**Work Paper SCE13HC005**

**Revision 1**

**Southern California Edison Company**

**Whole House Fan**

# At-a-Glance Summary

|  |  |
| --- | --- |
| ****Applicable Measure Codes:**** | AC-43904 |
| **Measure Description:** | Whole house fan can potentially eliminate the need to operate an air conditioner (not equipped with an economizer) when outside air temperature and relative humidity are more adequate than space conditions (e.g., cooler) |
| **Base Case Description:** | Mechanical Central AC with Gas Furnace / Central HP equipment for space heating and cooling without night ventilation and/or air economizing |
| **Energy Impact Common Units:** | Per Home |
| **Energy Savings :** | Refer to Excel Calculation Attachment |
| **Gross Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Measure Incremental Cost ($/unit):** | Refer to Excel Calculation Attachment |
| **Effective Useful Life (years):** | 20 |
| **Measure Application Type:** | Retrofit Add On (REA) |
| **Net-to-Gross Ratios:** | 0.55 (All ProgDelivID); 0.85 (DirInstall) |
| **Important Comments:** | This work paper document does not contain a data set in conformance with the 4/1/14 CPUC Ex Ante Database Specification; SCE will provide that data set separately. |

# Document Revision History

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Workpaper and Revision # | Tech. Revision | MM/DD/YY | Author/Affiliation | Summary of Changes |
| SCE13HC005.0 | No | 05/01/2012 | Joseph Ling/AESC | Original work paper template for 2013 PC |
| SCE13HC005.1 | Yes | 2/21/2014 | Andres Fergadiotti/SCE | Work paper updated for the reporting period, effective 7/1/14 – 12/31/14. |

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This work paper details the values used to estimate the impacts of installing a whole house fan (WHF) to reduce residential cooling energy requirements. The existing base case for this measure assumes a (mechanically cooled) conditioned home with no night ventilation and no economizer.

A whole house fan can be used to transfer cool outside air 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 to operate 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.

Table 1 Measure Names

|  |  |
| --- | --- |
| Solution Code | Measure name |
| AC-43904 | Whole House Fan |

The measure requires that base case includes HVAC system providing mechanical cooling. The base case HVAC system; however, does not include air-economizing.

Per Title-24 requirements, measure installation requires that WHF be sized at least 2 cfm/sqft. of conditioned floor area and have at least 1 sqft. of attic vent free area for each 375 cfm of rated whole house fan air flow. Some installation may include a control timer (e.g., 30 min. WHF operation) and/or a two speed controller (e.g., low fan speed and high fan speed).

Additionally, the Home Energy Efficiency Rebate (HEER) Program requirements dictate that the following conditions be met to be eligible for savings [[[1]](#endnote-1)]:

1. Whole house fan must move a minimum of 1000 cubic feet of air per minute (CFM)
2. Whole house fan must be used with an existing central air conditioning unit or ducted evaporative cooler
3. Whole house fan must be permanently installed (connected to the framing).

## 1.2 Technical Description

This technology includes a ventilation fan (generally installed in the attic space) to introduce colder outdoor air into the space when outdoor temperature and humidity are adequate. The measure requires openings in the space including windows and attic vents for introducing and recirculating the cooler outdoor air into the space. System flow in the measure is generally in the order of 2 cfm per gross area of conditioned space.

## 1.3 Measure Application Type

The program/install type for the above measures is:

* Retrofit Add-On (REA)

The delivery methods that are available for the measure are:

* Financial Support – Down-stream - Deemed
* Partnership – Down-stream – Deemed
* Financial Support – Direct Install
* Partnership – Direct Install

## 1.4 Measure and Base Case Cost Effectiveness Data

### 1.4.1 DEER Measure and Base Case Analysis

This measure is included in the Database for Energy Efficient Resources (DEER) [[[2]](#endnote-2)] using the READi software under Measure ID D03-441. In DEER 2011 and 2014, this measure displays data in common units of “Area-1kH”, presented by climate zone and building vintage. The common units used to normalize the savings data in DEER vary based on climate zone, building type and building vintage. The variance in common unit type is in accordance with standard DEER square footage/home per building type, climate zone and vintage type. For program planning purposes, this data was converted to common units of “per home”, and building vintages were reduced into representative weighted averages for each climate zone. Savings calculations for residential building types were performed for Residential Single Family (SFM), Residential Multi-Family (MFM) and Residential Mobile Home (DMO).

