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**WATER HEATING**  
**STORAGE WATER HEATER, COMMERCIAL**  
SWWH007-01

**C O N T E N T S**

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### Measure Name

Storage Water Heater, Commercial

### Statewide Measure ID

SWWH007-01

### Technology Summary

Commercial and industrial storage water heaters are used to produce hot water for a variety of applications. These units can be utilized for domestic purposes or could be used as process hot water. Storage water heaters heat and store water within the appliance at a thermostatically controlled temperature for delivery on-demand. Cold water supplied into the storage water heater via the supply line will be stored under pressure and heated by a natural gas burner placed at the bottom of the water heater. The natural gas burner will turn ON until the desired setpoint temperature inside the tank is reached. The high-temperature water is then supplied on-demand directly, or through a recirculation loop, depending on the application.

High efficiency units are characterized by a high energy factor (EF), thermal efficiency (TE), or uniform energy factor (UEF) rating. These ratings account for the amount of heat that is inputted into the system and the amount of heat that is successfully transferred into the water. Several factors determine the energy efficiency of a water heater, such as high-quality insulation and better heat transfer materials within the water heater.

Relative to a standard model, an energy efficient unit will typically have features such as larger heat exchange surfaces and/or additional tank insulation. The most efficient natural gas storage water heater is a *condensing* water heater. A condensing unit has more heat exchange surface between the hot exhaust gasses and the water being heated. This allows the water to absorb more of the exhaust gas heat, which in turn reduces the temperature of the exhaust gasses and condenses the exhaust by-products.

### Measure Case Description

The measure case is defined as the replacement of a standard efficiency gas storage water heater with an energy efficient gas storage water heater. The minimum qualifying efficiency ratings of each measure offering equipment size are shown below. Energy is calculated by climate zone for each measure offering.

### Measure Case Specification

Equipment Type	Measure Case Description
Large Storage Water heater with input rating > 75 kBtu/hr	TE > 83% UEF ≥ .48 for Medium Draw Unit UEF ≥ .56 for High Draw Units
	TE > 90% UEF ≥ .76 for Medium Draw Unit UEF ≥ .80 for High Draw Unit

Equipment Type	Measure Case Description
Small Storage Water heater with input rating ≤ 75 kBtu/hr	
30-gallon Medium Draw water heater	UEF ≥ 0.64 UES converted into Cap-kBtu/h
40-gallon Medium Draw water heater	
50-gallon Medium Draw water heater	
30-gallon High Draw water heater	UEF ≥ 0.68; UES converted into Cap-kBtu/h
40-gallon High Draw water heater	
50-gallon High Draw water heater	

### Base Case Description

The base case technology is defined as a gas storage water heater that meets the efficiency ratings specified below. The measure offerings are offered for normal replacement installations. Therefore, the baseline for each measure is defined by either Code or standard practice. In this case, all measure offerings were evaluated against the code defined by the California Appliance Efficiency Regulations (Title 20, see Code Requirements). The table below provides the base case description for each measure offering.

### Base Case Specification

Equipment Type	Base Case Description
Large Storage Water heater with input rating > 75 kBtu/hr	TE = 0.80 Standby Loss = 0.56%/hr
Small Storage Water heater with input rating ≤ 75 kBtu/hr	
30-gallon Medium Draw water heater	UEF ≥ 0.60
40-gallon Medium Draw water heater	UEF ≥ 0.58
50-gallon Medium Draw water heater	UEF ≥ 0.56
30-gallon High Draw water heater	UEF ≥ 0.65
40-gallon High Draw water heater	UEF ≥ 0.64
50-gallon High Draw water heater	UEF ≥ 0.63

### Code Requirements

Applicable state and federal codes and standards for commercial storage water heaters are noted in the

tables below.<sup>1</sup> The standards for Federally Regulated Water Heaters were updated in late 2016, which are directly matched in the California Appliance Efficiency Regulations (Title 20).

#### Applicable State and Federal Codes and Standards for Commercial Water Heaters

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20 (2018)	1605.1 (f)1605.3(f) Match standards for Federally Regulated Water Heaters	December 29, 2016
CA Building Energy Efficiency Standards – Title 24 (2016)	110.3	January 1, 2017
Federal Standards – Code of Federal Regulations	10 CFR 430.32(d)	December 29, 2016

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 all residential and some commercial water heating technologies are rated.<sup>2</sup> 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.<sup>3</sup> 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.

