure efficiency |
| DEER Version | DEER 2014 |
| DEER Run ID and Measure Name (Sample) | • Tankless Water Heater ≤200 MBtu/hr (Small / Medium), Tier 1 (≥0.84 EF) - NG-WtrHt-MedInst-Gas-76to200kBtuh-0p85Et  • Tankless Water Heater ≤200 MBtu/hr (Small / Medium), Tier 2 (≥0.90 EF) ­ NG-WtrHt-MedInst-Gas-76to200kBtuh-0p90Et  • Tankless Water Heater >200 MBtu/hr (Large), Tier 1 (≥84% TE) ­ NG-WtrHt-LrgInst-Gas-gt200kBtuh-0p85Et  • Tankless Water Heater >200 MBtu/hr (Large), Tier 2 (≥90% TE) ­ NG-WtrHt-LrgInst-Gas-gt200kBtuh-0p90Et |

## 1.3 Code Analysis

The 2014 California Title 20 Appliance Efficiency Regulations [[[8]](#endnote-8)] include standards for both federally regulated appliances and nonfederally-regulated appliances that are sold or offered for sale in California. Section 1605.1(f) include standards for water heaters:

1. Large Water Heaters. The thermal efficiency and standby loss of large water heaters manufactured during the applicable time period shall be not less than the applicable values shown in Table F-2.
2. 
3. Small Water Heaters. The energy factor of all small water heaters that are federally-regulated consumer products, (other than booster water heaters, hot water dispensers, and mini-tank electric water heaters) shall be not less than the applicable values shown in Table F-3.



The minimum qualifying measure efficiencies exceed the California Title 20 standards.

The 2013 California Title 24 Building Energy Efficiency Standards [[[9]](#endnote-9)] include standards to improve the energy efficiency of newly constructed building and additions and alterations to existing buildings for residential and nonresidential buildings. Section 110.3 includes the mandatory requirements for service water-heating systems and equipment, which essentially references Title 20 efficiency standards. The minimum qualifying measure efficiencies exceed Title 24 standards.

The Code of Federal Regulations, 10 CFR 430.32(d) [[[10]](#endnote-10)] include energy and water conservation standards and compliance dates for water heaters. See table below for water heater energy factor standards and compliance dates. The minimum baseline efficiencies are consistent with the Code of Federal Regulations standards.

|  |  |  |
| --- | --- | --- |
| **Product class** | **Energy factor as of January 20, 2004** | **Energy factor as of April 16, 2015** |
| Gas-fired Water Heater | 0.67−(0.0019 × Rated Storage Volume in gallons) | For tanks with a Rated Storage Volume at or below 55 gallons: EF = 0.675−(0.0015 × Rated Storage Volume in gallons). For tanks with a Rated Storage Volume above 55 gallons: EF = 0.8012−(0.00078 × Rated Storage Volume in gallons). |
| Oil-fired Water Heater | 0.59−(0.0019 × Rated Storage Volume in gallons) | EF = 0.68−(0.0019 × Rated Storage Volume in gallons). |
| Electric Water Heater | 0.97−(0.00132 × Rated Storage Volume in gallons) | For tanks with a Rated Storage Volume at or below 55 gallons: EF = 0.960−(0.0003 × Rated Storage Volume in gallons). For tanks with a Rated Storage Volume above 55 gallons: EF = 2.057−(0.00113 × Rated Storage Volume in gallons). |
| Tabletop Water Heater | 0.93−(0.00132 × Rated Storage Volume in gallons) | EF = 0.93−(0.00132 × Rated Storage Volume in gallons). |
| Instantaneous Gas-fired Water Heater | 0.62−(0.0019 × Rated Storage Volume in gallons) | EF = 0.82−(0.0019 × Rated Storage Volume in gallons). |
| Instantaneous Electric Water Heater | 0.93−(0.00132 × Rated Storage Volume in gallons) | EF = 0.93−(0.00132 × Rated Storage Volume in gallons). |

Table 3 Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 20 (2014) | 2014 CA Title 20 Appliance Efficiency Regulations, Section 1605.1(f) | July 1, 2014 |
| Title 24 (2013) | 2013 CA Title 24 Non-Residential Compliance Manual, Section 110.3 | July 1, 2014 |
| Federal Standards | Code of Federal Regulations, 10 CFR 430.32(d) | 04/16/2015 |

## 1.4 Measure Effective Useful Life

## DEER and the CPUC ED Workpaper Disposition for Lighting Retrofits documentation provide EUL and RUL information to be used on www.deeresources.com.