The measure in DEER 2014 holds the same assumptions as DEER 2011. One of these assumptions puts whole house fan efficiency at 0.125 Watts [W] /cubic feet per minute [cfm].

Table 2 DEER Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Modified DEER Methodology | Yes |
| Scaled DEER Measure | No |
| DEER Building Prototypes Used | No |
| Deviation from DEER | Normalized Units on a "Per Home" Basis |
| DEER Version | DEER14 |
| DEER Run ID and Measure Name (Sample) | D03-441 / Whole House Fans |

**Net to Gross**

The NTG value was obtained from the “DEER2011\_NTGR\_2012-05-16.xls” on the DEER website as required by Version 5 of the California Public Utilities Commission (CPUC) Energy Efficiency Policy Manual [351]. The relevant NTGR for this measure is shown in Table 3 below.

Table 3 Net-to-Gross Ratio

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NTGR\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID | NTG\* |
| Res-Default>2 | All other EEM with no evaluated NTGR; existing EEM with same delivery mechanism for more than 2 years | Res | Any | All | 0.55 |
| Res-Default-HTG-di | All other EEM with no evaluated NTGR; direct install hard-to-reach only. | Res | Any | DirInstall | 0.85 |

\*Denotes that the column is taken from the DEER NTG Table.

**Installation Rate**

The installation rate (IR) is identified in the calculation attachment. This value is obtained from the support table available in READi. Currently there is no versioning on the installation rate table. To address appropriate selection of the installation rate the date of the workpaper will serve as the last date checked for updated IR values. The installation rate varies by end use, sector, technology, application, and delivery method. The relevant IR values for this measure are shown in Table 4 below.

Table 4 Installation Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| GSIA\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID | GSIAValue\* |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1 |

**Spillage Rate**

Spillage rate will also be applied to measures however the values will not be tracked in the workpapers. The spillage rate will be tracked in an external table to be supplied to the Energy Division.

**READi Technology Fields**

To support the development of the ED ex ante tables, select fields from the ex ante database will be identified in the workpaper. For a full set of values associated with the measures in the workpaper refer the Excel calculation template.

Table 5 READi Tech IDs

|  |  |
| --- | --- |
| READi Field Name | Values included in this workpaper |
| Measue Case UseCategory | HVAC |
| Measure Case UseSubCats | VentAirDist |
| Measure Case TechGroups | HVAC Technology |
| Measure Case TechTypes | HVAC Ventilation Fan - General |
| Base Case TechGroups | HVAC Technology |
| Base Case TechTypes | Packaged Terminal AC |

### 1.4.2 Codes and Standards Analysis

Table 6 Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 24 (2013) | Title 24 Building Energy Efficiency Standards, Section 150.1, Table 150.1-A | July 01, 2014 |

**2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings**

**SECTION 150.1 – PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES FOR NEWLY**

**CONSTRUCTED 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 of the Standards (e.g., Climate Zones 8 through 14). When a WHF is required, comply with Subsections below:

A. Have installed one or more WHFs whose total Air Flow CFM as listed in the CEC Directory is at least

2 CFM/ft2 of conditioned floor area; and

B. Have at least 1 square foot of attic vent free area for each 375 CFM of rated whole house fan Air Flow

CFM; and

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

Per footnote requirements to TABLE 150.1-A: When whole house fans are required (REQ), only those whole house fans that are listed in the Appliance Efficiency Directory may be installed. Compliance requires installation of one or more WHFs whose total airflow CFM is capable of meeting or exceeding a minimum 2 cfm/square foot of conditioned floor area per Section 150.1(c)12.

