



MEASURE CHARACTERIZATION

Furnace, Residential

<https://www.caetrm.com/measure/SWHC031/01-3/>

<div>USE CATEGORY</div> <div>HC - HVAC</div>	<div>COMMITTED</div> <div>November 18, 2021 12:29 PM</div>
<div>STATUS</div> <div>CPUC Review</div>	<div>EFFECTIVE START DATE</div> <div>January 1, 2022</div>
<div>VERSION</div> <div>SWHC031-01-3</div>	<div>DOWNLOADED</div> <div>December 2, 2021 7:46 AM</div>

Technology Summary

A natural gas burning, forced-air furnace provides heat to a conditioned space by passing indoor air through a heat exchanger. A blower fan pulls cool air from inside the dwelling through the return air ducts and forces it through the furnace heat exchanger and heats the air by up to 50 °F. The cool air is then heated by passing over the heat exchanger connected to the combustion chamber. Warm air then flows back into the rooms through the ductwork. The combustion gases from the furnace are vented outside through the flue connected to the combustion unit near the heat exchanger.

The thermal efficiency of a furnace is represented by the annual fuel utilization efficiency (AFUE) rating. Expressed as a percentage, the AFUE is calculated as the ratio of energy output to energy input; a higher AFUE represents higher thermal efficiency. Furnaces with AFUE higher than 90% use two heat exchangers that lower the temperature of the combustion gases to the point at which the moisture condenses and is drained in a code-approved manner. These condensing furnaces use plastic flue piping and are thus easy to identify.

A fan energy rating (FER), released in 2014, requires all furnace manufacturers to meet a minimum efficiency rating of the blower motor on newly manufactured furnaces starting July 2019. Because of the FER rating, older PSC motors used in furnaces no longer meet code. To meet the new FER code, most major furnace manufacturers equip variable-speed motor (VSM) on furnace air handlers; some VSMs are built into the unit. VSM motors have integrated electronic controls that modulate the motor and fan speed based on the cooling or heating load of the system. Most VSMs are programmed to run at lower speed most of the time. Because of the (ideally) cubic relationship between fan power and fan speed, a small reduction in fan speed can result in considerable energy savings. Thus, VSM motors operate more efficiently and improve the quality of the air distribution. The typical VSM installed in furnaces are electronically commutated motors (ECM).

Measure Case Description

This measure is defined as the replacement of a standard efficiency central gas furnace with a high-efficiency central gas furnace with a variable speed motor (VSM) that is installed in a residential building. The measure offerings are specified below; energy and demand impacts vary by building type, HVAC, vintage, and climate zone.

Offering ID

STATEWIDE MEASURE OFFERING ID	DEER MEASURE ID
A	Res-GasFurnace-AFUE92-ECM
B	Res-GasFurnace-AFUE95-ECM
C	Res-GasFurnace-AFUE97-ECM



Base Case Description

The base case for this measure is defined as a non-condensing central gas furnace that meets the minimum AFUE of 80% and minimum code FER rating for a furnace with input capacity $\leq 225,000$ kBtu/hr.

Base Case Descriptions

STATEWIDE MEASURE OFFERING ID
A
B
C

Code Requirements

This measure is governed by the California Building Energy Efficiency Regulations (Title 24), the California Appliance Efficiency Regulations (Title 20), and federal standards, all of which stipulate the minimum thermal efficiency at 80% AFUE for gas furnaces with less than 225,000 kBtu/hr input capacity.  

Additionally, the federal energy conservation standard requires ECMs for residential furnace fans. 

Applicable State and Federal Codes and Standards

CODE	APPLICABLE CODE REFERENCE	EFFECTIVE DATE
CA Appliance Efficiency Regulations – Title 20	Table E-6	July 1, 2015
CA Building Energy Efficiency Standards – Title 24	Table 4-1	July 1, 2014
Federal Standards	10 CFR Part 430	July 3, 2019

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	SECTOR	DELIVERY TYPE
NC	Res	DnDeemDI
NC	Res	DnDeemed
NC	Res	UpDeemed
NR	Res	DnDeemDI
NR	Res	DnDeemed
NR	Res	UpDeemed

Eligibility requirements for this measure include:

- The customer must have natural gas distributed to the installation address.

ELIGIBLE PRODUCTS

This measure must meet the minimum AFUE efficiency ratings in the Measure Case Description.

A list of eligible furnaces can be found at <https://www.ahridirectory.org/ahridirectory/pages/home.aspx> (search for qualifying products that meet or exceed the measure case specification).

ELIGIBLE BUILDING TYPES AND VINTAGES

This measure is applicable for any residential building (single family, multifamily, mobile home) of any vintage.

ELIGIBLE CLIMATE ZONES

The high-efficiency furnace measure offerings are applicable in all California climate zones.

Program Exclusions

None.

Data Collection Requirements

Data collection requirements are to be determined.

