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WATER HEATING
BOILER, COMMERCIAL
SWWH005-01

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MEASURE NAME

Boiler, Commercial

STATEWIDE MEASURE ID

SWWH005-01

TECHNOLOGY SUMMARY

A commercial hot water boiler is a pressure vessel that transfers heat to water. In most boilers, a heat exchanger separates the combustion products from the water. A boiler can be configured as an integrated packaged boiler, or, in some cases, may be connected to a separate tank that contains an internal heat exchanger. The California Appliance Efficiency Regulations (Title 20) and Building Energy Efficiency Standards (Title 24) define an instantaneous water heater as “a water heater that has an input rating of at least 4,000 Btu per hour per gallon of stored water.”¹ Commercial domestic hot water boilers are included within this definition.

Due to the relatively larger burner size, a commercial domestic hot water boiler is capable of providing hot water on a continuous basis. The commercial boiler has a relatively high energy efficiency levels because standby losses of a storage tank is essentially eliminated. A hot water boiler is most efficient in combination with a large hot water storage tank or for a point-of-use application with no circulation loop. The commercial boiler is inefficient for applications without a storage tank 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 and no recirculation pump.

An energy efficient commercial boiler may have one or more of the following features: high efficiency/low NOx burner, power burner, water tube, relatively large heat exchanger surface, and/or flue exhaust heat recovery system.

Uniform energy factor (UEF) is the standard efficiency unit for instantaneous water heaters with a rated input ≤ 200 kBtu per hour.² Thermal efficiency (TE) is the standard efficiency unit for instantaneous water heaters with rated input > 200 kBtu per hour. Commercial domestic hot water boilers are included as instantaneous water heaters.

¹ California Energy Commission (CEC). 2017. *2016 Appliance Efficiency Regulations*. CEC-400-2017-002.

California Energy Commission (CEC). 2015. *2016 Building Energy Efficiency Standards for Residential and Nonresidential Buildings*. CEC-400-2015-037-CMF.

² U.S. Department of Energy (DOE). 2016. “Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters.” *Federal Register: The Daily Journal of the United States*. 81 Fed. Reg. 250. December 29, 2016.

MEASURE CASE DESCRIPTION

This measure is defined as the replacement of 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, as specified below. These measure efficiencies were adopted after consideration of the California Title 20 and Title 24 standards, and from analysis of the distribution of high-efficiency instantaneous water heaters certified in the California Energy Commission (CEC) Modernized Appliance Efficiency Database System.³ The minimum qualifying measure efficiencies exceed both the Title 20 and the Code of Federal Regulations minimum standards (see Code Requirements). The measure efficiency ratings are used for the calculation of energy savings by climate zone for each measure offering.

Measure Case Specification

| Boiler Efficiency Tier | Boiler Size | Rated Input (kBtu/hr) | Min. Qualifying Efficiency Rating | Measure Efficiency |
|-------------------------|-------------|-----------------------|-----------------------------------|--------------------|
| Non-condensing – Tier 1 | Small/Med | ≤ 200 | 0.82 UEF | 0.84 UEF |
| | Large | > 200 | 84% TE | 85% TE |
| Condensing – Tier 2 | Small/Med | ≤ 200 | 0.87 UEF | 0.89 UEF |
| | Large | > 200 | 90% TE | 90% TE |

Additional context regarding the measure case specification follows:

- *Small (≤ 200 kBtu/hr) Tier 1 hot water boiler.* Approximately 6% of the models in the CEC Appliance Efficiency Database have an EF equal to 0.84 (equivalent to 0.82 UEF). The minimum qualifying Energy Factor (EF) is set to 0.84 while calculating the savings at 0.85 EF.
- *Small (≤ 200 kBtu/hr) Tier 2 hot water boiler.* The qualifying EF is set to the standard Tier 2 value of 0.90 EF to be consistent across all types of boiler and water heaters (0.90 EF can only be achieved with condensing boilers). The measure is available at 0.90 EF (equivalent to 0.87 UEF), savings were calculated with 0.92 EF.
- *Large (> 200 kBtu/hr) Tier 1 hot water boiler.* Since the Title 20 and Title 24 standards require 80.0% thermal efficiency (TE), the qualifying TE is set equal to 84% because there is a good selection of boilers with TE between 84% and 87%. The qualifying TE is set equal to 84% and savings were calculated with 85% TE.
- *Large (> 200 kBtu/hr) Tier 2 hot water boiler.* The qualifying TE is set equal to the standard Tier 2 value of 90% to be consistent across all types of boiler and water heaters.

