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HVAC
GRAVITY WALL FURNACE
SWHC001-01

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MEASURE NAME

Gravity Wall Furnace, Residential

STATEWIDE MEASURE ID

SWHC001-01

TECHNOLOGY SUMMARY

A vented gravity wall furnace is a self-contained vented heater, complete with grills or the equivalent, designed to be incorporated in or permanently attached to a wall. This measure pertains to a natural-gas fired top-vent wall furnace that circulates heated air by gravity or radiates heat into the space to be heated through openings in the casing. A gravity wall furnace does not require an electric hookup. Combustion air may be drawn from the heated space, but flue gases are vented up through short ducts.

A top-vented gravity wall furnace is an easy like-for-like replacement of an old inefficient unit. The gas heat input capacity ratings of gravity wall furnaces are typically 25,000 Btu/hr, 35,000 Btu/hr, and 50,000 Btu/hr; the latter units are dual-wall furnaces used to heat two living spaces separated by a wall. The design of the better heat-exchanging surface differentiates higher efficiency units from standard efficiency models.

MEASURE CASE DESCRIPTION

The measure case is defined as a gravity wall furnace with an annual fuel utilization efficiency (AFUE) of at least 70%, and a qualifying input rate $\geq 19,000$ Btu/hr and $\leq 60,000$ Btu/hr. The measure offerings designated below distinguish by residence type and input capacity; the impacts of each offering are derived for each California climate zone.

Measure Case Specification

Residence Type	Efficiency (AFUE)	Input Capacity (kBtu/hr)
Single family	70% AFUE	> 19.0 and ≤ 27.0
Multifamily	70% AFUE	> 19.0 and ≤ 27.0

BASE CASE DESCRIPTION

The baseline efficiencies for the impact analysis were derived as the average AFUE of gravity wall furnaces available in the market (from three equipment manufacturers) for each capacity category, as shown below. See Code Requirements for minimum efficiency requirements. Excluding the largest size (50 kBtu/hr), the average AFUE is only slightly higher than the minimum efficiency required by Title 20.

Gravity Top Vent Wall Furnace Baseline AFUE Determination¹

OEM Trade Name	Input Capacity (Btu/hr)	Min. AFUE (Title 20)	Actual AFUE	Average Baseline AFUE of Capacity Range (%)
Manufacturer A	25,000	65%	70.7%*	65.0%
Manufacturer B			63.0%	
Manufacturer C			67.0%	
Manufacturer A	32,000	66%	68.8%	66.3%
Manufacturer B	35,000		64.1%	
Manufacturer C			66.0%	
Manufacturer A	50,000	67%	69.3%	66.8%
Manufacturer B			65.1%	
Manufacturer C			66.0%	

* Excluded because program qualified.

CODE REQUIREMENTS

The efficiency requirements for gas wall furnaces are governed by the California Appliance Efficiency Regulations (Title 20);² Section 1605.1 (Table E-2) specifies the minimum efficiencies of gravity wall furnaces.

Applicable State and Federal Codes and Standards

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20 (2014)	Section 1605.1, Table E-2	April 16, 2013
CA Building Energy Efficiency Standards – Title 24	None.	n/a
Federal Standards	None.	n/a

Minimum Efficiency Requirements of Gas Wall Furnaces (Title 20, Table E-2)

Design Type	Capacity (Btu/hr)	Minimum AFUE (%)
Gravity	≤ 10,000	65%
	> 10,000 and ≤ 12,000	
	> 12,000 and ≤ 15,000	
	> 15,000 and ≤ 19,000	
	> 15,900 and ≤ 27,000	
	> 27,000 and ≤ 46,000	66%
	> 46,000	67%

¹ Southern California Gas Company (SCG). 2013. "WPSCGREHV110603A_2013_Wall_Furnace_Results-Rev2.xlsx."

² California Energy Commission (CEC). 2014. *2014 Appliance Efficiency Regulations*. CEC-400-2014-009-CMF.

NORMALIZING UNIT

Each.