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

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<sup>1</sup> California Energy Commission (CEC). 2017. 2016 Appliance Efficiency Regulations. CEC-400-2017-002. Section 1605.3(f).

California Energy Commission. 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).

<sup>2</sup> 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.

<sup>3</sup> A.O. Smith. (n.d.) “What Does UEF Mean To You?”

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 <sub>r</sub> )	
		Low	0.5982 – (0.0019 x V <sub>r</sub> )	
		Medium	0.6483 – (0.0017 x V <sub>r</sub> )	
		High	0.6920 – (0.0013 x V <sub>r</sub> )	
	>55 gal and ≤100 gal	Very Small	0.6470 – (0.0006 x V <sub>r</sub> )	
		Low	0.7689 – (0.0005 x V <sub>r</sub> )	
		Medium	0.7897 – (0.0004 x V <sub>r</sub> )	
		High	0.8072 – (0.0003 x V <sub>r</sub> )	
	Oil-fired Storage Water Heater	≤50 gal	Very Small	0.2509 – (0.0012 x V <sub>r</sub> )
			Low	0.5330 – (0.0016 x V <sub>r</sub> )
			Medium	0.6078 – (0.0016 x V <sub>r</sub> )
			High	0.6815 – (0.0014 x V <sub>r</sub> )
Electric Storage Water Heaters	≥20 gal and ≤55 gal	Very Small	0.8808 – (0.0008 x V <sub>r</sub> )	
		Low	0.9254 – (0.0003 x V <sub>r</sub> )	
		Medium	0.9307 – (0.0002 x V <sub>r</sub> )	
		High	0.9349 – (0.0001 x V <sub>r</sub> )	
	>55 gal and ≤120 gal	Very Small	1.9236 – (0.0011 x V <sub>r</sub> )	
		Low	2.0440 – (0.0011 x V <sub>r</sub> )	
		Medium	2.1171 – (0.0011 x V <sub>r</sub> )	
		High	2.2418 – (0.0011 x V <sub>r</sub> )	
Tabletop Water Heater	≥20 gal and ≤120 gal	Very Small	0.6323 – (0.0058 x V <sub>r</sub> )	
		Low	0.9188 – (0.0031 x V <sub>r</sub> )	
		Medium	0.9577 – (0.0023 x V <sub>r</sub> )	
		High	0.9884 – (0.0016 x V <sub>r</sub> )	

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 <sub>r</sub> )
		Low	0.9984 – (0.0014 x V <sub>r</sub> )
		Medium	0.9853 – (0.0010 x V <sub>r</sub> )
		High	0.9720 – (0.0007 x V <sub>r</sub> )

\*V<sub>r</sub> 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.
18 gallons	51 gallons	Low.
51 gallons	75 gallons	Medium.
75 gallons	No upper limit	High.

*(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:*

In addition to the aforementioned federal standards, commercial storage and tankless water heaters are covered by ENERGY STAR.<sup>4</sup> *Note however that the measure case specification does not include a tier for ENERGY STAR-qualified equipment.*

**ENERGY STAR Commercial Water Heaters – Product Type Requirements**

Product Type	ENERGY STAR Requirement
Gas Storage	> 75,000 Btu/hr input
	≤ 140 gallons storage capacity
Gas Tankless	≥ 4,000 Btu/hr per gallon of stored water

**ENERGY STAR Commercial Water Heaters – Minimum Efficiency Requirements**

Product Type	Criteria	ENERGY STAR Requirement
Storage	Thermal Efficiency (TE) or Energy Factor (EF)	TE ≥ 0.94 or EF ≥ 0.93
Instantaneous		
Storage	Maximum Standby Loss	≤ 0.84 * [(Input Rate / 800) + 110(Volume) <sup>1/2</sup> ] (Btu/hr)
Instantaneous		n/a
Storage	Minimum Manufacturer Limited Warranty	3 years on tank and/or heat exchanger
Instantaneous		1 year on parts

**Normalizing Unit**

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

**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	DnDeemed	Com
Normal replacement	UpDeemed	Com

<sup>4</sup> ENERGY STAR. 2018. "ENERGY STAR Program Requirements for Commercial Water Heaters. Eligibility Criteria Version 2.0." Effective on October 1, 2018.

*Eligible Products*

Eligible commercial storage water heaters must meet the following requirements:

- Meet minimum qualifying efficiency ratings in the Measure Case Description.
- For *normal replacement installations*, only gas-for-gas replacements are eligible.
- Meet the definition of a storage water heater, as defined by the California Energy Commission:
  - Be used primarily for domestic hot water.
  - Have an input rating of less than 4,000 Btu per hour per gallon of stored water.