## To obtain the EUL value, the updated CPUC ED EUL table documentation issued on February 5, 2014, “DEER2014-EUL-table-update\_2014-02-05.xlsx”, was consulted. The table below identifies the value/methodology used for the measures in this work paper.

Table 4 DEER EUL Value/Methodology

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Market | Enduse | Measure | EUL (Years) | RUL (Years) |
| Non-Residential | ProcHeat | High Efficiency Boiler | 20 | 6.67 |

Table 5 identifies the EUL IDs used in this workpaper.

Table 5 EUL ID Summary

|  |  |  |
| --- | --- | --- |
| EUL\_ID | Description | Sector |
| PrcHt-Blr | High Efficiency Boiler | Com |

## 1.5 Net-to-Gross Ratios for Different Program Strategies

The NTG value was obtained from the “DEER2011\_NTGR\_2012-05-16.xls” [[[11]](#endnote-11)] on the DEER website as required by Version 4 of the California Public Utilities Commission (CPUC) Energy Efficiency Policy Manual. The relevant NTGR for this measure is shown in Table 6 below.

The Tier 1 measures use the “Com-Default > 2yrs” EUL ID, while the Tier 2 measures use the “All-Default <= 2yrs” EUL ID.

Table 6 Net-to-Gross Ratio Summary Table

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| NTGR\_ID | Description\* | Sector | BldgType | ProgDelivID |
| Com-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Com | Any | All |
| All-Default<=2yrs | All other EEM with no evaluated NTGR; new technology in program for 2 or fewer years | All | Any | All |

## 1.6 Time-of-Use Adjustment Factor

As directed by the CPUC in decision 06-06-063 dated June 29, 2006, time-of-use (TOU) adjustment factors are to be applied for 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 zero. Additionally, if a measure is assigned a DEER08 load shape, i.e. the load shape starts with “DEER:” the TOU assigned to that measure should also be zero.

Table 7 TOU Summary Table

|  |  |
| --- | --- |
| Measure | % |
| Commercial Boiler | 0 |

\*Note: Check Section 3 if a measure appears to require a non-zero percentage but is assigned zero. If the load shape is a DEER08 load shape, a TOU of zero is correct.

# Section 2. Energy Savings & Demand Reduction Calculations

## 2.1 Electric Energy Savings Estimation Methodologies

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

## 2.2 Demand Reduction Estimation Methodologies

## There are no anticipated demand reductions associated with this measure.

## 2.3 Gas Energy Savings Estimation Methodologies

* + 1. Annual Gas Energy Savings
       1. The annual gas energy savings are based on DEER 2014, with changes to the baseline and measure efficiency values based on the California Titles 20 and 24 standards and the California Energy Commission Energy Efficiency Appliance Database. Table 8 lists the baseline and qualifying efficiency measure efficiencies for instantaneous water heaters in the DEER 2014.
          1. The California Titles 20 and 24 standards use energy factor to describe the efficiency of small (rated input ≤200 MBtu/hr) instantaneous water heaters.
          2. The DEER 2014 data do not cover more efficient commercial domestic hot water boilers being used to replace less efficient commercial domestic hot water boilers.

Table 8 Base and Measure Instantaneous Water Heater Efficiencies in DEER 2014

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Equipment Type** | **Rated Input (MBtu/hr)** | **Efficiency Units** | **Base Efficiency** | **Qualifying Efficiency** |
| Small, < 2 gallons | ≤ 75 | EF | 0.60 | ≥ 0.82 |
| Medium | 76 - 200 | TE | 80% | 80%, 85%, 90% |
| Standby Loss | 0.56% per hour | N/A |
| Large | > 200 | TE | 80% | 80%, 85%, 90% |
| Standby Loss | 0.56% per hour | N/A |

