



WATER HEATING
CENTRAL STORAGE WATER HEATER, MULTIFAMILY
SWWH011-01

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MEASURE NAME

Central Storage Water Heater, Multifamily

STATEWIDE MEASURE ID

SWWH011-11

TECHNOLOGY SUMMARY

A typical gas-fired storage water heater is a large vertical insulated tank with a gas burner located under the tank. When hot water is drawn from the tank, cold water flows into the bottom of the tank. When the water temperature in the tank gets too low, a thermostat sensing the water temperature (often called an aquastat) turns on the burner. When the water temperature in the tank reaches the setpoint, the thermostat turns off the burner. The burner may be ignited by an electronic spark ignition, glow plug, or, in some models, by a standing pilot light.

Relative to a standard model, an energy efficient unit will typically have one or more features such as no standing pilot light, larger heat exchange surfaces, additional tank insulation, and the capability to condense moisture in the flue gas.

MEASURE CASE DESCRIPTION

The measure case is defined as the replacement of a standard efficiency central storage water heater with an energy efficient central storage water heater. The qualifying measure efficiency rating for each measure offering is specified below. Energy savings were calculated by climate zone for each offering.

Measure Case Specification

Equipment Tier Type	Rated Input (kBtu/hr)	Min. Qualifying Thermal Efficiency (TE)
Central Storage Water Heater, Tier 1 – Non-condensing	> 75	83%
Central Storage Water Heater, Tier 2 – Condensing		90%

BASE CASE DESCRIPTION

The base case is defined as standard efficiency central storage water heater. The minimum qualifying measure efficiencies exceed the California Appliance Efficiency Regulations (Title 20) standard for large gas storage water heaters with less than 4,000 Btu/hr of rated input per gallon of storage volume. (See Code Requirements.)

Base Case Specification

Equipment Type	Rated Input (kBtu/hr)	Min. Thermal Efficiency (TE)
Central Storage Water Heater	> 75	80%

CODE REQUIREMENTS

Applicable state and federal codes and standards for instantaneous heater/boilers are noted in the table below.¹ In addition to the state and federal energy use standards, water heating equipment must comply with nitrogen oxide (NOx) emissions limits set forth by air quality management districts (AQMDs) or air pollution control districts (APCDs) throughout the California.²

Applicable State and Federal Codes and Standards

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20 (2015)	Section 1605.3(f)	January 20, 2004
CA Building Energy Efficiency Standards – Title 24 (2013)	Section 110.3	November 26, 2013
Federal Standards – Code of Federal Regulations	10 CFR 430.32(d)	April 16, 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
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

NORMALIZING UNIT

The normalizing unit is per kBtu/hr of rated input capacity.

¹ California Energy Commission (CEC). 2015. 2015 Appliance Efficiency Regulations. CEC 400-2015-021. Section 1605.3(f).

California Energy Commission (CEC). 2012. 2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (Title 24). CEC-400-2012-004-CMF-REV2. Section 110.3.

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

² 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.

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	Res
Normal replacement	UpDeemed	Res
Normal replacement	DnDeemDI	Res
New construction	DnDeemed	Res
New construction	UpDeemed	Res
New construction	DnDeemDI	Res

Eligible Products

Program eligibility requirements for storage water heaters defined for this measure include:

- Measure offerings are applicable to multifamily properties.
- The large natural gas central water heaters must serve two or more dwelling units.
- The rated input for a natural gas fueled storage water heater for this multifamily residential measure must exceed 75 kBtu/hr.
- Qualifying storage water heaters must have a storage tank size of least 80 gallons.
- The rebate applies to normal replacement of gas-for-gas equipment.
- The equipment model must be registered in the California Energy Commission (CEC) Modernized Appliance Efficiency Database System.

Eligible Building Types

This measure is only applicable to existing multifamily building types of any vintage.

Eligible Climate Zones

The measure is applicable in all California climate zones.