Electric Savings (kWh)

The electric unit energy savings (UES) for this measure were retrieved directly from the Database of Energy Efficient Resources (DEER). The version used to calculate savings for these measures is DEER 2022 (D22v0). Savings values vary by building type, vintage, and climate zone.


The DEER measure ID and the associated statewide measure offering ID are provided below.

Measure Offering IDs and DEER Measure IDs

STATEWIDE MEASURE OFFERING ID	DEER MEASURE ID	RELATIONSHIP
A	Res-GasFurnace-AFUE92-ECM	Modified
B	Res-GasFurnace-AFUE95-ECM	Modified
C	Res-GasFurnace-AFUE97-ECM	Modified

The annual electric savings values provided in DEER were in units of kWh per kBtu/hr. These values were converted to annual energy savings per household by multiplying the DEER value by the furnace size (kBtu/hr) per household and climate zone that were used in the DEER building prototypes. Since federal code requires ECMs in the baseline due to the FER, there are no electric savings for this measure.

Peak Electric Demand Reduction (kW)

The approach to estimate peak demand reduction during the 4 p.m. to 9 p.m. peak period is the same approach to estimate electric energy savings; see Electric Savings.  (OP 1)

Gas Savings (Therms)

The gas unit energy savings (UES) for this measure were retrieved directly from the Database of Energy Efficient Resources (DEER). The version used to calculate savings for these measures is DEER 2022 (D22v0). Savings values vary by building type, vintage, and climate zone.

The DEER measure ID and associated statewide measure offering ID are provided below.


Measure Offering IDs and DEER Measure IDs

STATEWIDE MEASURE OFFERING ID	DEER MEASURE ID	RELATIONSHIP
A	Res-GasFurnace-AFUE92-ECM	Modified
B	Res-GasFurnace-AFUE95-ECM	Modified
C	Res-GasFurnace-AFUE97-ECM	Modified

The annual gas savings values provided in DEER were in units of therms per kBtu/hr. These values were converted to annual energy savings per household by multiplying the DEER value by the furnace size (kBtu/hr) per household and climate zone that were used in the DEER building prototypes.

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.


The EUL and RUL specified for high efficiency furnaces are specified below. The EUL adopted for this measure was specified in the *Energy Efficiency Policy Manual*.  (Page 16-17) Note that RUL is only applicable for add-on equipment and accelerated replacement measures thus not applicable for this measure.

Effective Useful Life and Remaining Useful Life


EFFECTIVE USEFUL LIFE ID	EUL DESCRIPTION	SECTOR	EUL YEARS (YR)	START DATE	EXPIRE DATE
HV-EffFurn	High Efficiency Furnace	Res	20.00	2013-01-01	

Base Case Material Cost (\$/Unit)

Base case costs were derived from furnace cost data obtained in 2017 from online list prices of HVAC equipment vendors that sell residential gas furnaces nationwide. The base case furnace cost per kBtu/hr was calculated as the average cost per kBtu/hr across all units in the database that meet the base case furnace specification. (Note that the base equipment cost of an 80% AFUE central natural gas furnace is not provided in the Database for Energy Efficient Resources, DEER.)


The average cost per kBtu/hr was then multiplied by the average furnace size per household to derive the average base case cost per household.  The average furnace size per each residential building type (below) was calculated as the average furnace size used in the DEER building prototypes across all climate zones and AFUE rating for each building type.

Base Case Cost Inputs

PARAMETER	VALUE	SOURCE
Base case furnace, 80% AFUE (\$/kBtu/hr)	\$12.00	Southern California Gas Company (SCG). 2021. "SWHC031-02 Res Furnaces Cost Data v2.0.xlsm."  Download (XLSM, 1.4 MB) <small>(See "Database" tab.)</small>
Average furnace size by household (kBtu/hr/household)		DEER building prototypes (DEER2020 Res-Furnace-dHIR)
Single family	57.6	
Multifamily	19.0	
Double-wide Mobile Home	55.0	

Measure Case Material Cost (\$/Unit)

The measure case equipment costs for a 92%, 95% and a 97% AFUE gas furnace with a VSM motor were derived as the average of data obtained in 2017 from online list prices of HVAC equipment vendors of equipment manufacturers of forced-draft residential gas furnaces that meet the measure case specification. (Note that the measure case equipment costs for a central gas natural furnace with a VSM motor were not provided in the Database for Energy Efficient Resources, DEER.)

The average cost per kBtu/hr was then multiplied by the average furnace size per household to derive the average measure case cost per household.  The average furnace size per each residential building type (below) was calculated as the average furnace size used in the DEER building prototypes across all climate zones and AFUE rating for each building type.