BASE CASE DESCRIPTION

The base case of this measure is defined by boiler size only (small/medium, ≤ 200 kBtu/hr and large, > 200 kBtu/hr). The minimum base case efficiencies are consistent with the Code of Federal Regulations minimum standards (see Code Requirements).

³ California Energy Commission (CEC). (n.d.) "Modernized Appliance Efficiency Database System (MAEDBS)." <https://cacertappliances.energy.ca.gov/Login.aspx>. Accessed in March 2012 and May 2014

Base Case Specification

| Boiler Size | Rated Input (kBtu/hr) | Min. Efficiency Rating |
|-------------|-----------------------|------------------------|
| Small/Med | ≤ 200 | 0.80 UEF |
| Large | > 200 | 80% TE |

CODE REQUIREMENTS

Applicable state and federal codes and standards and energy use standards for instantaneous heater/boilers are specified in the tables below.⁴ In addition, water heating equipment must comply with nitrogen oxide (NO_x) emissions limits set forth by air quality management districts (AQMDs) or air pollution control districts (APCDs) throughout the California.⁵

Applicable State and Federal Codes and Standards for Direct Contact Water Heaters

| Code | Applicable Code Reference | Effective Date |
|---|---------------------------|----------------------------------|
| CA Appliance Efficiency Regulations – Title 20 (2016) | Section 1605.3(f) | January 1, 2017 |
| CA Building Energy Efficiency Standards – Title 24 (2016) | Section 110.3 | January 1, 2017 |
| Federal Standards – Code of Federal Regulations | 10 CFR 430.32(d) | April 16, 2015 |
| | 10 CFR 431.110(a) | October 9, 2015 |
| California Air Quality Management and Air Pollution Control Districts | | |
| South Coast AQMD | Rule 1121 Rule 1146.2 | September 3, 2004 May 5, 2006 |
| Bay Area AQMD | Regulation 9, Rule 6 | November 7, 2007 |
| San Joaquin Valley APCD | Rule 4902 | March 19, 2009 |

⁴ California Energy Commission (CEC). 2017. *2016 Appliance Efficiency Regulations*. CEC-400-2017-002. Section 1605.3(f).

California Energy Commission (CEC). 2015. *2016 Building Energy Efficiency Standards for Residential and Nonresidential Buildings*. CEC-400-2015-037-CMF. Section 110.3.

Code of Federal Regulations at 10 CFR 430.32(d).

⁵ South Coast Air Quality Management District (AQMD). 2004. Rule 1121 - Control of Nitrogen Oxides from Residential-Type, Natural Gas-Fired Water Heaters. Amended September 3, 2004.

South Coast Air Quality Management District (AQMD). 2006. Rule 1146.2 - Emissions of Oxides of Nitrogen from Large Water Heaters and Small Boilers and Process Heaters. Amended May 5, 2006.

Bay Area Air Quality Management District (BAAQMD). 2007. *Regulation 9 – Inorganic Gaseous Pollutants: Rule 6 – Nitrogen Oxides Emissions from Natural Gas-Fired Boilers and Water Heaters*. November 7.

San Joaquin Valley Air Pollution Control District. 2009. *Rule 4902 - Residential Water Heaters*. Amended March 19, 2009.

Sacramento Metropolitan Air Quality Management District. 2010. *Rule 414, Water Heaters, Boilers and Process Heaters Rated Less Than 1,000,000 BTU Per Hour*. Amended March 25, 2010.

Yolo-Solano Air Quality Management District. 2009. *Rule 2.38 - Natural Gas-Fired Water Heaters and Small Boilers*. Revised April 8, 2009.

Ventura County Air Pollution Control District. 2010. *Rule 74.11 - Natural Gas-Fired Water Heaters*. Revised January 12, 2010.

| Code | Applicable Code Reference | Effective Date |
|---|---------------------------|------------------|
| Sacramento Metropolitan AQMD | Rule 414 | March 25, 2010. |
| Yolo-Solano AQMD | Regulation II, Rule 2.37 | April 8, 2009. |
| Ventura County Air Pollution Control District | Rule 74.11 | January 12, 2010 |

California Appliance Efficiency Regulations (Title 20) and Code of Federal Regulations

| Equipment Type | Rated Input (kBtu/hr) | Rated Volume (gal) | Efficiency Units | Minimum Efficiency | Maximum Standby Loss (Btu/hr) |
|---|-----------------------|--------------------|------------------|--------------------|-------------------------------|
| Instantaneous Water Heaters <i>V is the rated volume in gallons; Q is the rated input in Btu/hr.</i> | | | | | |
| Small federally-regulated (Medium & High Draw Pattern) | > 50 & ≤ 200 | < 2 | UEF | 0.81 | --- |
| Small non-federal regulated | ≤ 50 | Unspecified | UEF | 0.62-(0.0019xV) | --- |
| Small non-federal regulated | ≤ 200 | ≥ 2 | UEF | 0.62-(0.0019xV) | --- |
| Large | > 200 | < 10 | TE | 0.80 | n/a |
| Large | > 200 | ≥ 10 | TE | 0.80 | $Q/800 + 110\sqrt{V}$ |

