**Workpaper WPSCGREHC110603A**

**Revision 2**

**Southern California Gas Company**

**Customer Programs Department**

**Gravity Wall Furnaces in Single-Family and Multi-Family Homes**

Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision No. | Date | **Description** | **Author** |
| 0 | Dec. 14, 2011 | Release for program development.  Removed customer info from the embedded files. | Chan Paek,  Quest Energy |
| 1 | May 14, 2012 | Inclusion of Multi-Family market | Chan Paek |
| 2 | Jan. 10, 2014 | Updated Single-Family model results with CCZ 2010 weather | Quest Energy |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

# 

Measure Summary Table A

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Measure ID | Measure Name | Program Type (ER, ROB, NC, RC,CE) | EUL / RUL (yr) | CZ | Building Type | Building Vintage | Unit Definition | NTGR IMC | NTGR Savings | Implementation/ Delivery Method | GRR | ISR |
| 1 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 1 | Single- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 2 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 2 | Single- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 3 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 3 | Single- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 4 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 4 | Single- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 5 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 5 | Single- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 6 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 6 | Single- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 7 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 7 | Single- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 8 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 8 | Single- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 9 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 9 | Single- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 10 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 10 | Single- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 11 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 11 | Single- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 12 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 12 | Single- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 13 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 13 | Single- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 14 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 14 | Single- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 15 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 15 | Single- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 16 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 16 | Single- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 17 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 1 | Multi- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 18 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 2 | Multi- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 19 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 3 | Multi- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 20 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 4 | Multi- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 21 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 5 | Multi- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 22 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 6 | Multi- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 23 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 7 | Multi- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 24 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 8 | Multi- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 25 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 9 | Multi- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 26 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 10 | Multi- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 27 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 11 | Multi- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 28 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 12 | Multi- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 29 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 13 | Multi- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 30 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 14 | Multi- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 31 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 15 | Multi- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |
| 32 | Gravity Wall Furnace, 70% AFUE, Input Capacity > 19 kBtu/h & ≤ 27 kBtu/h | ROB | 0/20 | 16 | Multi- Family Residential | Any | therm | 0.6 | 0.6 | Prescriptive Rebate | 1 | n/a |

Measure Summary Table B

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Measure ID | 1st Baseline | | | | | | 2nd Baseline | | | | | |
| Gas Savings (Therms) | User Entered kW Savings per unit (kW/unit) | Gross Unit Annual Electricity Savings (kWh/unit) | Base Case Cost ($/unit) | Measure Cost ($/unit) | Incremental Measure Cost ($/unit) | Gas Savings (Therms) | User Entered kW Savings per unit (kW/unit) | Gross Unit Annual Electricity Savings (kWh/unit) | Base Case Cost ($/unit) | Measure Cost ($/unit) | Incremental Measure Cost ($/unit) |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 25.8 | 0 | 0 | 724 | 762 | 38 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 13.7 | 0 | 0 | 724 | 762 | 38 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 14.1 | 0 | 0 | 724 | 762 | 38 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 11.9 | 0 | 0 | 724 | 762 | 38 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 14.5 | 0 | 0 | 724 | 762 | 38 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 8.7 | 0 | 0 | 724 | 762 | 38 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 4.0 | 0 | 0 | 724 | 762 | 38 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 5.7 | 0 | 0 | 724 | 762 | 38 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 8.2 | 0 | 0 | 724 | 762 | 38 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 8.2 | 0 | 0 | 724 | 762 | 38 |
| 11 | 0 | 0 | 0 | 0 | 0 | 0 | 13.5 | 0 | 0 | 724 | 762 | 38 |
| 12 | 0 | 0 | 0 | 0 | 0 | 0 | 13.3 | 0 | 0 | 724 | 762 | 38 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 12.5 | 0 | 0 | 724 | 762 | 38 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 14.9 | 0 | 0 | 724 | 762 | 38 |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 | 4.8 | 0 | 0 | 724 | 762 | 38 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 18.6 | 0 | 0 | 724 | 762 | 38 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 27.8 | 0 | 0 | 724 | 762 | 38 |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 13.8 | 0 | 0 | 724 | 762 | 38 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 16.8 | 0 | 0 | 724 | 762 | 38 |
| 20 | 0 | 0 | 0 | 0 | 0 | 0 | 12.8 | 0 | 0 | 724 | 762 | 38 |
| 21 | 0 | 0 | 0 | 0 | 0 | 0 | 16.0 | 0 | 0 | 724 | 762 | 38 |
| 22 | 0 | 0 | 0 | 0 | 0 | 0 | 11.1 | 0 | 0 | 724 | 762 | 38 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 8.8 | 0 | 0 | 724 | 762 | 38 |
| 24 | 0 | 0 | 0 | 0 | 0 | 0 | 7.7 | 0 | 0 | 724 | 762 | 38 |
| 25 | 0 | 0 | 0 | 0 | 0 | 0 | 10.0 | 0 | 0 | 724 | 762 | 38 |
| 26 | 0 | 0 | 0 | 0 | 0 | 0 | 9.1 | 0 | 0 | 724 | 762 | 38 |
| 27 | 0 | 0 | 0 | 0 | 0 | 0 | 12.9 | 0 | 0 | 724 | 762 | 38 |
| 28 | 0 | 0 | 0 | 0 | 0 | 0 | 12.9 | 0 | 0 | 724 | 762 | 38 |
| 29 | 0 | 0 | 0 | 0 | 0 | 0 | 12.5 | 0 | 0 | 724 | 762 | 38 |
| 30 | 0 | 0 | 0 | 0 | 0 | 0 | 12.2 | 0 | 0 | 724 | 762 | 38 |
| 31 | 0 | 0 | 0 | 0 | 0 | 0 | 4.9 | 0 | 0 | 724 | 762 | 38 |
| 32 | 0 | 0 | 0 | 0 | 0 | 0 | 19.7 | 0 | 0 | 724 | 762 | 38 |