*Eligible Building Types*

This measure is applicable for any commercial domestic (or “service”) hot water application in a nonresidential facility of any existing building type or vintage.

*Eligible Climate Zones*

The measure is applicable in all California climate zones.

**Program Exclusions**

Water heaters or hot water boilers used for space conditioning, industrial (process) end-use applications, pools, or spas are not eligible.

**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) for this measure were estimated using the Database of Energy Efficient Resources (DEER) water heater calculator tool, 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. The DEER water heater calculator utilizes hourly output from the DOE2 building prototypes for hot water loads and ambient conditions to estimate hourly gas consumption. Version v3.3 was used for the gas energy savings analysis for this measure.<sup>5</sup>

Note, that the baseline energy factor (EF) values in DEER have been converted to uniform energy factor (UEF) to conform to the 2018 federal standards (see Code Requirements).<sup>6</sup>

The following table indicates the measures taken directly from or created with the DEER Remote Ex-Ante Database Interface (READI) tool.

**DEER Measure Codes**

Measure Code	Measure Name	READI Data
NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-30G-MD-0p64UEF	Medium Draw 30 Gallon Gas Storage Water Heater with >.64 UEF	DEER-WaterHeater-Calculator-v3.3
NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-40G-MD-0p64UEF	Medium Draw 40 Gallon Gas Storage Water Heater with >.64 UEF	DEER-WaterHeater-Calculator-v3.3
NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-50G-MD-0p64UEF	Medium Draw 50 Gallon Gas Storage Water Heater with >.64 UEF	DEER-WaterHeater-Calculator-v3.3
NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-30G-HD-0p68UEF	High Draw 30 Gallon Gas Storage Water Heater with >.68 UEF	DEER-WaterHeater-Calculator-v3.3
NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-40G-HD-0p68UEF	High Draw 40 Gallon Gas Storage Water Heater with >.68 UEF	DEER-WaterHeater-Calculator-v3.3
NG-WtrHt-SmlStrg-Gas-Ite75kBtuh-50G-HD-0p68UEF	High Draw 50 Gallon Gas Storage Water Heater with >.68 UEF	DEER-WaterHeater-Calculator-v3.3
NG-WtrHt-LrgStrg-Gas-gte75kBtuh-0p83Et	Large Gas Storage Water Heater, Et = 0.83, Stdbby Loss = 0.56%/hr	DEER 2014
NG-WtrHt-LrgStrg-Gas-gte75kBtuh-0p90Et	Large Gas Storage Water Heater, Et = 0.90, Stdbby Loss = 0.56%/hr	DEER 2014

**Annual Unit Energy Consumption**

The water heater calculator was used to estimate the baseline and measure case unit energy consumption (UEC); the UES was calculated as the difference.

The annual UEC is estimated with the expression below.

$$WH_{annual\ Therm} = \left[ \sum_{hour=1}^{8760} \left( \frac{(HW_{load} + UA_{load} - Aux_{load} + Btu_{Aux})}{RE * 100,000} \right)_{hour} \right]$$

<sup>5</sup> California Public Utilities Commission (CPUC), Energy Division. 2018. "DEER-WaterHeater-Calculator-v3.3.xlsm." Updated August 2018.

<sup>6</sup> California Public Utilities Commission (CPUC), Energy Division. 2018. "2018 Residential Water Heaters." March 1.

For each hour:

$$HW_{load} = Volume \times (T_{tank} - T_{main}) \times \frac{Btu}{Gal \times F}$$

$$UA_{load} = Tank_{UA} \times (T_{tank} - T_{ambient})$$

$$Tank_{UA} = \left( \frac{\frac{RE}{UEF} - 1}{\left( \frac{24}{\frac{41092}{UEF \times RE \times 1000}} - 1 \right)} \right) \div (67.5)$$

$$Aux_{load} = -(Btuh_{Aux} * Eff_{Aux})$$

$$Btuh_{Aux} = (pilot\ light \left( \frac{Btu}{hr} \right) \times 1hr \times \frac{1\ Therm}{100,000\ Btu})$$

*WH<sub>load annual</sub> = annual water heater energy consumption*

*HW<sub>load</sub> = hourly water heater load due to water use*

*UA<sub>load</sub> = hourly load due to tank shell loss*

*Aux<sub>load</sub> = pilot light heat rate*

*RE = recovery efficiency*

*UEF = uniform energy factor*

### Conversion from Energy Factor to Uniform Energy Factor – Small Commercial Water Heater

DEER presents water heating measures and baselines with efficiency in EF-denominated values. This measure analysis adopted the U.S. Department of Energy (DOE) methodology to convert EF values to UEF (see Code Requirements). It is important to note that while EF values were based on a single draw pattern, the UEF value is based on four different draw patterns.