* + 1. Boiler Efficiencies

1. Water heating products in the CEC Appliance Database intermingle instantaneous, storage, non-condensing, and condensing water heaters. The ratio of rated input to rated storage volume is used to sort the data for hot water boilers. First, water-heating products having a ratio less than 4,000 Btu/hr/gallon (“storage water heaters”) were removed from the database. Table 9 shows the range of water heater efficiencies found in the CEC Appliance Database for water heating products having a rated input to storage volume ratio greater than 4,000 Btu/hr/gallon. Non-condensing and condensing water heaters are intermingled, although a water heater with energy factor or thermal efficiency above about 88% is most likely a condensing water heater. See Attachment #2 for complete list [[[12]](#endnote-12)].
2. Figure 1 shows the distribution of energy factors for small instantaneous water heaters (rated input 75-200 MBtu/hr) in the CEC Appliance Database.
3. Figure 2 shows the distribution of thermal efficiencies for large instantaneous water heaters (rated input above 200 MBtu/hr) in the CEC Appliance Database.
4. These data are applicable to commercial domestic hot water boilers.

Table 9 Instantaneous Water Heater Efficiency Ranges from California Energy Commission Appliance Efficiency Database

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Equipment Type** | **Rated Input (MBtu/hr)** | **Efficiency Units** | **Minimum Efficiency** | **Maximum Efficiency** |
| Small | 50 – 199 | EF | 0.78 | 0.985 |
| Large | 200 – 2,400 | TE | 75.4% | 99% |

Figure 1 Energy Factor Distribution for Small Instantaneous Water Heaters (i.e., Commercial Hot Water Boilers) in the CEC Appliance Efficiency Database

Figure 2 Thermal Efficiency Distribution for Large Instantaneous Water Heaters (i.e., Commercial Hot Water Boilers) in the CEC Appliance Efficiency Database

* + 1. Standard Efficiencies
       1. Table 3 lists the California Titles 20 and 24 standards for instantaneous water heaters. Title 20 defines an "instantaneous water heater" to be a water heater that has an input rating of at least 4,000 Btu/hr per gallon of stored water.
       2. Energy factor is the standard efficiency unit for instantaneous water heaters with rated input ≤200 MBtu/hr. Thermal efficiency is the standard efficiency unit for instantaneous water heaters with rated input >200 MBtu/hr. The efficiencies of all of the instantaneous water heaters found in the CEC Appliance Database meet these standards. Commercial domestic hot water boilers are included as instantaneous water heaters.
    2. Baseline and Measure Efficiencies

1. Table 10 lists the efficiency units and efficiency values recommended for commercial hot water boilers.
2. The minimum baseline efficiencies and efficiency units for commercial hot water boilers match the California Titles 20 and 24 standards for instantaneous water heaters.
3. The baseline efficiencies have the following changes compared to the 2014 Database for Energy-Efficient Resources (DEER):
   1. The smallest (< 75 MBtu/hr) instantaneous water heater category in DEER has been dropped, since units with rated input less than 75 MBtu/hr are rarely used in commercial applications and few models are on the market.
   2. The DEER 2014 database does not cover more efficient commercial domestic hot water boilers being used to replace less efficient commercial domestic hot water boilers.
4. The qualifying measure efficiencies have the following changes compared to the 2014 Database for Energy-Efficient Resources (DEER):
   1. The smallest (< 75 MBtu/hr) instantaneous water heater category in DEER has been dropped, since units with rated input less than 75 MBtu/hr are rarely used in commercial applications and few models are on the market.
   2. The small (75-200 MBtu/hr) instantaneous water heater qualifying thermal efficiency has been converted to an energy factor (EF) to be consistent with Titles 20 and 24. Since the rated volume of an instantaneous water heater is negligible, the energy factor is assumed equal to the thermal efficiency.
   3. The DEER 2014 database does not cover more efficient commercial domestic hot water boilers being used to replace less efficient commercial domestic hot water boilers.

Table 10 Baseline and Qualifying Measure Efficiencies for High Efficiency Commercial Hot Water Boilers Replacing Baseline Commercial Hot Water Boilers

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Equipment Type** | **Rated Input (MBtu/hr)** | **Efficiency Units** | **Minimum Base  Efficiency** | **Qualifying  Efficiency** |
| Small, Tier 1 (non-condensing) | ≤200 | EF | 0.80 | 0.84 |
| Small, Tier 2 (condensing) | ≤200 | EF | 0.80 | 0.90 |
| Large, Tier 1 (non-condensing) | >200 | TE | 80% | 84% |
| Large, Tier 2 (condensing) | >200 | TE | 80% | 90% |