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

The purchase invoice must be provided as a proof that the gravity-type wall furnace has been purchased to replace a previously existing unit. Additionally, the customer must agree to a post measure installation inspection.

Eligible Products

Eligible products must meet the specifications in the Measure Case Description.

Eligible Building Types and Vintages

This measure is applicable for existing single family and multi-family residences of any vintage.

Eligible Climate Zones

This measure is applicable in all California climate zones.

PROGRAM EXCLUSIONS

None.

DATA COLLECTION REQUIREMENTS

Data collection requirements are to be determined.

USE CATEGORY

HVAC

ELECTRIC SAVINGS (kWh)

Not applicable.

PEAK ELECTRIC DEMAND REDUCTION (kW)

Not applicable.

GAS SAVINGS (Therms)

The gas energy savings of a gravity wall furnace was derived from computer building energy use simulation models of single and multifamily residential using eQuest software (DOE2.2). The energy models generated for the Database of Energy Efficient Resources (DEER) single family and multifamily homes were utilized in eQuest simulation.

Model Calibration

To calibrate the energy model and conduct the energy use simulations, the correlation between gas consumption and heating degree days (HDD) was established using the gas usage history of residential customers with a wall furnace in the Southern California Gas Company (SCG) service area from 2008 through 2010.

Sample homes in SCG territory. A sample of 889 homes in SCG territory³ identified to be equipped with a wall furnace for space heating was analyzed to calibrate the energy simulation models. The gas consumption history of these customers for the last three years was analyzed (see below) with respect to HDD data of each climate zone. The numerical data needed to calibrate the energy model was obtained through the review of individual consumption history and an extensive filtering and analysis of the data.

Because the size of each home in the sample was not available in the SCG customer database, some homes were specifically selected to manually identify the size of the living space using the data available on the Internet. The estimated average living area of single family and multifamily homes in the sample was 1,391 ft² and 950 ft², respectively.

The distribution of customers in the sample compared to the actual population distribution based upon U.S. Census is provided below. The SCG population distribution per climate zone was applied to calculate the weighted average of the gas impact of the measure.

³ Southern California Gas Company (SCG). (n.d.) "WPSCGREHC110603A.2 Customer Data.xls"

Comparison of Customer Sample with Population, by Climate Zone

SCG Climate Zone	% of SCG Sample in CZ	% of SCG Population in CZ
4	0.3%	1.0%
5	2.8%	2.4%
6	12.9%	15.2%
8	40.9%	22.1%
9	30.8%	27.8%
10	6.2%	12.5%
12	0.5%	0.0%
13	4.4%	4.6%
14	0.3%	4.2%
15	0.5%	2.2%
16	0.5%	7.4%

Sizing of the furnace. To determine the burner input capacity of the wall furnace (kBtu/hr) required for the area of the living space, the furnace selection methodology promoted by wall furnace manufacturers was adopted for this measure analysis.⁴

$$Capacity = Area \times Height \times (T_i - T_o) / 10$$

Capacity = Input capacity of the wall furnace (kBtu/hr)

Area = Area of the living space (ft²)

Height = Ceiling height (ft)

T_i = Set temperature

T_o = Average outside temperature during winter season

The assumptions for this calculation are specified below. Additionally, this analysis assumes adequate ceiling and wall insulation.

Input Assumptions

Input	Value	Source
Set temperature (°F)	70 °F.	The source for this data is unknown.
Average outside temperature during winter (°F)	30 °F	The source for this data is unknown.
Ceiling height (ft)	8.5	Professional judgement.

The resultant approximate input capacity rates for the living area are specified below.

⁴ Williams. (n.d.) "Williams Furnace Sizing Guide.pdf."