In December 2016 the U.S. Department of Energy (DOE) issued a Final Ruling in Docket No. EERE-2015-BT-TP-0007 that established a new efficiency rating for some commercial water heating technologies.⁶ All water heaters within the scope of the ruling will no longer be rated with the energy Factor (EF), thermal efficiency (TE), or standby loss ratings; the Uniform Energy Factor (UEF) is the new metric for the energy efficiency of water heaters. A UEF rating is determined by assigning a water heater into one of four different categories of hot water usage and then evaluating its performance based on that usage.⁷ The four categories are based on *draw pattern* – *very small, low, medium, and high*. This allows water heaters to be compared more easily between different types (i.e., storage and tankless), as long as units are compared within the same bin.

With this final ruling, the DOE established a mathematical conversion between the values determined using the ER, TE, and SL test procedures and the values determined using the uniform efficiency descriptor test procedure. The DOE used the conversion factors to derive minimum energy performance standards based on UEF. The standards denominated in UEF are neither more nor less stringent than the EF-denominated standards for consumer water heaters and for commercial water-heating equipment based on the TE and SL metrics.

⁶ U.S. Department of Energy (DOE). 2016. "Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters." *Federal Register: The Daily Journal of the United States*. 81 Fed. Reg. 250. December 29, 2016.

⁷ A.O. Smith. (n.d.) "What Does UEF Mean To You?"

The following table from the Final Ruling provides the conversion equations from EF to UEF.

Table II.1 – Consumer Water Heater Energy Conservation Standards Denominated in UEF

| Product class | Rated storage volume and input rating (if applicable) | Draw pattern | Uniform energy factor | |
|-------------------------------------|---|----------------------------|-------------------------------------|-------------------------------------|
| Gas-fired Storage Water Heater | ≥20 gal and ≤55 gal | Very Small | 0.3456 – (0.0020 x V _r) | |
| | | Low | 0.5982 – (0.0019 x V _r) | |
| | | Medium | 0.6483 – (0.0017 x V _r) | |
| | | High | 0.6920 – (0.0013 x V _r) | |
| | >55 gal and ≤100 gal | Very Small | 0.6470 – (0.0006 x V _r) | |
| | | Low | 0.7689 – (0.0005 x V _r) | |
| | | Medium | 0.7897 – (0.0004 x V _r) | |
| | | High | 0.8072 – (0.0003 x V _r) | |
| | Oil-fired Storage Water Heater | ≤50 gal | Very Small | 0.2509 – (0.0012 x V _r) |
| | | | Low | 0.5330 – (0.0016 x V _r) |
| | | | Medium | 0.6078 – (0.0016 x V _r) |
| | Electric Storage Water Heaters | ≥20 gal and ≤55 gal | Very Small | 0.8808 – (0.0008 x V _r) |
| Low | | | 0.9254 – (0.0003 x V _r) | |
| Medium | | | 0.9307 – (0.0002 x V _r) | |
| High | | | 0.9349 – (0.0001 x V _r) | |
| >55 gal and ≤120 gal | | Very Small | 1.9236 – (0.0011 x V _r) | |
| | | Low | 2.0440 – (0.0011 x V _r) | |
| | | Medium | 2.1171 – (0.0011 x V _r) | |
| | | High | 2.2418 – (0.0011 x V _r) | |
| Tabletop Water Heater | | ≥20 gal and ≤120 gal | Very Small | 0.6323 – (0.0058 x V _r) |
| | | | Low | 0.9188 – (0.0031 x V _r) |
| | | | Medium | 0.9577 – (0.0023 x V _r) |
| | | | High | 0.9884 – (0.0016 x V _r) |

| Product class | Rated storage volume and input rating (if applicable) | Draw pattern | Uniform energy factor |
|---|---|------------------|-------------------------------------|
| Instantaneous Gas-fired Water Heater**. | <2 gal and >50,000 Btu/h | Very Small | 0.80 |
| | | Low | 0.81 |
| | | Medium | 0.81 |
| | | High | 0.81 |
| Instantaneous Electric Water Heater**. | < 2 gal | Very Small | 0.91 |
| | | Low | 0.91 |
| | | Medium | 0.91 |
| | | High | 0.92 |
| Grid-Enabled Water Heater | >75 gal | Very Small | 1.0136 – (0.0028 x V _r) |
| | | Low | 0.9984 – (0.0014 x V _r) |
| | | Medium | 0.9853 – (0.0010 x V _r) |
| | | High | 0.9720 – (0.0007 x V _r) |

* V_r is the "Rated Storage Volume" (in gallons), as determined by 10 CFR 429.17.