* + 1. Energy Savings Calculation
       1. The energy savings data calculated for DEER 2014 are used as the basis for this workpaper.
       2. For calculating energy savings, the following assumptions are used:
          1. The average efficiencies for the baseline units for commercial hot water boilers are an energy factor of 0.80 for small hot water boilers and a thermal efficiency of 80% for large hot water boilers. The latter matches the California Title 20 code efficiency standards for instantaneous water heaters.
          2. The average efficiencies for commercial hot water boiler measure units are the Tier 1 and Tier 2 qualifying efficiencies for commercial hot water boilers stated above.
       3. Table 11 lists the base efficiencies, measure efficiencies, and calculated values for the six measures reported in the DEER calculations for instantaneous water heaters replacing storage water heaters. The data and calculations are included in an Excel file embedded as Attachment #1 [A].
          1. The energy savings calculated for DEER 2014 are across all IOU “Com” building types to produce a single value for each equipment type.
          2. Only existing building vintages are used for the calculations.
       4. With the above assumptions, the energy saved by a high-efficiency measure commercial hot water boiler can be calculated as follows using the DEER Method for Calculating Energy Savings as shown in Attachment #3 [[[13]](#endnote-13)]:

*∆Q3-4 = ∆Q1-2 x ( 1/E3 - 1/E4 ) / ( 1/E1 - 1/E2 )* ***Eqn-1***

where

* + - * 1. *∆Q* – Energy Saved (therms/yr). Savings which results from installing the high-efficiency measure equipment.
        2. *E* – Efficiency (%). Efficiency of equipment in appropriate efficiency units (energy factor, thermal efficiency, etc.).
        3. *Subscript 1* = DEER 2014 Tier 1 equipment (0.80 energy factor or 80% thermal efficiency instantaneous water heater)
        4. *Subscript 2* = DEER 2014 Tier 2 or Tier 3 measure equipment (0.85 or 0.90 energy factor, or 85% or 90% thermal efficiency instantaneous water heater)
        5. *Subscript 3* = Adjusted baseline equipment value (same as DEER Tier 1 at 0.80 energy factor or 80% thermal efficiency commercial boiler)
        6. *Subscript 4* = Adjusted measure equipment value (0.84 or 0.90 energy factor, or 84% or 90% thermal efficiency commercial boiler)
      1. Table 12 shows the adjusted energy savings calculations for commercial hot water boilers replacing commercial hot water boilers. The data and calculations are included in an Excel file embedded as Attachment #1 [A].
         1. The top section of the table shows the results of taking the appropriate differences between the DEER 2014 values for annual energy savings from Table 11. This Tier 1 is the difference between the DEER Tier 2 and the DEER Tier 1; and this Tier 2 is the difference between the DEER Tier 3 and the DEER Tier 1. This changes the baseline from a storage water heater to an instantaneous water heater with energy factor of 0.80 or thermal efficiency of 80%.
         2. The bottom section shows the calculation results for annual energy savings using Equation 1. The six variables in Equation 1 are identified in the row labels.
         3. The annual energy savings for Tier 1 instantaneous water heaters are reduced about 20% compared to the DEER 2014 results in the top section, but the annual energy savings for the Tier 2 instantaneous water heaters are the same as the DEER 2014 in the top section (since the efficiencies are unchanged).

Table 11 DEER Calculations of Annual Energy Savings for Instantaneous Water Heaters Replacing Storage Water Heaters

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Equipment Type** | **Small, Tier 1** | **Small, Tier 2** | **Small, Tier 3** | **Large, Tier 1** | **Large, Tier 2** | **Large, Tier 3** | |
| **Rated Input (MBtu/hr) 🡪** | **≤200** | **≤200** | **≤200** | **>200** | **>200** | **>200** |
| Storage Base Standby Loss | 0.56%/hr | 0.56%/hr | 0.56%/hr | 0.56%/hr | 0.56%/hr | 0.56%/hr |
| Storage Base Thermal Efficiency | 80% | 80% | 80% | 80% | 80% | 80% |
| Tankless Measure Thermal Efficiency | 80% | 85% | 90% | 80% | 85% | 90% |
| Average Annual Energy Savings (therms/yr/MBtuh) | 0.48 | 1.43 | 2.27 | 0.31 | 1.27 | 2.12 |

Table 12 Calculations of Annual Energy Savings for More Efficient Commercial Hot Water Boilers Replacing Baseline Commercial Hot Water Boilers