**Note: For the complete list of Measures, refer to the accompanying calculation spreadsheet**

# Table of Contents

[Revision History i](#_Toc378863337)

[Measure Summary Table A ii](#_Toc378863338)

[Measure Summary Table B v](#_Toc378863339)

[List of Figures viii](#_Toc378863340)

[List of Tables viii](#_Toc378863341)

[SECTION 1 - General Measure & Baseline Data 1](#_Toc378863342)

[1.01 Measure & Delivery Description 1](#_Toc378863343)

[1.02 DEER Differences Analysis 3](#_Toc378863344)

[1.03 Code Analysis 3](#_Toc378863345)

[1.04 Measure Effective Useful Life 3](#_Toc378863346)

[1.05 Net-to-Gross Ratios for Different Program StrategiEs 3](#_Toc378863347)

[1.06 Gross Realization Rate 3](#_Toc378863348)

[SECTION 2 - Energy Savings & Demand Reduction Calculations 4](#_Toc378863349)

[2.01 Methodology 4](#_Toc378863350)

[2.02 Energy Savings 6](#_Toc378863351)

[SECTION 3 - Base Case & Measure Costs 8](#_Toc378863352)

[3.01 Base Case Cost 8](#_Toc378863353)

[3.02 Measure Cost 8](#_Toc378863354)

[3.03 Gross Incremental Measure Cost 8](#_Toc378863355)

[References 9](#_Toc378863356)

List of Figures

[Figure 1 - Typical gas-fired top-vent gravity wall furnace 1](#_Toc325382049)

List of Tables

[Table 1 - Wall Furnace Minimum Heating Efficiency 1](#_Toc325381938)

[Table 2 - Baseline AFUE 2](#_Toc325381939)

[Table 3 - Examples of Area Served and Wall Furnace Size 4](#_Toc325381940)

[Table 4 - Distribution of sample customers in SCG climate zones 5](#_Toc325381941)

[Table 5 - Population distribution in SCG climate zones 5](#_Toc325381942)

[Table 6 - Baseline Efficiencies 5](#_Toc325381943)

[Table 7 - Baseline gas consumption for space heating 6](#_Toc325381944)

[Table 8 - Efficiency Comparison 6](#_Toc325381945)

[Table 9 - Estimated energy savings per CZ and per input rating 7](#_Toc325381946)

[Table 10 - Energy savings per unit of wall furnace 7](#_Toc325381947)

1. General Measure & Baseline Data

Measure & Delivery Description

* + 1. Technology
       1. A vented gravity wall furnace is a self-contained vented heater, complete with grills or the equivalent, designed for incorporation in, or permanent attachment to, a wall or a residence and furnishing heated air circulated by gravity or radiating heat into the space to be heated through openings in the casing.
       2. This measure is focused on natural-gas fired top-vent wall furnaces with air circulated by gravity. The gravity wall furnaces do not require an electric hookup. Combustion air may be drawn from the heated space, but flue gases are vented up short ducts (top vent, as shown in Figure 1).