PROGRAM EXCLUSIONS

Tankless water heaters or hot water boilers with a separate storage tank that are factory mounted on the same skid are not eligible.

Storage water heaters used for space heating applications and water heaters used for 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 calculation of the gas unit energy savings (UES) of a high-efficiency (measure case) storage water heater is shown below. The annual energy consumption (UEC) for each climate zone was derived by applying a climate zone adjustment factor to the average storage water heater gas UEC for multifamily apartments/units from the 2009 California Residential Appliance Saturation Study (RASS).³

$$UES = \frac{AvgUEC_{RASS} \times CZ_x \times \left(\frac{1 - TE_{Base}}{TE_{Measure}} \right)}{Cap}$$

³ KEMA, Inc. 2010. *2009 California Residential Appliance Saturation Survey. Volume 2: Results*. Prepared for the California Energy Commission. CC-200-2010-004.

- UES* = Gas unit energy savings (therms/yr)
- AvgUEC_{RASS}* = Average gas unit energy consumption for hot water usage per dwelling unit, reported in RASS (therms/yr)
- CZ_x* = Climate Zone adjustment factor (CZ 1 -16)
- TE* = Thermal efficiency rating (%)
- Cap* = Average Capacity per Dwelling Unit

Key parameters for the UES calculation are specified and explained below.

Gas Unit Energy Savings Input Parameters

Parameter	Base Case Model	Measure Case Model – Tier 1	Measure Case Model – Tier 2	Source
Average UEC per Dwelling Unit (therms/yr)	183	183	183	KEMA, Inc. 2010. <i>2009 California Residential Appliance Saturation Survey. Volume 2: Results.</i> Prepared for the California Energy Commission. CC-200-2010-004.
Climate Zone Adjustment Factor	1.00	Varies by CZ	Varies by CZ	Southern California Gas Company. (n.d.) "WPCSGREWH130613A-Rev1 BA-MF MODELING and ADJ FACTORS CALC.xls."
Average Capacity per Dwelling Unit (kBtu/hr/unit)	6.5	6.5	6.5	Professional judgement
Thermal Efficiency (%)	80%	83%	90%	Base Case: California Energy Commission (CEC). 2015. <i>2015 Appliance Efficiency Regulations.</i> CEC 400-2015-021. Section 1605.3(f). Measure Case: California Energy Commission (CEC). "Modernized Appliance Efficiency Database System (MAEDBS)." http://www.appliances.energy.ca.gov/AdvancedSearch.aspx . Accessed on March 7, 2012.

Average UEC per Dwelling Unit. The average storage water heater gas UEC per multifamily dwelling unit was drawn from the 2009 California Residential Appliance Saturation Study (RASS). This value represents the base case scenario.

Climate Zone Adjustment Factor. A parameter for determining the thermal efficiency (TE) and energy consumption of water heaters is the cold water temperature at the inlet to the storage water heater. The nominal ANSI standard temperature of the supply water entering the water heater is 70 °F. The actual inlet water temperature in California varies with climate zone and season, so adjustment factors were created based on groundwater temperature data for each climate zone to account for varying water heater consumption due to inlet water temperature. Specifically, the climate zone adjustment factors were developed using 2013 groundwater temperature data and the “Building America Multi-Family Central Water Heating Evaluation Tool” from the U.S. Department of Energy (DOE) Office of Energy

Efficiency and Renewable Energy⁴ to model the annual water heater gas UEC for each California climate zone. The annual UEC associated with each climate zone was then divided by the median UEC in all climate zones to estimate the adjustment factor for each climate zone, shown in the following table.

Climate Zone Adjustment Factors

Climate Zone	Groundwater Temperature (°F) ⁵	Climate Zone Adjustment Factor
1	51.38	1.07
2	57.29	1.03
3	57.05	1.03
4	59.51	1.02
5	55.83	1.04
6	61.75	1.00
7	62.55	1.00
8	63.74	0.99
9	63.82	0.99
10	64.15	0.99
11	63.19	0.99
12	60.88	1.01
13	64.10	0.99
14	62.67	1.00
15	75.47	0.92
16	51.75	1.07

Average Capacity per Dwelling Unit. The average rated input kBtu/hr per dwelling unit assumes a multifamily property with more than 10 dwelling units.