The conversion of a non-condensing ultra-low NOx storage water heater from EF value to UEF efficiency values is provided below.

$$UEF = 0.0746 + 0.8653 \times UEF_{WHAM}$$

$$UEF_{WHAM} = \left[ \frac{1}{\eta_r} + \left( \frac{1}{EF} - \frac{1}{\eta_r} \right) \left( \frac{aP\eta_r - b}{cP\eta_r - d} \right) \right]^{-1}$$

*η<sub>r</sub> = recovery efficiency*

*EF = energy factor*

*a, b, c, d = constant coefficients dependant on draw pattern*

*P = water heater input rate (Btu/hr)*



The new UEF value is dependent on four distinct draw patterns, hence a water heater will have one out of those four potential UEF values, as opposed to a single possible EF value. The four draw patterns are as followed: very small, low, medium and high. The water heater draw pattern depends on the first hour rating (FHR), FHR is defined as follows for a non-condensing ultra-low NOx water heater.

$$FHR = 25.0680 + 0.6535 \times FHR_p$$

*FHR<sub>p</sub> = prior first hour rating, associated with EF*

The four draw patterns associated with the new FHR are displayed in the table below.

**Table I: First Hour Rating**

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 .....	

The constant coefficients to compute UEF for each distinct draw pattern are in the following table.

**Table II: Constant Coefficient for UEF WHAM**

Draw pattern	a	b	c	d
Very Small .....	0.250266	57.5	0.039864	67.5
Low .....	0.065860	57.5	0.039864	67.5
Medium .....	0.045503	57.5	0.039864	67.5
High .....	0.029794	57.5	0.039864	67.5

*Sample Calculation*

To derive the UEC for each measure and baseline, the baseline must be converted to UEF through the process described above. Consider the DEER measure “RG-WtrHt-SmlStrg-Gas-lte75kBtuh-30G-Op65EF,” a code standard is a 30-gallon unit with an input capacity of 30 kBtuh and EF equal to 0.63. The average FHRP of these units is equal to 52 gallons, the new FHR is estimated as follows:

$$FHR = 25.0680 + 0.6535 \times 52 = 59.05$$

According to Table I, this new FHR value falls under a medium draw pattern. To estimate the UEF<sub>WHAM</sub>, and referencing the constant coefficients specified in Table II for a medium draw pattern yields the following:

$$UEF_{WHAM} = \left[ \frac{1}{0.81} + \left( \frac{1}{0.63} - \frac{1}{0.81} \right) \left( \frac{0.045503 \times 30,000 \times 0.81 - 57.5}{0.039864 \times 30,000 \times 0.81 - 67.5} \right) \right]^{-1} = 0.60796$$

Finally, the UEF for a medium draw is computed as:

$$UEF = 0.0746 + 0.8653 \times 0.60796 = 0.60067$$

The UEC for one hour of the year was calculated, per the water heating schedule used in the “DEER-WaterHeater-Calculator-v3.3”. The hot water load for hour 8, which heats 0.6 gallons of water in climate zone 9 for a single-family dwelling is calculated as follows:

$$HW_{load} = 0.6 * (135 - 44) * 8.2 = 386 \text{ Btu}$$

$$Tank_{UA} = \left( \frac{\frac{0.804}{0.60067} - 1}{\left( \frac{24}{\frac{41092}{0.60067 \times 0.804 \times 1000}} - 1 \right)} \right) \div (67.5) = \frac{9.53 \text{ Btu}}{\text{hr} \times F}$$

$$UA_{load} = 9.53 \times (135 - 44) = 867 \text{ Btu}$$

$$Aux_{load} = -(350 \times .67) = -235 \text{ Btu}$$

$$Btu_{Aux-for 1 hour} = (350) \left( \frac{\text{btu}}{\text{hr}} \right) * 1 \text{ hr} = 350 \text{ Btu}$$

$$WH_{1 \text{ hour load}} = \left[ \sum_{hour=1}^{8760} \left( \frac{(366 \text{ Btu} + 867 \text{ Btu} - 235 \text{ Btu} + 350 \text{ Btu})}{.804 * 100,000} \right)_{hour 8} \right] = 0.01617 \text{ Therm}$$

The above result is for one hour of the year; the process was repeated for all annual hours and summed to yield the annual water heater load. The savings were then computed as the difference between the measure annual sum and the baseline annual sum.