### 1.4.3 Non-DEER Study Review

A 2004 PG&E study [[[3]](#endnote-3)] suggests that whole house fan efficiency lies between 0.051 W/cfm to 0.077 W/cfm, which is approximately 50% of the DEER assumption. Modeling assumptions within DEER including fan power consumption that should be revisited and updated per the latest high efficient technologies as required.

### 1.4.4 Measure and Base Case Effective Useful Life

DEER14 update documentation provides EUL and RUL information to be used for the 2015 program cycle extension on [www.deeresources.com](http://www.deeresources.com). The DEER documentation “Summary of EUL-RUL Analysis for the April 2008 Update to DEER” provides the RUL value as a flat 1/3 of the EUL value. The RUL value will only be applied to the first baseline period for retrofit measures that have applicable code that will affect the energy savings. In all other installation types and retrofit with no applicable code that affects the energy savings, the RUL is not applicable to either the first or second baseline period.

To obtain the EUL value the DEER14 update documentation, EUL\_Summary\_10-1-08.xls [213], was consulted. Table 7 below identifies the value/methodology used for the measures in this work paper.

Table 7 DEER14 EUL Value/Methodology

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| READi EUL ID | Market | Enduse | Measure | EUL (Years) | RUL (Years) |
| HV - WHFan | Residential | HVAC | Whole House Fans | 20 | N/A |

EUL for Whole House Fans is 20 years for Retrofit Add-On (REA). This workpaper references DEER EUL\_ID HV-WHfan.

**Section 2. Energy Savings & Demand Reduction Calculations**

Savings data for Measure ID D03-441 was obtained using the READi software for DEER 2014 (version READI v.1.0.4 – “DEER for 2014 Code Update” database). The DEER14 data can be found in Table 11.

DEER 2014 savings for this measure are estimated per measure area (MeasArea) of home equivalent to Residential DEER prototypes for climate zone and building type and vintage type combination with Baseline Residential gross area of 1,000 sqft. All savings are normalized per the Baseline Residential gross area and scaling factor (NumUnits) generated by the READi software. Energy analysis is based on weighted (rWtd) building HVAC and average customer whole building kWh, kW, and Therms (e.g., ACustWBkW). See Table 11 READi Tool Outputs for general output parameters including prototype gross area and scaling factors.

Some of the kWh and Therm savings in the READi output are documented as negative indicative of whole house fan overcooling and/or overheating the space with lengthier fan operation hours. Actual operating hours on the whole house fan are expected to be lower than those documented in Building Attributes of the calculation sheet (e.g., Night Operation - 4,100 hours). Additionally, operating hours are expected to vary among Climate Zones.

New Whole House Fan technology is generally equipped with multi-speed fan settings and/or high fan speed and low fan speed and/or timers. Per DEER documentation, whole house fan power rating is assumed to be 0.125 W/cfm with ventilation rates in the order of 4.0 ACH and 2.5 ACH for single family and multi-family and mobile home respectively.

Table 8 below documents Residential building area per Residential building type in climate zone 6.

Table 8 - Square Feet per Home for Climate Zone 6 per Building Type

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Climate Zone | Bldg. Type | Bldg. Vintage | Bldg. HVAC | Square Feet/Home | Num. Unit |
| 6 | DMo | Ex | rWtd | 1,220 | 1.22 |
| 6 | MFm | Ex | rWtd | 1,000 | 1.00 |
| 6 | SFm | Ex | rWtd | 1,710 | 1.71 |

Average savings are estimated (and adjusted) using average customer whole building WBkWh and WBkW respectively adjusted per DEER measure area factors (number unit) included as part of the DEER analysis. See Table 11 READi Tool Outputs.

**Example Calculation:**

Residential building types in Climate Zone 6 have the following energy and demand and gas savings per 2014 DEER documentation. DEER data include adjustment units for normalizing savings based on building area of prototypical type. Following Tables sample savings methodology.