Base Case Central Storage Water Heater Thermal Efficiency (%). The base case storage water heater TE rating is consistent with the minimum efficiency as per state and federal code requirements. See Base Case Description and Code Requirements.

Measure Case Central Storage Water Heater Thermal Efficiency (%). Large storage water heaters for multifamily residential applications are not specified in the 2013 Database for Energy-Efficiency Resources (DEER2013) Update for 2014 Codes. The minimum qualifying DEER measure efficiencies for commercial storage water heaters were applied to the Tier 1 and Tier 2 large storage water heater measures for multifamily applications.

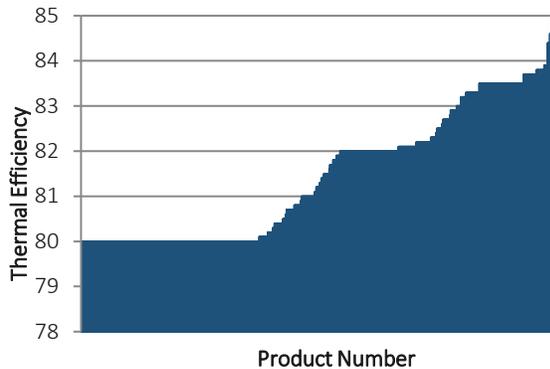
This measure is based upon the commercial storage water heater because they are typically installed in multifamily buildings. All commercial storage water heaters have standby losses of 0.56% per hour. Standby losses are expressed as a percentage of the energy stored in the hot water relative to the average ambient air temperature.

⁴ This reference could not be located.

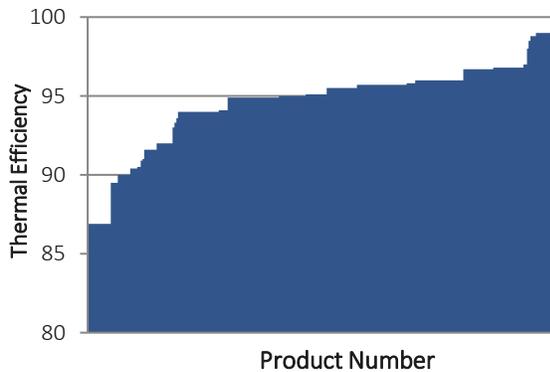
⁵ Reeves, P. (Consultant to California Public Utilities Commission, Energy Division). 2013. "Comparison-of-Ground-Temperatures-v2_byPaulReeves.xlsx."

Measure case efficiencies were then derived from analysis of high-efficiency storage water heaters listed in the California Energy Commission (CEC) Modernized Appliance Efficiency Database System (MAEDBS) as of May 2012.⁶ The figures below shows the distribution of TE ratings for the 965 large, non-condensing storage water heater products found in CEC database. About 80% of the products are considered base case while 20% of the models meet the minimum TE for Tier 1. Also shown is the distribution of TE ratings for the 266 large, condensing storage water heater products found in the CEC database. Over 90% of the models listed meet the minimum TE for Tier 2.

Distribution of Thermal Efficiency Ratings of Non-condensing Large Storage Water Heaters



Distribution of Thermal Efficiencies Ratings of Condensing Large Storage Water Heaters



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

⁶ California Energy Commission (CEC). "Modernized Appliance Efficiency Database System (MAEDBS)." <http://www.appliances.energy.ca.gov/AdvancedSearch.aspx>. Accessed March 7, 2012.

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 installations 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)

For a *normal replacement* or a *new construction installation*, the customer must buy a new storage water heater, so the base case cost is that of a standard efficiency storage water heater.

