Work Paper SCE13HC005

**Revision 2**

**Southern California Edison**

**Whole House Fan**

**For Work Paper Reviewer Use Only**

**List all major comments that occurred during the review. This table may only be removed during management review.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Major Comment** | **Reviewer Name** | **Date** | **Outcome/Resolution** |
| E.g. Please remove measure LT-12345 (LD123) from this work paper because it is no longer eligible for incentives. | Reviewer 1 | 6/1/15 | E.g. Comment incorporated. LT-12345 was removed. |
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|  |  |  |  |

# At-a-Glance Summary

|  |  |
| --- | --- |
| **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 |
| **Units** | Per Home |
| **Energy Savings** | Refer to Excel Calculation Attachment |
| **Full Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Incremental Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Effective Useful Life** | 20 years (HV-WHfan) |
| **Measure Installation Type** | Retrofit Add On (REA) |
| **Net-to-Gross Ratio** | 0.55 (All ProgDelivID); 0.85 (DirInstall) |
| **Important Comments** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 05/01/2012 | Joseph Ling/AESC | Original work paper template for 2013 PC |
| 1 | 2/21/2014 | Andres Fergadiotti/SCE | Work paper updated for the reporting period, effective 7/1/14 – 12/31/14. |
| 2 | 1/25/16 | Andres Fergadiotti/SCE | -New template update for 2016 program year  -WP effective from 1/1/2016 thru 12/31/2016 |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
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|  |  |  |  |  |  |

Cal TF website: <http://www.caltf.org/>

# 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.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Whole House Fan |
| Existing Condition | Mechanical Central AC with Gas Furnace / Central HP |
| Code/Standard | N/A |
| Industry Standard Practice | N/A |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
| N/A | N/A | AC-43904 | N/A | 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 Installation Types and Delivery Mechanisms

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

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Retrofit Add-on (REA) | Above Customer Existing | N/A | EUL | N/A |

A delivery mechanism is a delivery method paired with an incentive method. Delivery mechanisms are used by programs to obtain program participation and energy savings.

**Delivery Method Descriptions**

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |
| Partnership | The program implements projects through a partnership between the utility and an institutional, government, or community-based organization. |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Direct Install | The program implements energy efficiency measures for qualifying customers, at no cost to the customer. |
| Down-Stream Incentive | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

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].

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | Yes |
| Scaled DEER measure | Yes |
| DEER Base Case | Yes |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | Yes |
| DEER Version | DEER 2014 |
| Reason for Deviation from DEER | Normalized Units on a "Per Home" Basis |
| DEER Measure IDs Used | N/A |

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI tool. The relevant NTG values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| Res-Default>2 | All other EEM with no evaluated NTGR; existing EEM with same delivery mechanism for more than 2 years | Res | Any | Any | 0.55 |
| Com-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Res | Any | DirInstall | 0.85 |

**Spillage Rate**

Spillage rates are not tracked in work papers; they are tracked in an external document which will be supplied to the Commission Staff.

**Installation Rate**

The IR values were obtained using the DEER READI tool. The relevant IR values for the measures in this work paper are in the table below.

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

**Effective and Remaining Useful Life**

The EUL and RUL values were obtained using the DEER READI tool. DEER defines the RUL as 1/3 of the EUL value. The RUL value is only applicable to the first baseline period for an RET measure with an applicable code baseline. The relevant EUL and RUL values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| HV-WHfan | Whole House Fans | Res | HVAC | 20 | N/A |

### 1.4.2 Codes and Standards Analysis

**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.

Code Summary

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

## 1.5 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information

### 1.5.1 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.

# Section 2. Calculation Methodology

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

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.

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 |

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”.

The following table indicates measure impacts from DEER/READI utilized (and further adjusted as described earlier in Section 2) for estimating measure impacts. These results have not been modified and are only being included in the workpaper for reference.

READI Data Used

|  |  |  |
| --- | --- | --- |
| **Measure Code** | **Measure Name** | **READI Data** |
| AC-43904 | Whole House Fans |  |

# Section 3. Load Shapes

The ideal load shape for net benefits estimates would represent the difference between the base case and measure case. The closest load shapes that are applicable to the measures in this work paper are listed in the table below.

Building Types and Load Shapes

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

# Section 4. Costs

## 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 full measure cost (containing the Measure Case Cost) is used in the calculation of the incremental cost.

## 4.3 Full and Incremental Measure Cost

**Full and Incremental Measure Cost Equations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| ROB | (MEC + MLC) – (BEC + BLC) | (MEC + MLC) – (BEC + BLC) | N/A |
| NEW/NC |
| RET/ER | (MEC + MLC) – (BEC + BLC) | MEC + MLC | (MEC + MLC) – (BEC + BLC) |
| REF | (MEC + MLC) – (BEC + BLC) | MEC + MLC | N/A |
| REA | MEC + MLC | MEC + MLC | N/A |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

The Full 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 below.

Full Measure Cost

|  |  |  |  |
| --- | --- | --- | --- |
| **Size** | **Measure Equipment Cost** | **Labor Cost** | **Full 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.

**Full and Incremental Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure** | **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| AC-43904 | REA | $704.24 | $704.24 | N/A |

# Attachments

1. 
2. 

# References



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)