Table 9 – Non-Adjusted Energy and Demand Savings and Gas Savings Sample for Climate Zone 6

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Climate Zone | Bldg. Type | Num. Unit (Adjustment) | ACustWB\_kWh | ACustWB\_kW | ACustWB\_therm |
| 6 | DMo | 1.22 | 17.8 | 0.408 | -0.187 |
| 6 | MFm | 1.00 | 23.9 | 0.395 | -0.53 |
| 6 | SFm | 1.71 | 48.8 | 0.502 | -0.289 |

Table 10 – Adjusted Energy and Demand Savings and Gas Savings Sample for Climate Zone 6

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Climate Zone | Bldg. Type | ACustWB\_kWh | ACustWB\_kW | ACustWB\_therm |
| 6 | DMo | 14.590 | 0.334 | -0.153 |
| 6 | MFm | 23.900 | 0.395 | -0.530 |
| 6 | SFm | 28.538 | 0.294 | -0.169 |

Sample calculation methodology applied to all climate zones, and DMO, MFM and SFM building types. Estimated savings for all building types and climate zones using READi documentation can be found in Attachment 2 – “Sample Calculations DEER2014”.

Table 11 contains the data files for measures that are taken directly from the DEER 2014 READi Tool or were created using the READi Tool. These results have not been modified and are only being included in the workpaper for reference.

Table 11 READi Tool Outputs

|  |  |  |
| --- | --- | --- |
| Solution Code | Measure Name | READi Results |
| AC-43904 | Whole House Fans |  |

# Section 3. Load Shapes

The difference between the base case load shape and the measure load shape would be the most appropriate load shape; however, only end-use profiles are available. Therefore, the closest load shape chosen for this measure is the Economy\_cycle-Ret load shape. See Table 12 for a list of all Building Types and Load Shapes. See the KEMA report [31] for a more thorough discussion regarding the load shapes for this measure.

Table 12 Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| Building Type | E3 Alt. Building Type | Load Shape |
| Residential - Single-Family | Misc.\_Commercial | Economy\_cycle-Ret |
| Residential - Multi-Family | Misc.\_Commercial | Economy\_cycle-Ret |
| Residential - Double-Wide Mobile Home | Misc.\_Commercial | Economy\_cycle-Ret |

# Section 4. Base Case & Measure Costs

Work paper assumes that installation type in the measure is Retrofit Add-On (REA), where the new equipment has no pre-existing baseline. In this case, there is no RUL period for the equipment.

## 4.1 Base Case Cost

For a Retrofit Add-On (REA) measure, the base case cost is $0/home because the measure is not replacing and/or retrofitting an existing technology.

## 4.2 Measure Case Cost

For this measure category, the gross measure cost (containing the Measure Case Cost) is used in the calculation of the incremental cost.

## 4.3 Gross and Incremental Measure Cost

### 4.3.1 Gross Measure Cost

Per the E3, the gross measure cost is the cost to install an energy efficient measure. This definition implies two different meanings depending on the install type. In the case of RET, REA, and REF, GMC means the full cost of the measure to purchase and install.

For RET, REA, and REF, GMC is represented by the equation below:

***GMC = Measure Equipment Cost + Measure Labor Cost***

In the case of RET, REA, and REF, the customer is making a conscience decision to replace existing, working equipment before the useful life of the equipment has expired. Since this is a discretionary choice by the consumer, the cost invoked is the full cost of the equipment and installation of the energy efficient equipment.

The Gross Measure Cost including both Measure Case (Equipment) Cost and Labor Cost obtained from DEER 2005 Measure Cost Study Final Report [[[4]](#endnote-4)]. For Retrofit Add-On (REA) these are the same since there is no base case cost. The entry for this measure type was found in the DEER 2008 measure cost update, however the costs in this entry were determined to be invalid or not applicable at this time (cost << $1.00). It was therefore deemed appropriate to maintain DEER 2005 cost estimates. The cost is shown in Table 13.