1. Typical gas-fired top-vent gravity wall furnace
   * + 1. A top-vented gravity wall furnace is an easy like-for-like retrofit to replace old inefficient units in older homes. Typical gas heat input capacities of gravity wall furnaces on the market are 25,000 Btu/hr, 35,000 Btu/hr, and 50,000 Btu/h.
       2. Typical 50,000 Btu/h units are dual-wall furnaces used to heat two living spaces separated by a wall.
     1. Efficiency
        1. Title 20 specifies the minimum efficiencies of gravity wall furnaces. All wall furnace products must meet the corresponding AFUE requirement to be sold in California.
2. Wall Furnace Minimum Heating Efficiency

|  |  |  |
| --- | --- | --- |
| **Type** | **Capacity** | **AFUE** |
| Gravity Type | over 10,000 Btu/hour up to 12,000 Btu/hour | 65% |
|  | over 12,000 Btu/hour up to 15,000 Btu/hour | 65% |
|  | over 15,000 Btu/hour up to 19,000 Btu/hour | 65% |
|  | **over 19,000 Btu/hour up to 27,000 Btu/hour** | **65%** |
|  | **over 27,000 Btu/hour up to 46,000 Btu/hour** | **66%** |
|  | **over 46,000 Btu/hour** | **67%** |
| Source: California Appliance Efficiency Regulations[[1]](#endnote-1) | | |

* Units with capacities up to 19,000 Btu/hour (grey) are not available in the market.
  + - 1. Although the efficiency requirements had been established over 20 years ago, there still are a large number of older wall furnace units in operation that may not meet the current requirements.
      2. The baseline efficiencies were determined by averaging the AFUEs of the products available in the market for each category of input rate as shown in Table II below.

1. Baseline AFUE

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| OEM Trade Name | Equipment Type | Type | Input (Btu/hr) | Model Status | Min AFUE T20 | AFUE | **Average Efficiency (%)** |
| Manufacturer A | Wall Furnace | gravity, top-vent | 25000 | Active | 65 | **70.7** | (qualified) |
| Manufacturer B | Wall Furnace | gravity, top-vent | 25000 | Active | 65 | 63.0 |  |
| Manufacturer C | Wall Furnace | gravity, top-vent | 25000 | Active | 65 | 67.0 | **65.0** |
|  |  |  |  |  |  |  |  |
| Manufacturer A | Wall Furnace | gravity, top-vent | 32000 | Active | 66 | 68.8 |  |
| Manufacturer B | Wall Furnace | gravity, top-vent | 35000 | Active | 66 | 64.1 |  |
| Manufacturer C | Wall Furnace | gravity, top-vent | 35000 | Active | 66 | 66.0 | **66.3** |
|  |  |  |  |  |  |  |  |
| Manufacturer A | Wall Furnace | gravity, top-vent | 50000 | Active | 67 | 69.3 |  |
| Manufacturer B | Wall Furnace | gravity, top-vent | 50000 | Active | 67 | 65.1 |  |
| Manufacturer C | Wall Furnace | gravity, top-vent | 50000 | Active | 67 | 66.0 | **66.8** |

* + 1. Measure case
       1. The design of the better heat-exchanging surface is the essence of achieving the higher efficiency in this relatively simple technology of gravity wall furnaces. The Annual Fuel Utilization Efficiency (AFUE) on the new measure furnace must exceed 70%. The minimum qualifying input rate is 19,000 Btu/h, and the maximum qualifying input rate is 60,000 Btu/h.
    2. Delivery
       1. The measure type is Replace-On-Burnout (ROB) where a new like-for-like replacement of a gravity wall furnace is installed in place of an existing gravity wall furnace.
       2. The delivery mechanism is through either a midstream or a downstream prescriptive rebates program offering.
       3. The target market for this measure is single-family and multi-family residential customers.
    3. Term and Conditions
       1. The measures described herein are only available to California Investor-Owned Utility (IOU) Customers whom are paying the Public Goods Charge, and are Customers of the IOU for which the particular measure (or measures) described herein are being offered through the IOU’s Energy Efficiency program.
       2. Participants in the program must be in good standing with the administering IOU.
       3. The applicable market segments allowed to participate are single-family and multi-family residential markets.
       4. Purchase invoice must be provided as a proof that the gravity-type wall furnace has been purchased to replace a burnt out unit.
       5. Customer agrees that the IOU will conduct a post measure implementation inspection.