### Conversion from Energy Factor to Uniform Energy Factor – Large Commercial Water Heater

This measure analysis utilized the DEER UES values for large commercial water heaters but adds a UEF annotation for the large sized water heaters with a UEF rating as opposed to thermal efficiency (TE) and standby loss ratings.

To estimate the UEF values,<sup>7</sup> the AHRI Directory of Certified Product Performance was accessed to identify the large commercial water heaters using the water classification adopted for the 2003 California Appliance Efficiency Regulations (Title 20), shown below.

<sup>7</sup> Southern California Gas Company (SCG). 2018. “WPSCGNRWH120206A-Rev10\_Att. A - Calculation Spreadsheet.xlsx.” See “Ahri Database + UEF Calcs” tab.

Table F-2  
Standards for Large Water Heaters Effective October 29, 2003

Appliance	Input to Volume Ratio	Size (Volume)	Minimum Thermal Efficiency (%)	Maximum Standby Loss <sup>1,2</sup>
Gas storage water heaters	< 4,000 Btu/hr/gal	any	80	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Gas instantaneous water heaters	$\geq 4,000$ Btu/hr/gal	< 10 gal	80	—
		$\geq 10$ gal	80	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Gas hot water supply boilers	$\geq 4,000$ Btu/hr/gal	< 10 gal	80	—
		$\geq 10$ gal	80	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Oil storage water heaters	< 4,000 Btu/hr/gal	any	78	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Oil instantaneous water heaters	$\geq 4,000$ Btu/hr/gal	< 10 gal	80	—
		$\geq 10$ gal	78	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Gas hot water supply boilers	$\geq 4,000$ Btu/hr/gal	< 10 gal	80	—
		$\geq 10$ gal	78	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Electric storage water heaters	$\geq 4,000$ Btu/hr/gal	any	—	$0.3 + 27/V_m$ %/hr

<sup>1</sup> Standby loss is based on a 70° F temperature difference between stored water and ambient requirements. In the standby loss equations,  $V_r$  is the rated volume in gallons,  $V_m$  is measured volume in gallons, and  $Q$  is the nameplate input rate in Btu/hr.  
<sup>2</sup> Water heaters and hot water supply boilers having more than 140 gallons of storage capacity are not required to meet the standby loss requirement if the tank surface is thermally insulated to R-12.5, if a standing pilot light is not installed, and for gas- or oil-fired storage water heaters, there is a flue damper or fan-assisted combustion.

The input to volume ratio was used for “Gas Storage Water Heaters” to isolate the water heaters in the AHRI Database to be included in the calculation. The UEF calculation was then applied to all water heaters within the database to estimate the first hour rating (FHR), medium draw UEF, and high draw UEF. The average values for the medium and high draw UEF ratings were computed for both Tier 1 ( $\geq 83\%$  TE) and Tier 2 ( $\geq 90\%$  TE) large storage water heaters. These values are used in parallel with the original requirements for both large tier commercial water heating measures.

**Average Large Tier UEF Values**

	Tier 1 ( $\geq 83\%$ TE)	Tier 2 ( $\geq 90\%$ TE)
Average Medium Draw UEF	0.48	0.63
Average High Draw UEF	0.56	0.72

The table below maps each California climate zone to an IOU service area to identify the appropriate saving value for each California climate zone.

**Climate Zone-IOU Service Area Mapping**

Program Administrator	Climate Zone
SCE	CZ06, CZ08, CZ09, CZ10, CZ13, CZ14, CZ15, CZ16
PG&E	CZ01, CZ02, CZ03, CZ04, CZ05, CZ11, CZ12
SDG&E	CZ07

**Conversion to Cap-kBTUh Savings**

To standardize the normalizing unit to kBtu per hour of rated input capacity (Cap-kBtuh) for all measure offerings, it was necessary to convert the DEER UES values that are based upon “each” to UES values based upon Cap-kBtuh.