Examples of Area Served and Wall Furnace Size

Living Area (ft ²)	Input Capacity (kBtu/hr)
500	17.0
750	25.5
1,000	34.0
1,500	51.0
2,000	68.0

The correlation between monthly gas consumption and HDD data⁵ of each home between 2008 through 2010 was estimated for each of the 16 California climate zones. Specifically, for each home in the sample the correlation between gas consumption and HDD data was estimated with a linear trend line slope equation:⁶

$$m = \frac{\Sigma(x - \bar{x})(y - \bar{y})}{\Sigma(x - \bar{x})^2}$$

x = Monthly heating degree days, HDD/month

y = Monthly gas consumption, therms/month

The y-intercept $b = (\bar{y} - m\bar{x})$ of the regression was included to account for non-space heating gas consumption. This represents the gas consumption required for other gas-fired appliances, such as water heater, cooking stove, oven, and clothes dryer. The R-squared value for each regression was also calculated to identify and exclude the outliers.

Baseline Efficiency and Gas Usage

The baseline AFUE efficiencies were calculated as the average AFUE of gravity wall furnace models available in the market.⁷ (See Base Case Description.) The resultant average baseline AFUE by input capacity range is specified below.

Baseline Efficiencies

Input Capacity (Btu/hr)	Baseline AFUE (%)
25,000	65.0%
35,000	66.3%
50,000	66.8%

⁵ Southern California Gas Company (SCG). (n.d.) "WPSCGREHC110603A.2 HDD QuestEnergy.xls"

⁶ Southern California Gas Company (SCG). 2014. "WPSCGREHC110603A.2 2013 Analysis 012014.xlsx." January 20.

⁷ Southern California Gas Company (SCG). 2013. "WPSCGREHV110603A_2013_Wall_Furnace_Results-Rev2.xlsx."

The analysis results of gas usage history from selected homes with a wall furnace are presented below.⁸ The single-family results were drawn from the eQuest energy simulation models using the data from the regression analysis of the customer consumption data.

Multifamily results were drawn directly from the regression analysis of the customer data, and not from eQuest simulation models because the multifamily building model designed for DEER resulted in incorrect values as shown in the analysis file due to several bugs imbedded in the building model.

Baseline Gas Consumption for Space Heating

Climate Zone	97.5% DD	HDD	% of SCG Population	Single Family - Annual Gas Usage for Heating (Therms/home)	Multifamily - Annual Gas Usage for Heating (Therms/home)
CZ01	37 °F	5,132	0.0%	552.6	415.6
CZ02	31 °F	3,006	0.0%	346.7	243.4
CZ03	38 °F	3,008	0.0%	292.8	243.5
CZ04	34 °F	2,582	1.0%	277.5	209.0
CZ05	35 °F	3,123	2.4%	330.8	252.8
CZ06	43 °F	1,675	15.2%	153.4	135.6
CZ07	42 °F	1,376	0.5%	73.1	111.4
CZ08	39 °F	1,340	22.1%	114.1	108.5
CZ09	40 °F	1,669	27.8%	159.5	135.1
CZ10	35 °F	1,784	12.5%	185.6	144.5
CZ11	32 °F	2,736	0.0%	334.3	221.5
CZ12	33 °F	2,675	0.0%	321.2	216.6
CZ13	34 °F	2,520	4.6%	291.6	204.1
CZ14	26 °F	2,997	4.2%	426.8	242.7
CZ15	37 °F	897	2.2%	102.6	72.6
CZ16	20 °F	5,511	7.4%	604.3	446.2
Weighted Average	35 °F	2,394		205.7	163.3

Measure Case Efficiency

The higher efficiency rating of wall furnace is assumed to be 70% AFUE for wall furnace units of all sizes. The percentage of efficiency improvement represents the percent increase of AFUE of the measure case compared to the baseline.

⁸ Southern California Gas Company (SCG). 2014. "WPSCGREHC110603A.2 2013 Analysis 012014.xlsx." January 20.

Efficiency Comparison

	Furnace Capacity (Btu/hr):		
	25,000	35,000	50,000
Baseline AFUE	65.0%	66.3%	66.8%
Measure AFUE	70.0%	70.0%	70.0%
% Efficiency Improvement	7.1%	5.3%	4.6%

Unit Energy Savings Calculation

The unit energy savings (UES) of a like-for-like replacement of gravity wall furnace were derived from the data analysis and the energy use simulation models.⁹

The UES of gravity wall furnace installations in the SCG territory was computed as the weighted average UES for each capacity category, weighted by the percent of the SCG residential population in climate zone.

