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| HVAC  Whole House Fan, Residential  SWHC030-02 |

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Measure Name

Whole House Fan, Residential

Statewide Measure ID

SWHC030-02

Technology Summary

A whole-house fan can be used to transfer cool air from outside to warm areas of a home through fenestration, similar to natural ventilation assisted by propeller fans in front of open windows. Using a whole-house fan eliminates the need for an air conditioner (not equipped with an economizer) when outside air is already cooler than inside air. This can reduce electrical demand by powering only a fan motor, rather than both a fan motor and a compressor motor. In addition, cooling a space with nighttime and morning air will delay the need for an air conditioner until later in the day.

The measure requires openings in the space including windows and attic vents for introducing and recirculating the cooler outdoor air into the space.

The following study serves as a primary reference for this technology.

**Program & Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER) /Business & Consumer Electronics (BCE) (Research Into Action, 2012).** [[1]](#footnote-1) This study found that 39% of surveyed retailers offered whole house fans. The report also tabulated the electric and therms savings from PG&E program data. Finally, this study reported that 8% of households had a whole-house fan installed.

Measure Case Description

The measure case is defined as the installation of a whole-house fan in a mechanically-cooled single family residential building. The measure offerings vary by fan size (cfm/ft2 of conditioned space) and motor (W/cfm).

Measure Case Specification

| **Statewide Measure Offering ID** | **Air Flow  (cfm/ft2)** | **Motor Type** | **Motor Power (W/cfm)** |
| --- | --- | --- | --- |
| SWHC030A | 0.7 | ECM | 0.124 |
| SWHC030B | 0.7 | PSC | 0.150 |
| SWHC030C | 1.5 | ECM | 0.124 |
| SWHC030D | 1.5 | PSC | 0.150 |
| SWHC030E | 2.0 | ECM | 0.124 |
| SWHC030F | 2.0 | PSC | 0.150 |
| SWHC030G | 3.0 | ECM | 0.124 |
| SWHC030H | 3.0 | PSC | 0.150 |

Base Case Description

The base case for this measure assumes a (mechanically-cooled) conditioned home that does not include air-economizing and/or any type of central mechanical ventilation.

Code Requirements

This measure is subject to the California Building Energy Efficiency Standards (Title 24) [[2]](#footnote-2) which specifies air flow and attic vent requirements.

Applicable State and Federal Codes and Standards

|  |  |  |
| --- | --- | --- |
| **Code** | **Applicable Code Reference** | **Effective Date** |
| CA Appliance Efficiency Regulations – Title 20 | None. | n/a |
| CA Building Energy Efficiency Standards – Title 24 (2019) | Section 150.1, Table 150.1 | January 1, 2020 |
| Federal Standards | None. | n/a |

Section 150.1(c)12 of the Title 24 code requires whole-house fans in low-rise residential buildings in climate zones 8 through 14. The following is the extract from code.

SECTION 150.1 – PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES FOR LOW-RISE RESIDENTIAL BUILDINGS

(C) Prescriptive Standards/Component Package

12. Ventilation Cooling. Single family homes shall comply with the Whole House Fan (WHF) requirements shown in TABLE 150.1-A. When a WHF is required, comply with Subsections A. through C. below:

A. Have installed one or more WHFs whose total Air Flow CFM is equal to or greater than 1.5 CFM/ft2 of conditioned floor area. Air Flow CFM for WHF's shall be determined based on the Air Flow listed in the Energy Commission's database of certified appliances, which is available at: www.energy.ca.gov/appliances/database; and

B. Have at least 1 square foot of attic vent free area for each 750 CFM of rated whole house fan Air Flow

CFM, or if the manufacturer has specified a greater free vent area, the manufacturers’ free vent area specifications; and EXCEPTION to Section 150.1(c)12B: WHFs that are directly vented to the outside.

C. Provide homeowners who have WHFs with a one page “How to operate your whole house fan” Informational sheet.

Per footnote requirements to Table 150.1-A, when a whole-house fans is required, only a whole-house fan that is listed in the Modernized Appliance Efficiency Database System[[3]](#footnote-3) (MAEDS) of the California Energy Commission (CEC) may be installed. Compliance requires the installation of one or more whole-house fans with total airflow that will meet or exceed the minimum 1.5 cfm/ft2 of conditioned floor area as specified by Section 150.1(c)12.