** For instantaneous water heaters the standard is represented as a single value rather than as a function of storage volume. Because the UEF standard only applies to models with less than 2 gallons of storage volume, the coefficient becomes zero, and the standard does not vary for models between 0 and 2 gallons.

The final ruling also includes tables that define each of the draw patterns categories, as follows:

Section 429.17 (B) Determine the applicable draw pattern as follows:

(1) For consumer gas-fired water heaters, consumer oil-fired water heaters, consumer electric water heaters, tabletop water heaters, grid enabled water heaters, residential-duty commercial gas water heaters, residential-duty commercial oil filed water heaters: Use the New FHR [First Hour Rating] ... to select the applicable draw pattern from the table in this paragraph:

Storage Water Heater Draw Patterns

| New FHR greater than or equal to: | and new FHR less than: | Draw pattern |
|-----------------------------------|------------------------|---|
| 0 gallons | 18 gallons | Very Small. Low. Medium. High. |
| 18 gallons | 51 gallons | |
| 51 gallons | 75 gallons | |
| 75 gallons | No upper limit | |

(2) For instantaneous gas-fired water heaters, instantaneous electric water heaters, and residential-duty commercial electric instantaneous water heaters: Use New Max GPM ... to select the applicable draw pattern from the table in this paragraph:

Instantaneous Water Heater Draw Patterns

| New max GPM greater than or equal to: | And new max GPM rating less than: | Draw pattern |
|---------------------------------------|-----------------------------------|---|
| 0 gallons/minute | 1.7 gallons/minute | Very Small. Low. Medium. High. |
| 1.7 gallons/minute | 2.8 gallons/minute | |
| 2.8 gallons/minute | 4 gallons/minute | |
| 4 gallons/minute | No upper limit | |

NORMALIZING UNIT

kBtu per hour of rated input capacity (Cap-kBtu/hr).

PROGRAM REQUIREMENTS

Measure Implementation Eligibility

All combinations of measure application type, delivery type, and sector that are established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial incentives or other services) is targeted. This table also designates the broad market sector(s) that are applicable for this measure.

Note that some of the implementation combinations below may not be allowed for some measure offerings by all program administrators.

Implementation Eligibility

| Measure Application Type | Delivery Type | Sector |
|--------------------------|---------------|--------|
| Normal replacement | DnDeemDI | Com |
| Normal replacement | DnDeemed | Com |
| Normal replacement | UpDeemed | Com |
| New Construction | DnDeemDI | Com |
| New Construction | DnDeemed | Com |
| New Construction | UpDeemed | Com |

Eligible Products

Boilers must meet the following eligibility requirements:

- Meet minimum qualifying efficiency ratings in the Measure Case Description and must comply with emission limits per air district, if applicable. Note that Tier 2 hot water heaters are condensing and often require flue modifications to handle the condensate.
- Only gas-for-gas normal replacement installations are eligible.
- Meet the definition of a tankless water heater, as defined by the California Energy Commission:
 - Be used primarily for domestic hot water
 - Provide hot water only when there is a hot water draw from the end use.
 - Have an input rating of at least 4,000 Btu per hour per gallon of stored water.

Eligible Building Types

This measure is applicable to any domestic hot water application in any existing commercial building of any vintage.

Eligible Climate Zones

The measure is applicable in all California climate zones.

PROGRAM EXCLUSIONS

This measure does not include water heaters or hot water boilers used for space conditioning, industrial (process) end-use applications, pools, or spas.

This measure cannot be used to supply hot water to a circulation loop without an intermediary hot water storage tank.

DATA COLLECTION REQUIREMENTS

Data collection requirements are to be determined.

USE CATEGORY

Service & domestic hot water

ELECTRIC SAVINGS (kWh)

Not applicable.

PEAK ELECTRIC DEMAND REDUCTION (kW)

Not applicable.