Measure Cost Inputs

PARAMETER	VALUE	SOURCE
Furnace, 92% AFUE-VSM (\$/kBtu/hr)	\$14.06	Southern California Gas Company (SCG). 2021. "SWHC031-02 Res Furnaces Cost Data v2.0.xlsm." Download (XLSM, 1.4 MB) See "Database" tab.
Furnace, 95% AFUE-VSM (\$/kBtu/hr)	\$18.91	
Furnace, 97% AFUE-VSM (\$/kBtu/hr)	\$30.51	
Average furnace size by household (kBtu/hr/household)		DEER building prototypes (DEER2020 Res-Furnace-dHIR)
Single family	57.6	
Multifamily	19.0	
Double-wide Mobile Home	55.0	

Base Case Labor Cost (\$/Unit)

The base case installation labor costs (\$/kBtu/hr) were obtained from the Database of Energy Efficient Resources (DEER) version 2008 (v2.05).

The average labor cost per kBtu/hr was then multiplied by the average furnace size per household to derive the average base case labor cost per household. The average furnace size per each residential building type (below) was calculated as the average furnace size used in the DEER building prototypes across all climate zones and AFUE rating for each building type. R1555

Base Case Installation Labor Cost Inputs

PARAMETER	VALUE	SOURCE
Installation labor cost (\$/kBtu/hr)	\$5.84	Database of Energy Efficient Resources (DEER) version 2008 (20v1).
Average furnace size (kBtu/hr/household)		DEER building prototypes (DEER2020 Res-Furnace-dHIR)
Single family	57.6	
Multifamily	19.0	
Double-wide Mobile Home	55.0	

Measure Case Labor Cost (\$/Unit)

Measure installation labor costs were obtained from the Database of Energy Efficient Resources (DEER) version 2008 (v2.05). The installation cost per kBtu/hr in the DEER 2008 database is the same regardless of the measure case efficiency. See Base Case Material Cost for the conversion to a per-household value. ^{R1555}

The average labor cost per kBtu/hr was then multiplied by the average furnace size per household to derive the average labor cost per household. The average furnace size per each residential building type (below) was calculated as the average furnace size used in the DEER building prototypes across all climate zones and AFUE rating for each building type. ^{R1555}

Measure Case Installation Labor Cost Inputs

PARAMETER	VALUE	SOURCE
Installation labor cost (\$/kBtu/hr)	\$5.84	Database of Energy Efficient Resources (DEER) version 2008 (v2.05).
Average furnace size (kBtu/hr/household)		DEER building prototypes (DEER2020 Res-Furnace-dHIR)
Single family	57.6	
Multifamily	19.0	
Double-wide Mobile Home	55.0	

Net-to-Gross

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. ^{R103} (Page 15-4, Table 15-3) 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 Ratio – Residential

NET TO GROSS RATIO ID	NTGRKWH (RATIO) R103	NTGRTHERM (RATIO) R103
Res-Default>2	0.5500	0.5500

Gross Savings Installation Adjustment (GSIA)

The gross savings installation adjustment (GSIA) 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. R105

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Gross Savings Installation Adjustments – Default

GSIA ID	GSIA (RATIO) R105
Def-GSIA	1.0000

Non–Energy Impacts

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

DEER Differences Analysis

This section provides a summary of inputs and methods used from 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
Modified DEER methodology	No
Scaled DEER measure	Yes
DEER Base Case	Yes
DEER Measure Case	Yes
DEER Building Types	Yes
DEER Operating Hours	Yes
DEER eQUEST Prototypes	Yes
DEER Version	DEER2022
Reason for Deviation from DEER	DEER values were converted to savings per household.
DEER Measure IDs Used	Res-GasFurnace-AFUE92-ECM Res-GasFurnace-AFUE95-ECM Res-GasFurnace-AFUE97-ECM

References

- R103** Itron, Inc. 2011. *DEER Database 2011 Update Documentation*. Prepared for the California Public Utilities Commission.
[Download](#) (PDF, 2.6 MB)
- R104** California Public Utilities Commission (CPUC), Energy Division. 2003. *Energy Efficiency Policy Manual v 2.0*. [Download](#) (PDF, 159.0 KB)
- R1047** U.S. Department of Energy (DOE), Energy Conservation Program. 2019. “Energy Conservation Program for Consumer Products: Energy Conservation Standards for Residential Furnace Fans; Correction.” *Federal Register*. Vol. 84, No. 26. February 7.
[Download](#) (PDF, 223.4 KB)

R105 California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. [Download](#) (PDF, 1.3 MB)

R1555 Southern California Gas Company (SCG). 2021. “SWHC031-02 Res Furnaces Cost Data v2.0.xlsm.” [Download](#) (XLSM, 1.4 MB)

R1558 .

R183 California Energy Commission (CEC). 2015. *2015 Appliance Efficiency Regulations*. CEC 400-2015-021. July. [Download](#) (PDF, 2.9 MB)

R184 California Energy Commission (CEC). 2012. *2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (Title 24)*. CEC-400-2012-004-CMF-REV2. [Download](#) (PDF, 1.9 MB)

R622 California Public Utilities Commission (CPUC). 2018. *Resolution E-4952*. October 11. [Download](#) (PDF, 2.4 MB)