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Equipment Type** | **Small, Tier 1** | **Small, Tier 2** | **Large, Tier 1** | **Large, Tier 2** | |
| **Rated Input (MBtu/hr) 🡪** | **≤200** | **≤200** | **>200** | **>200** |
| **DEER 2014 with Instantaneous Water Heater Baseline** | | | | |
| Efficiency units | EF | EF | TE | TE |
| Boiler Base Efficiency, E1 | 0.80 | 0.80 | 80% | 80% |
| Boiler Measure Efficiency, E2 | 0.85 | 0.90 | 85% | 90% |
| Adjusted Annual Energy Savings (therms/yr/MBtuh), ∆Q1-2 | 0.95 | 1.79 | 0.96 | 1.81 |
|  |  |  |  |  |
| **Adjusted Values with Instantaneous Water Heater Baseline** | | | | |
| Efficiency units | EF | EF | TE | TE |
| Boiler Base Efficiency, E3 | 0.80 | 0.80 | 80% | 80% |
| Boiler Measure Efficiency, E4 | 0.84 | 0.90 | 84% | 90% |
| Adjusted Annual Energy Savings (therms/yr/MBtuh), ∆Q3-4 | 0.77 | 1.79 | 0.78 | 1.81 |

* + 1. For all the savings discussed above, there is an installation rate applied to values associated with the installation GSIA ID in Table 13. The GSIA ID is identified in the ex-ante implementation tables for all programs and measures. The installation rate (IR) is applied to the gross savings calculations using the values associated with the IDs below.

Table 13 Gross Savings Installation Adjustment (GSIA) IDs

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| GSIA\_ID | Description | Sector | BldgType | UseCategory | TechType |
| Def-GSIA | Default GSIA | Any | Any | Any | Any |

# Section 3. Load Shapes

The difference between the base case load shape and the measure load shape would be the most appropriate load shape; however, only end-use profiles are available. Therefore, for the sake of the E3 calculation, the closest load shape chosen for this measure is the 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH load shape. See Table 14 for a list of all Building Types and Load Shapes. See the KEMA report for a more thorough discussion regarding the load shapes for this measure.

Table 14 Building Types and Load Shapes

|  |  |
| --- | --- |
| Building Type | Load Shape |
| Assembly | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Education - Primary School | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Education - Secondary School | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Education - Community College | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Education - University | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Grocery | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Food Store | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Health/Medical - Hospital | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Health/Medical - Nursing Home | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Health/Medical - Clinic | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Lodging - Hotel | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Lodging - Guest Rooms | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Lodging - Motel | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Manufacturing - Bio/Tech | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Manufacturing - Light Industrial | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Misc - Commercial | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Office - Large | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Office - Small | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Restaurant - Fast-Food | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Restaurant - Sit-Down | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Retail - Multistory Large | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Retail - Single-Story Large | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Retail - Small | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Storage - Conditioned | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Storage - Unconditioned | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Transportation - Communication - Utilities | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |
| Warehouse - Refrigerated | 12-MBT-Manufacturing–Bio/Tech-PROC\_OTH |

# Section 4. Base Case & Measure Costs

## 4.1 Base Case Cost

* + 1. When the customer is replacing equipment on burnout (ROB) or buying new equipment (NEW), the customer must buy a new water heater to continue operating, so the base case cost is that of a baseline (standard) water heater. The baseline water heater is a less-efficient commercial hot water boiler.
    2. The base case costs are shown in Table 15 below. Table 15 is focused on more efficient commercial hot water boilers replacing baseline commercial hot water boilers for domestic hot water use.
       1. The table lists the results of a survey of equipment vendors that sell water heaters in California, in cost per MBtu/hr. The vendor calls produced data for most of the categories of water heater type, rated input, and efficiency used in this Workpaper. The base measure costs shown in 0represent an arithmetic average of the corresponding equipment cost/MBtuh in each category. The cost data and calculations are included in an Excel file embedded as Attachment #4 [[[14]](#endnote-14)].

## 4.2 Gross Measure Cost

1. The gross measure costs include the cost of the equipment, excluding installation and start-up costs. For the purposes of determining incremental measure costs, the installation and start-up costs are assumed to be the same for the base case and measure equipment.
2. The gross measure costs are shown in Table 15 below.
   1. The table lists the results of a survey of equipment vendors that sell water heaters in California, in cost per MBtu/hr. The gross measure costs shown in 0represent an arithmetic average of the equipment cost per MBtu/hr in each category. The cost data and calculations are included in an Excel file embedded as Attachment #4 [N].