GAS SAVINGS (THERMS)

The unit energy savings (UES) of smaller high efficiency commercial boilers rated in energy factor (EF) or uniform energy factor (UEF) were modeled using the Database for Energy Efficient Resources (DEER) methodologies. Specifically, the UES were derived using the DEER water heater calculator tool,⁸ a macro-enabled Excel workbook developed by consultants of the California Public Utilities Commission (CPUC) Energy Division to standardize the inputs and savings calculations for water heating measures. Version 3.3 of the calculator utilizes hourly output from the DEER2015 DOE2 building prototypes for hot water loads and ambient conditions along with new technology definitions to estimate the hourly energy use of gas, electric, and heat pump water heaters. This tool was updated from a previous version (version 3.2) developed to accommodate the modeling requirements of heat pump water heaters and to provide a relatively easy method to add new measures and technologies based on program requirements.”⁹ Further, the "simulation tool ... uses the technology definitions to determine the hot water energy use for each climate zone, building type and building vintage that are part of the standard DEER applicability parameters. Measure savings are determined by comparing the energy use associated with the technologies defined in the measure definition.”¹⁰

For larger boilers and heaters rated in thermal efficiency (TE) or combustion efficiency (CE), UES were calculated directly in the calculation engines within DEER. The version used to calculate savings for these measures is DEER 2015. Results were reported in the Remote Ex-Ante Database Interface (READI) tool.

The table below provides the base case and measure case efficiencies for commercial boilers water heaters in DEER 2015. Note that DEER 2015 does not include large (> 200 kBtu/hr) high-efficiency commercial domestic hot water boilers that replace less efficient commercial domestic hot water boilers. Therefore, the instantaneous water heater cases in the DEER 2015 database were adapted for this purpose. Additional points regarding the efficiency ratings in DEER:

- The smallest instantaneous water heater category (≤ 75 kBtu/hr) in DEER 2015 has been dropped, since units with rated input ≤ 75 kBtu/hr are rarely used in commercial applications.
- The small instantaneous water heater (76 to 200 kBtu/hr) qualifying energy factors (EFs) from DEER 2015 are used.
- The large (> 200 kBtu/hr) instantaneous water heater qualifying thermal efficiencies from DEER 2015 are used for large commercial boilers, except that the three DEER tiers for instantaneous water heater thermal efficiencies have been reduced to two tiers for large commercial boilers.

⁸ California Public Utilities Commission (CPUC), Energy Division. 2017. DEER2015 Small Storage and Small Instantaneous Water Heater Energy Use Calculator. "DEER-WaterHeater-Calculator-v3.3.xlsm." Updated August 30, 2018.

⁹ California Public Utilities Commission (CPUC), Energy Division. 2014. "DEER2015 Service and Domestic Water Heater Measures Update." October 1. Page 3.

¹⁰ California Public Utilities Commission (CPUC), Energy Division. 2014. "DEER2015 Service and Domestic Water Heater Measures Update." October 1. Page 10.

Base Case and Measure Case Instantaneous Water Heater Efficiencies in DEER 2015

| Boiler Size | Rated Input (kBtu/hr) | Efficiency Units | Baseline Efficiency | Measure Case Efficiency |
|--------------------|-----------------------|------------------|---------------------|-------------------------|
| Small, < 2 gallons | ≤ 75 | EF | 60% | ≥ 82% |
| Small | 150 (76-200) | TE | 0.82 | 0.84, 0.92 |
| Large | > 200 | TE | 0.80 | 0.80, 0.86, 0.90 |
| | | Standby Loss | 0.56% per hour | n/a |

Boiler Efficiencies. Water heating products certified in the California Energy Commission (CEC) Modernized Appliance Efficiency Database System (MAEDS) include instantaneous, storage, non-condensing, and condensing water heaters. The ratio of rated input to rated storage volume was used to sort the data for hot water boilers. Water heating products with a ratio less than 4,000 Btu/hr/gallon (“storage water heaters”) were removed from the database. The table provides shows the range of water heater efficiencies in the CEC database of water heating products with a rated input to storage volume ratio greater than 4,000 Btu/hr/gallon.¹¹ Non-condensing and condensing water heaters were included, although a water heater with an EF > than 0.88 or a thermal efficiency (TE) > 88%, respectively, is most likely a condensing water heater.