Base case labor and material costs were derived from data drawn from the U.S. Department of Energy (DOE) Technical Support Document (TSD) "Commercial Water Heating Equipment (EERE-2014-BT-STD-0042)".⁷ Condensing water heaters typically use PVC for venting flue exhaust, which is cheaper and easier to install than sheet metal used for non-condensing water heaters. The cost difference in venting material and installation is accounted for in the data extracted from the TSD.

The TSD reports the total installed cost for large storage water heaters as the sum of the equipment retail price and the installation cost but does not present each cost component separately.

MEASURE CASE MATERIAL COST (\$/UNIT)

Measure case labor and material costs were derived from data drawn from the U.S. Department of Energy (DOE) Technical Support Document (TSD) "Commercial Water Heating Equipment (EERE-2014-BT-STD-0042)".⁸ Condensing water heaters typically use PVC for venting flue exhaust, which is cheaper and easier to install than sheet metal used for non-condensing water heaters. The cost difference in venting material and installation is accounted for in the data extracted from this TSD.

The TSD reports the total installed cost for large storage water heaters as the sum of the equipment retail price and the installation cost but does not present each cost component separately.

⁷ 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.

Southern California Gas Company. 2012. "WPSCGREWH130613A-Rev1 Vendor Cost Data.xlsx"

⁸ 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.

Southern California Gas Company. 2012. "WPSCGREWH130613A-Rev1 Vendor Cost Data.xlsx"

BASE CASE LABOR COST (\$/UNIT)

Labor installation costs were derived from Technical Support Document (TSD) “Commercial Water Heating Equipment (EERE-2014-BT-STD-0042)”.⁹ The TSD reports the total installed cost for large storage water heaters as the sum of the equipment retail price and the installation cost, and thus does not present the labor cost component separately.

MEASURE CASE LABOR COST (\$/UNIT)

Labor installation costs were derived from Technical Support Document (TSD) “Commercial Water Heating Equipment (EERE-2014-BT-STD-0042)”.¹⁰ The TSD reports the total installed cost for large storage water heaters as the sum of the equipment retail price and the installation cost, and thus does not present the labor cost component separately.

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 residential 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 residential sector programs for more than two years and for which impact evaluation results are not available.

Net-to-Gross Ratios

Parameter	Value	Source
NTG - residential	0.55	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.

⁹ 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.

Southern California Gas Company. 2012. "WPSCGREWH130613A-Rev1 Vendor Cost Data.xlsx"

¹⁰ 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.

Southern California Gas Company. 2012. "WPSCGREWH130613A-Rev1 Vendor Cost Data.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 Difference Summary

DEER Item	Comment / Used for Workpaper
Modified DEER methodology	
Scaled DEER measure	
DEER Base Case	
DEER Measure Case	
DEER Building Types	
DEER Operating Hours	
DEER eQUEST Prototypes	
DEER Version	
Reason for Deviation from DEER	
DEER Measure IDs Used	
NTG	Source: DEER2014. NTG of 0.55 is associate with NTG ID: <i>Res-Default>2yrs</i> .
GSIA	GSIA ID: <i>Def-GSIA</i>
EUL/RUL	Source: DEER2014. The EUL of 15 years is associated with EUL ID: <i>WtrHt-MF-Gas</i> . <i>This EUL ID is a proposed ID that is based upon the EUL ID WtrHt-Com with a value of 15 years.</i>

REVISION HISTORY

Measure Characterization Revision History

Revision Number	Revision Complete Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision Effective Date and Approved By
01	03/14/2018	Jennifer Holmes, Cal TF Staff	The draft of the text fields for this statewide measure is based upon: WPSCGREWH130613A Revision 1 (September 8, 2016) Consensus reached among Cal TF members
	02/28/2019	Jennifer Holmes, Cal TF Staff	Revisions for submission of version 01.
	08/02/2021	Soe K Hla PG&E	Adopted all measures for PG&E. Removed unrelated data starting row 101, fixed incorrect sector and EUL_ID from EAD Measure Tab. Relocate cost values from GenCost to MatlCost in EAD.