Table 13 Gross Measure Cost

|  |  |  |  |
| --- | --- | --- | --- |
| **Size** | **Measure Equipment Cost** | **Labor Cost** | **Gross Measure Cost** |
| < 4000 CFM | $450.91 | $244.12 | $695.03 |
| 4000 – 6000 CFM | $425.74\* | $269.72 | $695.46 |
| 6000 – 8000 CFM | $400.56 | $295.32 | $695.88 |
| > 8000 CFM | $409.65 | $320.92 | $730.57 |
| Average | $421.72 | $282.52 | **$704.24** |

\* The 2005 Measure Cost Study indicates an equipment cost of $243.17 for a “4000-6000 CFM” whole house fan. This value was discarded and replaced with $425.74, an average of the “< 4000 CFM” and “6000-8000 CFM” equipment costs.

### 4.3.2 Incremental Measure Cost

Incremental Measure Cost (IMC) is the premium cost to install an energy efficient measure over a standard efficiency measure or code baseline measure. While IMC has a straight forward definition depending on the install type, the equation does vary. The incremental cost is only used to help determine program incentives. It is not affected by the first and second baseline periods and may differ from the cost used for cost effectiveness calculations.

For NEW, ROB, RET, and REF measures, there exists a theoretical base case that the measure can be compared to in cost. Because a base case exists for NEW, ROB, RET, and REF IMC is represented by the equation below:

IMC = (Measure Equipment Cost + Measure Labor Cost) –

(Base Case Equipment Cost + Base Case Labor Cost)

\*Note: Unless stated otherwise the measure case labor and base case labor are assumed to be the same value reducing the equation to the following:

*IMC = Measure Equipment Cost – Base Case Equipment Cost*

For REA there exists no base case to compare the measure to, as in the case of an economizer added to a HVAC system. Adding the economizer is the energy efficient measure and the base case is the absence of an economizer therefore there truly is no base case cost. Because of this, for REA, IMC is represented by the equation below:

*IMC = Measure Equipment Cost + Measure Labor Cost*

As there is no existing standard efficiency or code baseline measure, for NEW and RET Whole House Fan measures, a theoretical base case does not exist. Because of this for NEW and RET, therefore IMC = GMC.

# Attachments

1. 
2. 

# References



[31]

[213]

[351]

# Appendix A – SCE/ED Application Types

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| SCE Program Type | ED Application Type | 1st Baseline Savings | 2nd Baseline Savings | 1st Baseline Cost | 2nd Baseline Cost | 1st Baseline Life | 2nd Baseline Life |
| New | New Construction (Nc) | Above Code/Standard | N/A | Incremental Cost | N/A | EUL | 0 |
| Replace on Burnout (ROB) | Replace on Burnout (Rob)/Normal Replacement (NR) | Above Code/Standard | N/A | Incremental Cost | N/A | EUL | 0 |
| Retrofit (RET) | Early Replacement (ER) | Above Cust. Existing | Above Code/Standard | Full Cost | Incremental Cost | RUL | EUL-RUL |
| Retrofit – First Baseline Only (REF) | Early Replacement RUL (ErRul) | Above Cust. Existing | N/A | Full Cost | N/A | EUL | 0 |
| Retrofit Add-on (REA) | N/A | Above Cust. Existing | N/A | Full Cost | N/A | EUL | 0 |

1. [] <http://www.sce.com/residential/rebates-savings/heating-cooling/whole-house-fan.htm> [↑](#endnote-ref-1)
2. [] 2011 Database for Energy Efficient Resources (DEER) Version 2011.4.00, September 2011. [↑](#endnote-ref-2)
3. [] Fernstorm G. B., “Analysis of Standard Options for whole House Fans”, CASE Initiative Study, PG&E, April 28, 2004 [↑](#endnote-ref-3)
4. [] <http://deeresources.com/deer2005/downloads/DEER2005UpdateCostDataAndUsersGuide.exe> [↑](#endnote-ref-4)