Normalizing Unit

Per household.

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** |
| Add-on equipment (AOE) | DnDeemDI | Res |
| Add-on equipment (AOE) | DnDeemed | Res |
| New construction (NC) | DnDeemDI | Res |
| New construction (NC) | DnDeemed | Res |

Eligible Products

In addition to meeting the measure case requirements (see Measure Case Description), the following eligibility requirements apply:

* There must be an existing central air conditioning unit or ducted evaporative cooler prior to the whole-house fan installation.
* The whole-house fan must be permanently installed (connected to the framing)
* Equipment selection and installation must comply with all applicable regulations, including but not limited to latest applicable National Electrical Code (NEC) and/or California Building Energy Efficiency Standards (Title 24). See Code Requirements.

*Downstream delivery* of this measure requires collection of the following data from each applicant:

* Type of air conditioning system (Note that this measure is only applicable when there is existing central air conditioning unit or ducted evaporative cooler.)
* Manufacturer and model number of the whole-house fan
* Square feet area of conditioned space to be served by the whole-house fan
* Nominal CFM provided by whole-house fan
* Nameplate horsepower of fan motor

Eligible Building Types and Vintages

This measure is applicable for all vintages of single-family residential buildings.

Eligible Climate Zones

This measure is only applicable in California climate zones 2 through 16.

Per the Title 24 standards, this measure is eligible for new construction installations in climate zones 2 through 7, 15, and 16.

This measure has negative therm savings which vary by climate zone. PAs may evaluate the therm impact and restrict eligibility in specific climate zones as they deem fit.

Program Exclusions

The following are the program exclusions:

* All nonresidential building types
* Multifamily homes and mobile homes
* All residential and nonresidential buildings in climate zone 01
* New construction in climate zones 8 through 14

Data Collection Requirements

Data requirements are to be determined.

Use Category

HVAC

Electric Savings (kWh)

The electric unit energy savings (UES) of a whole-house fan were drawn from the Database of Energy Efficient Resources (DEER) version DEER2020 (D20v1, 9/11/2020). Savings were adopted with no changes. Savings vary by climate zone and building vintage and were reported in “per household” units for the single-family building type. As these savings come directly from the DEER database, it is understood that they included savings that have been weighted across all five DEER thermostat types.

The DEER Measure IDs and associated Measure Offering IDs and description are provided below.

Measure Offering IDs and DEER Energy Impact IDs

|  |  |  |
| --- | --- | --- |
| **Statewide Measure Offering ID** | **DEER Energy Impact ID** | **Measure Offering Description** |
| SWHC030A | WHFan-0.7-ECM | Whole House Fan with an air flow of 0.7 CFM per square foot of conditioned area; ECM motor using 0.124 W/CFM |
| SWHC030B | WHFan-0.7-PSC | Whole House Fan with an air flow of 0.7 CFM per square foot of conditioned area; PSC motor using 0.15 W/CFM |
| SWHC030C | WHFan-1.5-ECM | Whole House Fan with an air flow of 1.5 CFM per square foot of conditioned area; ECM motor using 0.124 W/CFM |
| SWHC030D | WHFan-1.5-PSC | Whole House Fan with an air flow of 1.5 CFM per square foot of conditioned area; PSC motor using 0.15 W/CFM |
| SWHC030E | WHFan-2.0-ECM | Whole House Fan with an air flow of 2.0 CFM per square foot of conditioned area; ECM motor using 0.124 W/CFM |
| SWHC030F | WHFan-2.0-PSC | Whole House Fan with an air flow of 2.0 CFM per square foot of conditioned area; PSC motor using 0.15 W/CFM |
| SWHC030G | WHFan-3.0-ECM | Whole House Fan with an air flow of 3.0 CFM per square foot of conditioned area; ECM motor using 0.124 W/CFM |
| SWHC030H | WHFan-3.0-PSC | Whole House Fan with an air flow of 3.0 CFM per square foot of conditioned area; PSC motor using 0.15 W/CFM |

Peak Electric Demand Reduction (kW)

The peak demand reduction values for the whole-house fan were drawn from the Database of Energy Efficient Resources (DEER) version DEER2020 (D20v1, 9/11/2020). Demand reduction values vary by climate zone and building vintage and were reported in “per household” units. See Electric Savings for an explanation of the approach.