Instantaneous Water Heater Efficiency Ranges

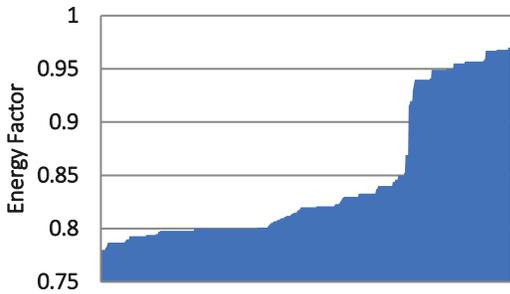
| Boiler Size | Rated Input (kBtu/hr) | Minimum Efficiency | Maximum Efficiency |
|-------------|-----------------------|--------------------|--------------------|
| Small | 50 – 199 | 0.780 EF | 0.985 EF |
| Large | 200 – 2,400 | 75.4% TE | 99.0% TE |

The figure illustrates the distribution of EF ratings of small instantaneous water heaters (rated input of 75 to 200 kBtu/hr) and TE ratings of large instantaneous water heaters (rated input > 200 kBtu/hr) in the CEC MAEDS database. Note that the MAEDS does not consider emission compliance, thus the number of water heaters available is significantly reduced for populations in the counties subject to ultra-low NOx requirements.

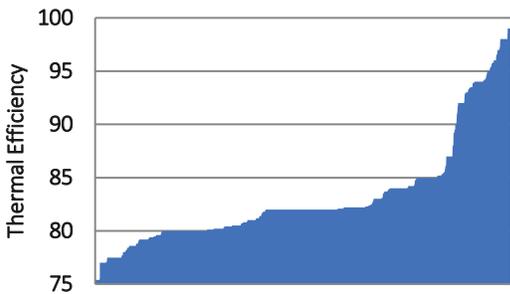
¹¹ Pacific Gas and Electric (PG&E). 2007. “Large Gas Oil Boilers Certified to the Energy Commission as of August 17, 2007.”

Distribution of Efficiency Ratings of Hot Water Boilers

Small Commercial Hot Water Boilers



Large Commercial Hot Water Boilers



Standard Efficiencies. The efficiency ratings for base case and measure case commercial hot water boilers are specified below. Note that large, Tier 1 measure efficiency is calculated at 85% TE, but measure offering (qualifying efficiency or QE) is listed as starting at 84% TE. Small, Tier 2 measure efficiency is calculated at 0.92 EF (0.89 UEF), but measure offering (qualifying efficiency or QE) is listed as starting at 0.90 EF (0.87 UEF).

Baseline and Measure Case Efficiencies for High Efficiency Commercial Hot Water Boilers

| Boiler Efficiency Tier | Boiler Size | Rated Input (kBtu/hr) | Min. Baseline Efficiency | Measure Case Efficiency |
|-------------------------|-------------|-----------------------|--------------------------|-------------------------|
| Non-condensing – Tier 1 | Small/Med | ≤ 200 | 0.80 UEF | 0.82 UEF |
| | Large | > 200 | 80% TE | 84% TE |
| Condensing – Tier 2 | Small/Med | ≤ 200 | 0.80 UEF | 0.87 UEF |
| | Large | > 200 | 80% TE | 90% TE |

Gas Unit Energy Savings Calculation

The UES calculated for DEER 2015 were used as the basis for the derivation of savings for this measure. However, the normalized units for a small instantaneous water heater that replaces a small instantaneous water heater were changed from “each” to “Cap-kBTU/hr” by dividing by the input rating of 150 kBtu/hr.¹²

For calculating UES, the following assumptions were adopted:

- The average efficiency rating for the base case commercial hot water boiler is 0.82 EF (0.80 UEF) for small hot water boilers and 80% TE for a large hot water boiler. This aligns with the California Title 20 efficiency standards for instantaneous water heaters.
- The average efficiency rating for commercial hot water boiler measure case units are the Tier 1 and Tier 2 qualifying efficiencies for commercial hot water boilers.

The energy savings calculated for DEER 2015 are across all “Com” building types to produce a single value for each climate zone for the smaller boilers rated in EF.

LIFE CYCLE

Effective Useful Life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. EUL is often, but not always, derived from measure persistence or retention studies. Remaining Useful Life (RUL) is an estimate of the median number of years that a technology or piece of equipment replaced or altered by an energy efficiency program would have remained in service and operational had the program intervention not caused the replacement or alteration.

The EUL specified for this measure is specified below. Note that RUL is only applicable for add-on equipment and accelerated replacement measures and is not applicable for this measure.

Effective Useful Life and Remaining Useful Life

| Parameter | Value | Source |
|-----------|-------|--|
| EUL (yrs) | 20.0 | California Public Utilities Commission (CPUC), Energy Division. 2003. <i>Energy Efficiency Policy Manual v 2.0</i> . Page 18 Table 4.1. California Public Utilities Commission (CPUC). 2014. “DEER2014-EUL-table-update_2014-02-05.xlsx.” |
| RUL (yrs) | n/a | n/a |

¹² California Public Utilities Commission (CPUC), Energy Division. 2016. *Disposition for Workpapers Covering Natural Gas Water Heaters*. Issued April 8, 2016.