DEER Differences Analysis

This is a new measure that is not covered in the Database for Energy Efficient Resources (DEER).

DEER V2.05 contains high efficiency furnace measures for single family homes and double-wide mobile homes. However, gravity-type wall furnaces discussed herein are not in DEER.

Code Analysis

* + 1. The efficiency requirements for gas wall furnaces are covered under California’s Title 20 Appliance Efficiency Standards[[2]](#endnote-2) as shown in Table I above.
    2. These efficiencies were in effect since 1988. Prior to 1988 Title 20 “Appliance Efficiency Standards” which uses AFUE for the rating, the efficiency of a gravity wall furnace was regulated by “thermal efficiency”, instead of AFUE, per ANSI Z21.44-1981 at 70% minimum.

Measure Effective Useful Life

* + 1. The California Public Utilities Commission 2008 Database for Energy Efficient Resources (DEER) provides EUL values for high-efficiency gas furnaces of 20 years.
    2. Due to the nature of relatively austere design of wall furnaces, the expected useful life is expected to be over 20 years. Since EUL of gravity type wall furnaces are not available from DEER, 20 years of gas furnace EUL from 2008 is applied.

Net-to-Gross Ratios for Different Program StrategiEs

* + 1. Default NTGR value of 0.70 for new residential measures is applied[[3]](#endnote-3).

Gross Realization Rate

* + 1. The gross realization rate of 1.00 is applied.
  1. Time-of-Use Adjustment Factor
     1. Not applicable.

1. Energy Savings & Demand Reduction Calculations

Methodology

* + 1. Computer simulation of single- and multi-family residential models was performed using eQuest software (DOE2.2) to estimate the energy savings. The energy models generated for DEER single-family and multi-family homes were utilized in eQuest simulation. In order to calibrate the energy model and perform the simulation, the correlation between gas consumption and Heating Degree Days (HDD)[[4]](#endnote-4) was established using the gas usage history of SCG residential customers with wall furnace.
       1. Sizing of the furnace
          1. To determine the required burner input rate of the wall furnace (Btu/hr) for the living space served (sq. ft.), the selection process offered by two of the wall furnace manufacturers is used[[5]](#endnote-5). Table III below shows the approximate result of the proper input rates for the living area with the assumption of adequate ceiling/wall insulation, the average winter temperature of 30 degrees F, and the ceiling heights of 8.5 ft.

1. Examples of Area Served and Wall Furnace Size

|  |  |
| --- | --- |
| Sq. Ft | Btu/Hr |
| 500 | 17,000 |
| 750 | 25,500 |
| 1,000 | 34,000 |
| 1,500 | 51,000 |
| 2,000 | 68,000 |

* + - * 1. Actual equation used in worksheet for the determination of wall furnace size.

 Capacity (*Btu/h*) = Area (*sq.ft.*) × Height × (Ti – To)]/10

Where Ti = set temperature, assumed to be 70 degree F.,

To = average outside temperature during winter season

* + - 1. Sample homes in SCG territory[[6]](#endnote-6)
         1. A sample of 889 homes in SCG territory identified to be equipped with wall furnaces for space heating was studied to calibrate the energy models[[7]](#endnote-7). The gas consumption history of these customers for the last three years was analyzed 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.
      2. Analysis of data
         1. Monthly gas consumption in therms from each home during 2008~2010 (full three years) is evaluated in respect to monthly HDD data during the same period in each of 16 climate zones.
         2. For each home, the correlation between gas consumption and HDD data was calculated by using linear trend line slope equation

.