Gas Savings (Therms)

The gas unit energy savings (UES) of a whole-house fan were drawn from the Database of Energy Efficient Resources (DEER) version DEER2020 (D20v1, 9/11/2020). Savings vary by climate zone and building vintage and were reported in “per household” units. See Electric Savings for an explanation of the approach.

Note that the gas UES values for this measure in DEER2020 are negative, which suggests the measure over-ventilates the space inducing slightly higher heating requirements compared to the base case.

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 methodology to calculate the RUL conforms with Version 5 of the Energy Efficiency Policy Manual, which recommends “one-third of the effective useful life in DEER as the remaining useful life until further study results are available to establish more accurate values.”[[4]](#footnote-4) This approach provides a reasonable RUL estimate without the requiring any a prior knowledge about the age of the equipment being replaced.[[5]](#footnote-5) Further, as per Resolution E-4807, the California Public Utilities Commission (CPUC) revised add-on equipment measures so that the EUL of the measure is equal to the lower of the RUL of the modified system or equipment or the EUL of the add-on component. [[6]](#footnote-6)

The EUL and RUL specified for whole house fans are specified below. A measure retention study estimated that the lifetime of a whole-house fan exceeds 20 years;[[7]](#footnote-7) the lifetime specified for this measure, however, is capped at 20 years as per policy of the CPUC.[[8]](#footnote-8)

For add-on equipment installations, the EUL of the measure is equal to the RUL.

Effective Useful Life and Remaining Useful Life

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value** | **Source** |
| EUL (yrs) – whole-house fan | 20.00 | California Public Utilities Commission (CPUC), Energy Division.  2003. Energy Efficiency Policy Manual v 2.0. Page 16. |
| RUL (yrs) – whole-house fan | 6.67 | California Public Utilities Commission (CPUC). 2016. *Resolution E-4807.* December 16. Page 13. |

Base Case Material Cost ($/unit)

Insofar as the whole-house fan is an add-on equipment or new construction measure, the base case cost is $0 because the measure is not replacing and/or retrofitting an existing technology.

Measure Case Material Cost ($/unit)

The measure case material and labor costs were derived from costs drawn from 2020 RSMeans data[[9]](#footnote-9), and retail costs collected in the fourth quarter of 2020.

Material cost was calculated using a combination of fan size dependent costs ($/CFM) and fan size independent costs ($/Fan). Since the system capacities in RSMeans do not align with system capacities of the whole-house fan measure offerings, it was necessary to determine the average cost per cfm from the RS Means cost data and use that metric to calculate the material cost for this measure. The approach to derive the final measure case cost is described below.

1. **Calculate the Cost per cfm from RSMeans Costs.** The cost of (single fan) whole-house fan measures for various whole-house fan system capacities were obtained from RSMeans. A wall type whole house fan was selected as it is assumed the fan will be installed in the attic wall. A material cost per cfm was calculated, as shown below.
2. **Calculate System Airflow Capacity for Measure Offerings**. According to the DEER2020 measure impacts documentation for building vintage Existing/ Median, a whole-house fan is assumed to serve an average conditioned space area of 2,200 ft2. System airflow capacity (cfm) was then calculated by multiplying the proposed system capacity rates (cfm/ft2) for each measure offering and the assumed conditioned area (ft2).
3. **Calculate the Material Cost per Fan.** The total cost per fan is equal to the product of the cost per cfm and the total system capacity.
4. **Differentiate Material Cost by Motor Technology.** Although not explicit, the costs reported in the RSMeans are assumed to be for a whole-house fan with a PSC motor. To determine the material cost difference between ECM whole house fan systems and PSC whole house fan systems, the following steps were taken:
   1. The RSMeans descriptions for the whole house fans did not include fan motor horsepower values, only total CFM. The horsepower values for fan motors were estimated using the CFM from RSMeans and assuming a static pressure of 0.5’’ w.c.[[10]](#footnote-10) and system efficiency (fan and motor) of 50% using the formula:

50% system efficiency was selected based on CPUC guidance[[11]](#footnote-11) for PSC motor efficiencies and the default fan system efficiency used in eQuest for residential AC systems.[[12]](#footnote-12)

* 1. To determine the fraction of the system cost associated with the motor, PSC motor costs that corresponded to the whole house fan motor capacities were taken from 2020 RSMeans data. A ratio of the PSC motor cost to the total whole house fan motor cost was found.
  2. RS Means did not have cost data on ECM motors. To estimate the ECM motor material cost, a ratio of ECM motor cost and PSC motor cost was found using 2020 online retailer (Grainger, SupplyHouse, and Zoro) cost data.
  3. The PSC motor cost to whole house fan motor cost ratio and ECM motor cost to PSC motor cost ratio were multiplied to determine the material cost increase between an ECM whole house fan system and a PSC whole house fan system.

Other material costs associated with the measure were then added to the fan size dependent costs. These costs are required per installation and do not vary by CFM or by motor type. The fan size independent costs include the cost of a junction box and the electrical cable to connect the new fan system to the existing electrical system. Metal clad cable was assumed as it is most common in residential applications.

Complete costing calculations can be found in the MeasureDataSpec attachment.[[13]](#footnote-13)

Base Case Labor Cost ($/unit)

Insofar as the whole-house fan is an add-on equipment (AOE) or new construction (NC) measure, the base case cost is $0 because the measure is not replacing and/or retrofitting an existing technology.

Measure Case Labor Cost ($/unit)

Labor cost was derived from the average estimated labor hours to install for the various whole house fan system sizes from 2020 RSMeans[[14]](#footnote-14) data and a residential electrician labor rate adjusted for the California region ($91.61/hr)[[15]](#footnote-15).

Labor cost was calculated using a combination of fan size dependent costs ($/CFM) and fan size independent costs ($/Fan).

Fan size dependent costs included installation of the fan and creating the wall opening. Labor hours for the fan installation were estimated based on a calculated cost per CFM of whole house fans in RSMeans. Labor hours for creating the wall opening were sourced from RS Means labor data for window demolition, the closest available line item for the task. Labor data for 2’x2’ and 3’x3’ windows were used, which match the typical fan sizes used in cost estimation.

Fan size independent costs included installation of a junction box, installation of electrical cable, and a residential electrician trip charge. The trip fee is the common base fee associated with residential contractors was estimated to be one hour based on online research.

Since the installation scope of work will remain the same irrespective of the motor type, the labor costs for a PSC motor and an ECM motor are the same.

Complete costing calculations can be found in the MeasureDataSpec attachment.17

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 values are 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. *DEER Database 2011 Update Documentation.* 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. The GSIA rate specified for whole house fans is the current “default” rate specified for measures for which an alternative GSIA has not been estimated and approved.

Gross Saving Installation Adjustment Rate

|  |  |  |
| --- | --- | --- |
| **Parameter** | **GSIA** | **Source** |
| GSIA - Default | 1.0 | California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. 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 | No |
| Scaled DEER measure | No |
| DEER Base Case | Yes |
| DEER Measure Case | Yes |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | Yes |
| DEER Version | DEER 2020 per READI v.2.5.1 (Preliminary Ex Ante Review data) |
| Reason for Deviation from DEER | n/a |
| DEER Measure IDs Used | WholeHouseFan-0.7CFM-ECM  WholeHouseFan-0.7CFM-PSC  WholeHouseFan-1.5CFM-ECM  WholeHouseFan-1.5CFM-PSC  WholeHouseFan-2.0CFM-ECM  WholeHouseFan-2.0CFM-PSC  WholeHouseFan-3.0CFM-ECM  WholeHouseFan-3.0CFM-PSC |
| NTG | Source: DEER2019. The NTG of 0.55 is associated with NTG ID: *Res-Default>2* |
| GSIA | Source: DEER2011. The GSIA of 1.0 is associated with GSIA ID: *Def-GSIA* |
| EUL/RUL | For NC: The value is 20 years. Source: DEER2014. EUL ID: *HV-WHfan.*  FOR AOE: The value is 6.67 (EULHOST/3). Source: DEER2014. EUL ID: *HV-WHfan.* |