BASE CASE MATERIAL COST (\$/UNIT)

When the customer replaces equipment on burnout (normal replacement) or buys new equipment, the customer must buy a new water heater to continue operating, therefore the base case material cost is equal to the cost of a base case (standard) boiler/tankless water heater.

The base case material cost was derived from two U.S. Department of Energy (DOE) Technical Support Documents (TSDs): Pool Heaters, Direct Heating Equipment and Water Heaters (EERE-2006-STD-0129)¹³ and Commercial Water Heating Equipment (EERE-2014-BT-STD-0042).¹⁴

- TSD “Pool Heaters, Direct Heating Equipment and Water Heaters (EERE-2006-STD-0129)” reports total installed cost (IP) for small tankless water heaters as the sum of consumer product price (CPP) and cost to the consumer to install products (INST) (IP = CPP + INST). The small tankless water heaters are reported in those cost details.
- TSD “Commercial Water Heating Equipment (EERE-2014-BT-STD-0042)” reports the total installed cost for large tankless water heaters as the sum of equipment retail price and the installation cost but does not present the exact equipment retail and installation cost values used in the summation. The large tankless water heaters are reported as one single cost value.

An online vendor cost survey and the 2010-2012 Ex Ante Measure Cost Study conducted by Itron, Inc. were considered as resources to develop the cost data. The vendor cost survey provided a reference point for product cost but did not provide sufficient data to represent installation costs due to the various installation set-ups. The Itron Measure Cost Study did not appear to take ultra-low NOx production cost into consideration for gas tankless water heaters. Air quality regulations were only mentioned in the study in reference to boiler projects.

MEASURE CASE MATERIAL COST (\$/UNIT)

The measure case material cost was derived from two U.S. Department of Energy (DOE) Technical Support Documents (TSDs): Pool Heaters, Direct Heating Equipment and Water Heaters (EERE-2006-STD-0129)¹⁵ and Commercial Water Heating Equipment (EERE-2014-BT-STD-0042).¹⁶

- TSD “Pool Heaters, Direct Heating Equipment and Water Heaters (EERE-2006-STD-0129)” reports total installed cost (IP) for small tankless water heaters as the sum of consumer product price

¹³ U.S. Department of Energy (DOE). 2009. *Technical Support Document: Energy Conservation Program for Consumer Products: Energy Conservation standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters*. Prepared by Navigant Consulting, Inc. and Lawrence Berkeley National Laboratory. Docket ID: EERE-2006-STD-129.

¹⁴ U.S. Department of Energy (DOE). 2016. *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Water Heating Equipment*. Prepared by Navigant Consulting, Inc. and Pacific Northwest National Laboratory. Docket ID: EERE-2014-BT-STD-0042.

¹⁵ U.S. Department of Energy (DOE). 2009. *Technical Support Document: Energy Conservation Program for Consumer Products: Energy Conservation standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters*. Prepared by Navigant Consulting, Inc. and Lawrence Berkeley National Laboratory. Docket ID: EERE-2006-STD-129.

¹⁶ U.S. Department of Energy (DOE). 2016. *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Water Heating Equipment*. Prepared by Navigant Consulting, Inc. and Pacific Northwest National Laboratory. Docket ID: EERE-2014-BT-STD-0042.

(CPP) and cost to the consumer to install products (INST) ($IP = CPP + INST$). The small tankless water heaters are reported in those cost details.

- TSD “Commercial Water Heating Equipment (EERE-2014-BT-STD-0042)” reports the total installed cost for large tankless water heaters as the sum of equipment retail price and the installation cost but does not present the exact equipment retail and installation cost values used in the summation. The large tankless water heaters are reported as one single cost value.

Venting material used with non-condensing water heaters are not suitable for condensing due to material properties. Plastics used for condensing water heaters have lower vent temperature limits and are not suitable for non-condensing water heaters. Condensing tankless water heaters are able to use PVC for venting which cost less than traditional venting for non-condensing tankless water heaters. This cost difference can lead to lower overall cost for the Tier 2 small tankless water heater in some cases. Data taken from the TSD “Pool Heaters, Direct Heating Equipment and Water Heaters” (EERE-2006-STD-0129) presents this case. The cost differences in these set-ups are taken into consideration in the cost analysis.

An online vendor cost survey and the 2010-2012 Ex Ante Measure Cost Study conducted by Itron, Inc. were considered as resources to develop the cost data. The vendor cost survey provided a reference point for product cost but did not provide sufficient data for installation cost due to the various installation set-ups. The Itron Measure Cost Study did not appear to take ultra-low NO_x production cost into consideration for gas tankless water heaters. Air quality regulations were only mentioned in the study in reference to boiler projects.