Where x = monthly heating degree days, HDD/mo

y = monthly gas consumption, therms/mo

* + - * 1. Also, y-intercept was obtained to account for non-space heating gas consumption. This represents the consumption on appliances such as water heater, cooking stove, oven, and clothes dryer.
        2. R-squared value for each regression is also calculated to be used to filter out the outliers.
        3. Because the sizes of sample homes are not available within SCG’s customer database, some of these homes were selected to manually identify the size of the living space using the data available on the Internet.

The average living area of single family homes in the sample is recognized to be 1391 square feet.

The average living area of multifamily homes in the sample is recognized to be 950 square feet.

* + - * 1. The distribution of customers examined in this measure development is shown in Table 4 below, and actual population distribution (US Census data) is shown in Table 5.

1. Distribution of sample customers in SCG climate zones

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCG Climate Zone | 4 | 5 | 6 | 8 | 9 | 10 | 12 | 13 | 14 | 15 | 16 |
| % of Customer in CZ | 0.3% | 2.8% | 12.9% | 40.9% | 30.8% | 6.2% | 0.5% | 4.4% | 0.3% | 0.5% | 0.5% |

1. Population distribution in SCG climate zones

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCG Climate Zone | 4 | 5 | 6 | 8 | 9 | 10 | 12 | 13 | 14 | 15 | 16 |
| % of Customer in CZ | 1.0% | 2.4% | 15.2% | 22.1% | 27.8% | 12.5% | 0.0% | 4.6% | 4.2% | 2.2% | 7.4% |

* + - * 1. SCG population distribution per climate zone (Table V above) was applied to calculate the weighted average of the gas impact of the measure.
    1. Baseline efficiencies and energy consumption for space heating
       1. As shown in Table 2 in Section 1.01, baseline efficiencies were calculated by averaging the AFUEs of wall furnaces available in the market. Excluding the largest size (50 kBtu/h), the units are found to be only slightly higher than the minimum values required by Title 20.

1. Baseline Efficiencies

|  |  |
| --- | --- |
| Input (Btu/hr) | **Average Efficiency (%)** |
| 25,000 | **65.0** |
| 35,000 | **66.3** |
| 50,000 | **66.8** |

* + - 1. The analysis of gas usage history from selected homes with wall furnace resulted in followingTable 7.
         1. Single family results shown in the analysis file7 are a result of eQuest modeling using the data reduced from the regression analysis of the customer consumption data.

Multi-family results are taken directly from the regression analysis of the customer data, and not from eQuest modeling because the MF building model designed for DEER resulted in incorrect values as shown in the analysis file due to several bugs imbedded in the building model.

1. Baseline gas consumption for space heating

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Climate Zone | 97.5% DD | HDD | SCG Population Distribution | Heating Therms / **SF** Home / yr | Heating Therms / **MF** Home / yr |
| 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** | **100%** | **205.7** | **163.3** |

\*See Attachment 7 for Excel calculations.

* + 1. Measure efficiencies
       1. The higher efficiency standard of wall furnace is set at 70% AFUE for wall furnace units in all sizes.

1. Efficiency Comparison

|  |  |  |  |
| --- | --- | --- | --- |
| Furnace Capacity (Btu/h): | 25,000 | 35,000 | 50,000 |
| Baseline AFUE: | 65.0% | 66.3% | 66.8% |
| Measure AFUE: | 70.0% | 70.0% | 70.0% |
| Savings: | 7.1% | 5.3% | 4.6% |

Energy Savings

* + 1. Data analysis and the simulation of the energy models7 for Like-for-Like replacement of gravity wall furnace produced the estimated energy savings as shown in the table IX below. The energy savings (therms/yr) are per unit of wall furnace. The savings amount depends on the size input capacities (Btu/hr) of wall furnaces.