Revision History

Measure Characterization Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision Number** | **Date** | **Primary Author, Title, Organization** | **Revision Summary and Rationale for Revision**  **Effective Date and Approved By** |
| 01 | 06/30/2018 | Jennifer Holmes  Cal TF Staff | Draft of consolidated text for this statewide measure is based upon:  SCE17HC005, Revision 0 (October 30, 2017)  SCE1HC005, Revision 2 (January 25, 2016)  Consensus reached among Cal TF members. |
| 03/25/2019 | Akhilesh Endurthy, Solaris-Technical | Updated to DEER2020  Applied DEER2020 Vintage weights  Updated costs using escalation factor for 2019 |
| 05/31/2019 | Jennifer Holmes  Cal TF Staff | Revisions for submittal of version 01. |
| 05/19/2020 | Jesse Manao  SCE | Correction in EAD Table:  - Offering and Energy Impact ID  - Measure Impact Type  - Version and VersionSource |
| 02 | 7/16/2021 | Stephen Brett Reno, P.E., TRC  Lake Casco, P.E., TRC | Updated materials and labor costing using new 2020 data and new materials sources.  Updated cost methodology to break out motor costs from fan system costs, and to differentiate between fan size dependent variables and fan size independent variables.  Updated measure savings to DEER2020 D20v1 values from 9/11/2020. |

1. Research Into Action and Energy Market Innovations (EMI). 2012. *Program & Technology Review of Two Residential Product Programs: Home Energy Efficiency Rebate (HEER) /Business & Consumer Electronics (BCE)*. Study # SCE0306. Prepared for Southern California Edison (SCE) and Pacific Gas and Electric Company (PG&E). August 30. [↑](#footnote-ref-1)
2. California Energy Commission (CEC). December 2018. *2019 Building Energy Efficiency Standards for Residential and Nonresidential Buildings*. CEC-400-2018-020-CMF [↑](#footnote-ref-2)
3. <https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx> [↑](#footnote-ref-3)
4. California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 32. [↑](#footnote-ref-4)
5. KEMA, Inc. 2008. "Summary of EUL-RUL Analysis for the April 2008 Update to DEER." Memorandum submitted to Itron, Inc. [↑](#footnote-ref-5)
6. California Public Utilities Commission (CPUC). 2016. *Resolution E-4807.* December 16. Page 13.   [↑](#footnote-ref-6)
7. GDS Associates, Inc. 2007. Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for the New England State Program Working Group (SPWG).  [↑](#footnote-ref-7)
8. California Public Utilities Commission (CPUC), Energy Division.  2003. Energy Efficiency Policy Manual v 2.0. Page 16. [↑](#footnote-ref-8)
9. Gordian. (n.d.) *RSMeans Cost Index.pdf*. 2020. [↑](#footnote-ref-9)
10. California Energy Commission (CEC). December 2018. *2019 Residential Compliance Manual for the 2019 Building Energy Efficiency Standards*. CEC-400-2018-017-CMF. Section 4.4.1.16 “Airflow and Fan Efficacy Testing Versus Return Duct Sizing” [↑](#footnote-ref-10)
11. California Public Utility Commission (CPUC). January 2021. “CPUCcomm\_SWHC030-02\_WholeHouseFan\_012621\_Response.docx*”* [↑](#footnote-ref-11)
12. Lawrence Berkley National Laboratory and James J. Hirsch & Associates. 2017 “DOE-2.3 Building Energy Use and Cost Analysis Program, Volume 3: Topics” Page 299. Template for “RESYS” systems, SUPPLY-EFF keyword. [↑](#footnote-ref-12)
13. Southern California Edison (SCE). (n.d.) "SWCR030-02 MeasureDataSpec.xls", “Cost Data” and “Cost Source” tabs. [↑](#footnote-ref-13)
14. Gordian. (n.d.) *RSMeans Cost Index.pdf*. 2020. [↑](#footnote-ref-14)
15. RSMeans 2020 Residential Labor Rates. https://www.rsmeansonline.com/References/LABORRATE/2-Year%202020%20Labor%20Rates/Residential%20Labor%20Rates.PDF [↑](#footnote-ref-15)