## 4.3 Incremental Measure Cost

1. The incremental measure cost (IMC) is the difference between the cost of the average baseline unit and the average high efficiency measure.
2. The incremental measure costs are shown in Table 15 below. Table 15 is focused on more efficient commercial hot water boilers replacing baseline commercial hot water boilers for domestic hot water use. The cost data and calculations are included in an Excel file embedded as Attachment #4 [N].

Table 15 Gross and Incremental Measure Cost for More Efficient Commercial Hot Water Boilers Replacing Baseline Commercial Hot Water Boilers

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Equipment Type** | **Small Tier 1** | **Small Tier 2** | **Large Tier 1** | **Large Tier 2** |
| **Rated Input (MBtu/hr) 🡪** | **≤200** | **≤200** | **>200** | **>200** |
| **2014 Vendor Survey Data Cost per MBtuh** |  |  |  |  |
| Average Base Cost ($/MBtuh) | $4.42 | $4.42 | $9.06 | $9.06 |
| Average Gross Measure Cost ($/MBtuh) | $6.06 | $8.13 | $13.54 | $20.48 |
| Average Incremental Measure Cost ($/MBtuh) | **$1.64** | **$3.71** | **$4.48** | **$11.42** |

# Attachments

1. 

1. **
2. **
3. **

1. 

# References

1. [] Attachment #1 – Calculation Template v2.2.xlsm. [↑](#endnote-ref-1)
2. [] SDG&E’s Energy Efficiency Business Rebates Natural Gas Catalog. <http://www.sdge.com/rebates-finder/earn-rebates-your-improvements> [↑](#endnote-ref-2)
3. [] *California Code of Regulations, Title 20. Public Utilities and Energy, Division 2. State Energy Resources Conservation and Development Commission*, California Energy Commission, CEC-140-2008-001-REV1, August 2008 (Accessed Mar. 12, 2012 at <http://www.energy.ca.gov/regs/title20/index.html>). [↑](#endnote-ref-3)
4. [] *2008 Building Energy Efficiency Standards, Nonresidential Compliance Manual*, Title 24, California Energy Commission, CEC-400-2008-017-CMF-Rev1, December 2008, Revised August 2009, Revised March 2010, Revised July 2010 (Accessed Mar. 12, 2012 at <http://www.energy.ca.gov/title24/>). [↑](#endnote-ref-4)
5. [] Attachment #5 - *Commercial Boilers Workpaper*, EEA Report No. B-REP-05-599-20B, March 2006.  [↑](#endnote-ref-5)
6. [] Database for Energy Efficiency Resources, 2014. http://www.deeresources.com/ [↑](#endnote-ref-6)
7. [] California Energy Commission Appliance Efficiency Database, 2014. http://www.appliances.energy.ca.gov/AdvancedSearch.aspx [↑](#endnote-ref-7)
8. [] The 2014 Appliance Efficiency Regulations – Title 20: http://www.energy.ca.gov/2014publications/CEC-400-2014-009/CEC-400-2014-009-CMF.pdf [↑](#endnote-ref-8)
9. [] The 2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings – Title 24, Part 6: http://www.energy.ca.gov/2012publications/CEC-400-2012-004/CEC-400-2012-004-CMF-REV2.pdf [↑](#endnote-ref-9)
10. [] 10 CFR 430.32, Energy and water conservation standards and their compliance dates. http://www.ecfr.gov/cgi-bin/text-idx?SID=e4564dae8e11ceef59e1eca4019d24ea&node=10:3.0.1.4.18.3.9.2&rgn=div8 [↑](#endnote-ref-10)
11. [] DEER2011 Update Net-To-Gross table (05/16/2012) <http://www.deeresources.com/files/DEER2011/download/DEER2011_NTGR_2012-05-16.xls> [↑](#endnote-ref-11)
12. [] Attachment #2 – CEC Database [↑](#endnote-ref-12)
13. [] Attachment #3 – Method for Calculating Energy Savings [↑](#endnote-ref-13)
14. [] Attachment #4 – Commercial Water Heater Vendor Cost Data [↑](#endnote-ref-14)