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HVAC

WHOLE HOUSE FAN, RESIDENTIAL

SWHC030-01

CONTENTS

MEASURE NAME

Whole House Fan, Residential

STATEWIDE MEASURE ID

SWHC030-01

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] 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/ft^2)	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

[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.

Statewide Measure Offering ID	Air Flow (cfm/ft^2)	Motor Type	Motor Power (W/cfm)
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] 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-A	January 1, 2020
Federal Standards	None.	n/a

Section 150.1(c)12 of the Title 24 code requires whole-house fans in single family 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.

[2] California Energy Commission (CEC). December 2018. *2019 Building Energy Efficiency Standards for Residential and Nonresidential Buildings*. CEC-400-2018-020-CMF

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] (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/ft^2 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)

[3] https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx

- 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.

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). Savings vary by climate zone and building vintage and were reported in “per household” units for the single-family building type.

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

The UES values in DEER2020 are available for “Old”, “Existing”, “Recent” and “New” vintages. For ease of implementation, Old and Existing are consolidated into “Ex” vintage using DEER2020 residential vintage weights[4] and weighted average approach. The Recent vintage is dropped as it covers only the three year period of 2017 to 2019.

DEER2020 residential vintage weights are available as a function of program administrator (PA), building type, building location (climate zone, CZ), and building vintage (by model year). Year-style vintages are mapped to DEER2020 style vintages (old, “ex” representing median existing, recent, and new). Consolidation of building weights and UES was required as follows to match with the measure offerings.

1. Since the measure offerings distinguish building age at the era-style vintages, the weights table indexed by year-style vintage needed to be transformed to align with the indexing of the DEER measure UES and measure offerings. For example, the weights for model year vintages 2003 to 2015 (representing buildings with actual vintages from 2002 to 2016) were summed to determine the weights of the “ex” era for each combination of PA, building type, and building location.
2. The DEER2020 UES values for “new” are provided for “Any” PA; however, the weights table is indexed by specific PAs. Hence, for “new”, the weights of all the PAs were combined in each climate zone that intersects the service areas of more than one PA.
3. The DEER2020 UES values for “old, ex, recent” are provided for each specific PA (SCE, PGE, SDG), so there are multiple UES entries in each climate zone that intersects more than one PA service

[4] California Public Utilities Commission (CPUC), Energy Division. (n.d.) “DEER2020-Building-Weights.xlsx.”

area. For example, “ex” vintage UES for CZ15 are provided for SCE, PGE, and SDG. In such cases the corresponding PA specific weights from Step 1 were applied.

4. Finally, using the above steps, the weighted average energy and demand UES values were calculated and presented as combinations for any PA, single family building type; ex and new vintages, and the 15 climate zones where this measure is applicable.[5]

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). 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). 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.”[6] This approach provides a reasonable RUL estimate without the requiring any a prior knowledge about the age of the equipment being replaced.[7] 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. [8]

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[5] Southern California Edison (SCE). 2019. “SWHC030-01 Calcs.xlsx.”

[6] California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 32.

[7] KEMA, Inc. 2008. "Summary of EUL-RUL Analysis for the April 2008 Update to DEER." Memorandum submitted to Itron, Inc.

[8] California Public Utilities Commission (CPUC). 2016. *Resolution E-4807.* December 16. Page 13.

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;[9] the lifetime specified for this measure, however, is capped at 20 years as per policy of the CPUC.[10]

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 the 2010-2012 WO017 Ex Ante Measure Cost Study ("WO017") conducted by Itron, Inc.,[11] and retail costs recorded in 2017.[12] Because the system capacities in WO017 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 WO017 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 WO017 Costs.** The cost of a (single fan) whole-house fan measure for various whole-house fan system capacities were obtained from the WO017 study. (System capacities in WO017 are based on manufacturer cut sheets.) A material cost per cfm was calculated, as shown below.
2. **Convert the Cost per cfm to 2019 values.** Material costs in WO017 were based upon RSMeans 2013 cost data.[13] To convert the WO017 costs to 2019 values, an escalation factor (i.e., a price index) was created as the ratio of the referenced RSMeans costs (motors) to the comparable 2019 data. The

[9] 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).*

[10] California Public Utilities Commission (CPUC), Energy Division. 2003. *Energy Efficiency Policy Manual v 2.0.* Page 16.