BASE CASE LABOR COST (\$/UNIT)

Labor costs were derived using the same methodology to develop base case material costs.

MEASURE CASE LABOR COST (\$/UNIT)

Labor costs were derived using the same methodology to develop measure case material costs.

NET-TO-GROSS (NTG)

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention. This NTG value is based upon the average of all NTG ratios for all evaluated 2006 – 2008 commercial programs, as documented in the 2011 DEER Update Study conducted by Itron, Inc. This sector average NTG (“default NTG”) is applicable to all energy efficiency measures that have been offered through commercial sector programs for more than two years and for which impact evaluation results are not available.

Net-to-Gross Ratios

| Parameter | Value | Source |
|------------------|-------|---|
| NTG - commercial | 0.60 | Itron, Inc. 2011. <i>DEER Database 2011 Update Documentation</i> . Prepared for the California Public Utilities Commission. Page 15-4 Table 15-3. |

GROSS SAVINGS INSTALLATION ADJUSTMENT (GSIA)

The gross savings installation adjustment (GSIA) rate represents the ratio of the number of verified installations of the measure to the number of claimed installations reported by the utility. This factor varies by end use, sector, technology, application, and delivery method. This GSIA rate is the current “default” rate specified for measures for which an alternative GSIA has not been estimated and approved.

Gross Savings Installation Adjustment Rates

| Parameter | Value | Source |
|-----------|-------|---|
| GSIA | 1.0 | California Public Utilities Commission (CPUC), Energy Division. 2013. <i>Energy Efficiency Policy Manual Version 5</i> . Page 31. |

NON-ENERGY IMPACTS

Non-energy impacts for this measure have not been quantified.

DEER DIFFERENCES ANALYSIS

This section provides a summary of DEER-based inputs and methods, and the rationale for inputs and methods that are not DEER-based.

DEER Difference Summary

| DEER Item | Comment / Used for Workpaper |
|---|--|
| Modified DEER methodology | Yes |
| Scaled DEER measure | No |
| DEER Base Case | Yes |
| DEER Measure Case | |
| DEER Building Types | |
| DEER Operating Hours | |
| DEER eQUEST Prototypes | |
| DEER Version | DEER 2015 |
| Reason for Deviation from DEER | Changed normalized units for small instantaneous water heater from “each” to “per cap-KBtu/hr” Modified DEER three tiers to two tiers for large instantaneous water heaters DEER does not contain cost data for these measures |
| DEER Run and Measure IDs Used (original EF IDs used as UEF based IDs are not available) | Instantaneous Water Heater, ≤ 200 kBtu/hr (Small / Medium), Tier 1 (≥0.84 EF) - NG-WtrHt-SmInst-Gas-150kBtuh-lt2G-Op84EF-82EF Instantaneous Water Heater, ≤ 200 kBtu/hr (Small / Medium), Tier 2 (≥0.90 EF) - NG-WtrHt-SmInst-Gas-150kBtuh-lt2G-Op92EF-82EF Instantaneous Water Heater, > 200 kBtu/hr (Large), Tier 1 (≥ 84% TE) - NG-WtrHt-LrgInst-Gas-gt200kBtuh-Op85Et Instantaneous Water Heater, > 200 kBtu/hr (Large), Tier 2 (≥ 90% TE) - NG-WtrHt-LrgInst-Gas-gt200kBtuh-Op90Et |
| NTG | Source: DEER. NTG of 0.60 is associate with NTG ID: <i>Com-Default>2yrs</i> |
| GSIA | GSIA ID: <i>Def-GSIA</i> |

| DEER Item | Comment / Used for Workpaper |
|-----------|---|
| EUL/RUL | The EUL of 20 years is associated with EUL ID: <i>WtrHt-Instant-Com</i> |

REVISION HISTORY

Measure Characterization Revision History

| Revision Number | Date | Primary Author, Title, Organization | Revision Summary and Rationale for Revision Effective Date and Approved By |
|-----------------|------------|--|--|
| 01 | 03/08/2018 | Jennifer Holmes, Cal TF Staff | The draft of the text fields for this statewide measure is based upon: Workpaper WPSSCGNRWH120206C Revision 6 (July 26, 2016) Consensus reached among Cal TF members |
| | 08/20/2018 | Rebecca Jenkins, SCG Chan Paek, SCG | Replace the qualifying efficiency of small (<200 kBtuh) instantaneous water heaters from EF to UEF. |
| | 02/27/2019 | Jennifer Holmes, Cal TF Staff | Revisions for submittal of version 01. |