All gas UES values based upon “each” provided by the calculator were divided by the appropriate average input rating in the DEER water heater calculator to derive the UES value per Cap-kBtuh input rating.<sup>8</sup>

### 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 and RUL specified for this measure are 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)	15.0	California Public Utilities Commission (CPUC). 2014. “DEER2014-EUL-table-update_2014-02-05.xlsx.”
RUL (yrs)	n/a	n/a

### Base Case Material Cost (\$/unit)

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

The base case material costs for this measure were derived from the 2010-2012 Ex Ante Measure Cost Study conducted by Itron, Inc.<sup>9</sup> A linear regression analysis using the data from the Itron study was conducted to conform costs to UEF ratings.<sup>10</sup> The cost analysis assumes that unit costs will remain consistent with the past units.

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<sup>8</sup> Southern California Gas Company (SCG). 2018. “WPSCGNRWH120206A-Rev10\_Att. A - Calculation Spreadsheet.xlsx.” See “Energy Impact Tables\_Unit Conv” tab

<sup>9</sup> Itron, Inc. 2014. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report*. Prepared for the California Public Utilities Commission.

<sup>10</sup> Southern California Gas Company (SCG). 2018. “WPSCGNRWH120206A-Rev10\_Att. C - Cost Regression.xlsx”

### Measure Case Material Cost (\$/unit)

The measure case material costs for this measure were derived from the 2010-2012 Ex Ante Measure Cost Study conducted by Itron, Inc.<sup>11</sup> A linear regression analysis using the data from the Itron study was conducted to conform costs to UEF ratings.<sup>12</sup> The cost analysis assumes that labor costs will remain consistent with the past units.

### Base Case Labor Cost (\$/unit)

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

### Measure Case Labor Cost (\$/unit)

Labor costs were derived using the same methodology to develop base case and 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. These NTG values are 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.

<sup>11</sup> Itron, Inc. 2014. 2010-2012 WO017 Ex Ante Measure Cost Study Final Report. Prepared for the California Public Utilities Commission.

<sup>12</sup> Southern California Gas Company (SCG). 2018. “WPCSGNRWH120206A-Rev10\_Att. C - Cost Regression.xlsx”

**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 measures for all small storage water heaters were provided by the approved water heater calculator and given in a per-unit savings basis. Savings were converted to a per Cap-kBTU<sub>h</sub> savings basis.

**DEER Difference Summary**

DEER Item	Comment
Modified DEER methodology	Yes
Scaled DEER measure	Yes
DEER Base Case	Yes
DEER Measure Case	Yes
DEER Building Types	Yes
DEER Operating Hours	Yes
DEER eQUEST Prototypes	n/a
DEER Version	DEER 2018
Reason for Deviation from DEER	Changed normalized units for small storage water heater from “each” to “per cap-kBTU <sub>h</sub> ”
DEER Run and Measure IDs Used	NG-WtrHt-SmlStrg-Gas-lte75kBtuh-30G-MD-Op64UEF NG-WtrHt-SmlStrg-Gas-lte75kBtuh-40G-MD-Op64UEF NG-WtrHt-SmlStrg-Gas-lte75kBtuh-50G-MD-Op64UEF NG-WtrHt-SmlStrg-Gas-lte75kBtuh-30G-HD-Op68UEF NG-WtrHt-SmlStrg-Gas-lte75kBtuh-40G-HD-Op68UEF NG-WtrHt-SmlStrg-Gas-lte75kBtuh-50G-HD-Op68UEF NG-WtrHt-LrgStrg-Gas-gte75kBtuh—Op83Et NG-WtrHt-LrgStrg-Gas-gte75kBtuh—Op90Et
NTG	Source: DEER2015. NTG of 0.60 is associate with NTG ID: <i>Com-Default&gt;2yrs</i> ,
GSIA	GSIA ID: <i>Def-GSIA</i>
EUL/RUL	Source: DEER 2015. The EUL of 15 years is associated with EUL ID: <i>WtrHt-Com</i>

## Revision History

## Measure Characterization Revision History

Revision Number	Revision Complete Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision
01	03/14/2018	Jennifer Holmes, Cal TF Staff	The draft of the text fields for this statewide measure is based upon: WPSCGNRWH120206A Revision 9 (July 26, 2016) Consensus reached among Cal TF members
	01/04/2019	Jennifer Holmes, Cal TF Staff	Updated draft based upon: WPSCGNRW120206A, Revision 10 (October 1, 2018)
	2/15/2019	Matthew Mendoza, SoCalGas	Minor Edits to references and text document language
	02/27/2019	Jennifer Holmes, Cal TF Staff	Revisions for submission of version 01.