[11] Itron, Inc. 2014. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report.* Prepared for the California Public Utilities Commission.

[12] Southern California Edison (SCE). 2019. "SWHC030-01 Cost Sources.xlsx."

[13] Southern California Edison (SCE). 2019. "SWHC030-01 Cost Sources.xlsx."

resultant escalation factor was then applied to convert the WO017 values to 2019 values.. The material escalation factor is calculated to be 114.76%

Whole-house Fan Material Cost, by System Capacity

	System Capacity (cfm)				Total (9750)	Source
	2300	1600	2500	4500		
Material Cost ($)	$620.20	$535.10	$649.58	$903.98	$2708.86	Itron, Inc. 2014. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report.* Prepared for the California Public Utilities Commission.
Material Cost (2013 $/cfm)	$0.27	$0.33	$0.26	$0.20	$0.25	Calculated
Material Cost (2019 $/cfm)	$0.31	$0.38	$0.30	$0.23	**$0.29**	RSMeans Engineering Department. 2013 and 2019. RSMeans *Electrical* Cost Data 201*3 and 2019.* Line Numbers 267113200010/050/060/070/080/090/100

3. 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 ft^2. System airflow capacity (cfm) was then calculated by multiplying the proposed system capacity rates (cfm/ft^2) for each measure offering and the assumed conditioned area (ft^2).

4. 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.

5. Differentiate Material Cost by Motor Technology. Although not explicit, the costs reported in the WO017 study are assumed to be for a whole-house fan with a PSC motor, since PSC motors were previously described to be the default motor supporting this technology.[14] To estimate the ECM motor material cost, a ratio of the cost of an ECM to a PSC motor was calculated. PSC motor cost was from 2017 RSMeans[15] and ESC motor cost was obtained from www.grainger.com.[16] This ECM/PSC cost ratio was then applied to the cost of PSC motor to calculate the material cost of a whole-house fan with an ECM motor.

ECM/PSC Motor Costs

Motor Capacity (hp)	PSC Motor Cost ($)	ECM Motor Cost ($)	ECM/PSC Cost Ratio
1/3	$232.00	$312.50	135%

[14] Davis Energy Group and Energy Solutions. 2004. *Codes and Standards Enhancement Initiative for PY2004: Title 20 Standards Development - Analysis of Standards Options for Whole House Fans.* Prepared for Pacific Gas and Electric (PG&E). April 28. Page 2.

[15] RSMeans Engineering Department. 2017. *RSMeans Electrical Cost Data 2017.* Line Numbers 2671132000070/080/090

[16] Southern California Edison (SCE). 2019. "SWHC030-01 Cost Sources.xlsx."

Motor Capacity (hp)	PSC Motor Cost ($)	ECM Motor Cost ($)	ECM/PSC Cost Ratio
1/2	$194.00	$349.00	180%
3/4	$271.00	$381.50	141%
1	$290.00	$427.00	147%
Average ECM/PSC Ratio			**151%**

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 estimated labor hours and labor rate to install a whole-house fan documented in the 2010-2012 WO017 Ex-Ante Measure Cost Study ("WO017") conducted by Itron, Inc.[17] Because the installation scope of work will remain the same irrespective of the motor type, the labor costs for a PSC motor is considered to be the same as an ECM motor. The approach to derive measure case labor costs is the same as the approach to determine the measure case material costs (see Measure Case Material Cost).

Installation Labor Cost Inputs

Parameter	Value	Source
Labor Hours	6.0	Itron, Inc. 2014. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report.* Prepared for the California Public Utilities Commission.
Labor Rate (2013 $/hour)	$67.02	
Escalation Rate	108.73%	RSMeans Engineering Department. 2013 and 2019. *RSMeans Electrical Cost Data 2013 and 2019.* Line Numbers 267113200010/050/060/070/080/090/100
Total Labor Cost (2019 $/hour)	$72.87	Calculated

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.

[17] Itron, Inc. 2014. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report.* Prepared for the California Public Utilities Commission. Table 4-13, Page 4-30.

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

DEER Item	Comment / Used for Workpaper
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