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. 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.

Due to the nature of the relatively austere design of wall furnaces, the estimated lifetime is expected to exceed 20 years. Since EUL of gravity wall furnaces are not available from the Database of Energy Efficient Resources (DEER), the estimated life of a high efficiency gas furnace is adopted for this measure. The high efficiency furnace EUL was updated in 2008 and assumed the maximum EUL, as stipulated in the *Energy Efficiency Policy Manual*, which states, “[i]n order to minimize uncertainty, EULs will be limited to a maximum of 20 years, even if particular devices may be expected to survive longer.”

The EUL and RUL specified for this measure are presented 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). 2014. “DEER2014-EUL-table-update_2014-02-05.xlsx.” California Public Utilities Commission (CPUC), Energy Division. 2008. “EUL_Summary_10-1-08.xls.” California Public Utilities Commission (CPUC), Energy Division. 2003. <i>Energy Efficiency Policy Manual v 2.0</i> . Page 16.

⁹ Southern California Gas Company (SCG). 2014. “WPCSGREHC110603A.2 2013 Analysis 012014.xlsx.” January 20.

Parameter	Value	Source
RUL (yrs)	n/a	-

BASE CASE MATERIAL COST (\$/UNIT)

The base case material case was calculated as the average of the gravity wall furnace manufacturer suggested retail prices (MSRPs) of each input capacity size category. The MSRPs were obtained directly from three major manufacturers (prior to 2014).¹⁰

MEASURE CASE MATERIAL COST (\$/UNIT)

The measure case cost is equal to the manufacturer suggested retail price (MSRP) of a qualifying gravity wall furnace model in the 25,000 Btu/hr capacity category obtained from a furnace manufacturer (prior to 2014).¹¹ Models in the 35,000 Btu/hr and 50,000 Btu/hr for which prices were provided did not meet the measure case specification of 70% AFUE. Thus, the measure case material cost only represents the 25,000 Btu/hr size category.

BASE CASE LABOR COST (\$/UNIT)

The installation cost is assumed to be same as measure installation case cost.

MEASURE CASE LABOR COST (\$/UNIT)

The installation cost is assumed to be same as base installation case cost.

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. The relevant NTG values for this measure are specified in below.

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.

¹⁰ Southern California Gas Company (SCG). (n.d.) "WPSCGREHC110603A.2 Gravity Wall Furnace Costs.xls"

¹¹ Southern California Gas Company (SCG). (n.d.) "WPSCGREHC110603A.2 Gravity Wall Furnace Costs.xls"

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 benefits for this measure have not been quantified.

DEER DIFFERENCES ANALYSIS

This section provides a summary of inputs and methods based upon the Database of Energy Efficient Resources (DEER), and the rationale for inputs and methods that are not DEER-based.

DEER Difference Summary

DEER Item	Comment / Used for Workpaper
Modified DEER methodology	No
Scaled DEER measure	No
DEER Base Case	No
DEER Measure Case	No
DEER Building Types	No
DEER Operating Hours	No
DEER eQUEST Prototypes	No
DEER Version	n/a
Reason for Deviation from DEER	This measure is not in DEER.
DEER Measure IDs Used	n/a
NTG	Source: DEER. The NTG of 0.70 is associated with NTG ID: XX
GSIA	Source: DEER. The GSIA of 1.0 is associated with GSIA ID: <i>Def-GSIA</i>
EUL/RUL	The value of 20 years is associated with EUL ID: <i>HV-EffFurn</i> . Updated in 2006-08.

REVISION HISTORY

Measure Characterization Revision History

Revision Number	Revision Complete Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision
01	09/30/2018	Jennifer Holmes, Cal TF Staff	Draft of consolidated text for this statewide measure is based upon: WPCSGREHC110603A Revision 2 (January 31, 2014) Consensus reached among Cal TF members.
	04/26/2019	Rebecca Jenkins, SCG Jennifer Holmes, Cal TF Staff	Minor revisions and updates for submittal of version 01.