1. Estimated energy savings per CZ and per input rating

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | SF (therms/yr) | | | MF (therms/yr) | | |
|  | 25,000 Btu/h | 35,000 Btu/h | 50,000 Btu/h | 25,000 Btu/h | 35,000 Btu/h | 50,000 Btu/h |
| CZ 1 | 25.8 | 26.7 | 33.0 | 27.8 | 28.8 | 35.6 |
| CZ 2 | 13.7 | 14.2 | 17.5 | 13.8 | 14.3 | 17.7 |
| CZ 3 | 14.1 | 14.6 | 18.0 | 16.8 | 17.4 | 21.5 |
| CZ 4 | 11.9 | 12.3 | 15.2 | 12.8 | 13.3 | 16.4 |
| CZ 5 | 14.5 | 15.1 | 18.6 | 16.0 | 16.6 | 20.4 |
| CZ 6 | 8.7 | 9.1 | 11.2 | 11.1 | 11.5 | 14.2 |
| CZ 7 | 4.0 | 4.2 | 5.1 | 8.8 | 9.1 | 11.3 |
| CZ 8 | 5.7 | 5.9 | 7.2 | 7.7 | 8.0 | 9.9 |
| CZ 9 | 8.2 | 8.5 | 10.5 | 10.0 | 10.3 | 12.7 |
| CZ 10 | 8.2 | 8.4 | 10.4 | 9.1 | 9.5 | 11.7 |
| CZ 11 | 13.5 | 14.0 | 17.3 | 12.9 | 13.4 | 16.5 |
| CZ 12 | 13.3 | 13.8 | 17.1 | 12.9 | 13.4 | 16.6 |
| CZ 13 | 12.5 | 12.9 | 15.9 | 12.5 | 13.0 | 16.0 |
| CZ 14 | 14.9 | 15.5 | 19.1 | 12.2 | 12.6 | 15.6 |
| CZ 15 | 4.8 | 5.0 | 6.1 | 4.9 | 5.0 | 6.2 |
| CZ 16 | 18.6 | 19.3 | 23.8 | 19.7 | 20.4 | 25.3 |

\*See Attachment 7 for Excel calculations.

* + 1. Using Table 5 and Table 9, the weighted average savings in SCG territory were calculated per wall furnace unit basis as shown below.

1. Energy savings per unit of wall furnace

|  |  |  |  |
| --- | --- | --- | --- |
|  | Savings per unit (therms/yr) | | |
|  | 25,000 Btu/h | 35,000 Btu/h | 50,000 Btu/h |
| **Single-Family** | **9.0** | **9.4** | **11.6** |
| **Mult- Family** | **10.5** | **10.9** | **13.5** |

1. Base Case & Measure Costs

Base Case Cost

* + 1. MSRP (Manufacturer’s Suggested Retail Price) of gravity wall furnaces were obtained directly from three major manufacturers and shown in “Wall Furnace Costs.xls”[[8]](#endnote-8) file in References section. The base case cost of a 25,000 Btu/hr unit is determined to be $724 from the average of MSRPs of two comparable products available in the market.
    2. Although installation cost is usually involved with the replacement of the wall furnaces, it is assumed to be the same for the base case and the measure case, and it is not addressed here.

Measure Cost

* + 1. The MSRP of the qualifying 25,000 Btu/hr wall furnace is $762. The installation cost is assumed to be same as base case cost.
    2. The measure costs of wall furnaces with the input rate of 35,000 Btu/hr and 50,000 Btu/hr are to be determined in the future since all available models in these categories do not qualify as high-efficiency gravity wall furnace, 70% AFUE.

Gross Incremental Measure Cost

* + 1. IMC of a 25,000 Btu/hr unit is $38.
    2. IMC of a 35,000 Btu/hr unit and a 50,000 Btu/hr unit are expected to be same as IMC of a 25,000 Btu/hr wall furnace, $38. This value will be updated as the qualifying units become market available.

References

1. 2005 Building Energy Efficiency Standards, California Energy Commission, Residential Compliance Manual, CEC-400-2005-005-CMF Revision 3 [↑](#endnote-ref-1)
2. California’s Title 20 Appliance Efficiency Standards [http://www.energy.ca.gov/2009publications/CEC-400-2009-013/CEC-400-2009-013.PDF](http://www.energy.ca.gov/2009publications/CEC-400-2009-013/CEC-400-2009-013.PDFf) [↑](#endnote-ref-2)
3. Updated DEER NTGR Values- 053008.xls

    [↑](#endnote-ref-3)
4. Monthly heating degree days for each climate zone for the years of 2008~2010

    [↑](#endnote-ref-4)
5. Sizing the wall furnace

    [↑](#endnote-ref-5)
6. Raw data of sample homes and gas consumption

    [↑](#endnote-ref-6)
7. Customer gas usage data analysis

    [↑](#endnote-ref-7)
8. Baseline, measure, and incremental measure costs

    [↑](#endnote-ref-8)