|  |
| --- |
| HVAC  Fan controller for air conditioner, residential  SWHC029-01 |

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Measure Name

Fan Controller for Air Conditioner, Residential

Statewide Measure ID

SWHC029-01

Technology Summary

A typical residential air conditioner cycles the compressor and the evaporator fan off when the thermostat setpoint temperature is reached. When the compressor and evaporator fan are cut off in response to the thermostat control, the evaporator coil is still partially flooded with the liquid refrigerant. This residual liquid refrigerant can be used to provide space cooling to optimize and improve system efficiency. This can occur by running the evaporator fan for a short time after the compressor cycles off, referred to as “fan delay time.” After the compressor stops running, the evaporator fan will continue to circulate the indoor air across the evaporator coil to provide additional sensible cooling. Additional sensible cooling provided during the fan delay period postpones the start of the next cooling cycle. The reduction in the duration of the cooling period will result in energy savings, outweighing the energy use associated with the increased run time of the fan.

Two types of add-on fan controllers are commercially available. One type has *built-in logic* to delay the evaporator fan cycle-off time based on compressor and/or evaporator fan cycling. The control logic directly correlates fan delay periods with compressor run times. The other type of fan controller is a *manual evaporator fan controller* that extends evaporator fan operation for 0 to 90 seconds after the compressor has turned off. This controller allows the installation of a fan controller with a built-in logic. Fan controllers with a manually prescribed delay time are allowed only when installed and commissioned by an approved HVAC contractor.

Measure Case Description

The measure case is defined as a residential central HVAC system with an evaporator fan controller based on a manual prescribed time or a built-in logic to delay the evaporator fan cycle off time. The built-in control logic is based on equipment (compressor and fan) operation and cycling to improve HVAC system efficiency.

Measure Case Specification

|  |  |
| --- | --- |
| **Statewide Measure Offering ID** | **Measure Offering Description** |
| SWHC029A | Fan Controller for Residential Air Conditioners |

Base Case Description

The base case is defined as a residential central HVAC system with standard fan controls and operation without manual or logic-based evaporator fan controller to improve HVAC system efficiency.

Code Requirements

There are currently no federal, state, or regional codes that impact fan controllers for residential air conditioners. However, Chapter 4, Article 4, Section 1605.1(c), Table C.3 of California’s Title 20[[1]](#footnote-1) code requires split system air conditioners installed after January 1, 2015 to have a minimum SEER rating of 14.0.

Applicable State and Federal Codes and Standards

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

Normalizing Unit

Each (HVAC Unit)

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 how the measure is incentivized and deployed. 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 |

Eligible Products

The fan controller must meet conditions specified in the Measure Case Description.

Both automated (logic-based) fan controllers and manually set time-delay fan controllers are eligible.

The installation of a manually set time-delay fan controller requires the invoice and/or installation contract that verifies the equipment was installed by a qualified HVAC contractor.

This measure only applies to a fully functional central residential air conditioning unit equipped with cooling/evaporator (dx) coils.

All installations shall comply with all current applicable regulations, code, and standards including (but not limited to) the California Building Energy Efficiency Standards (Title 24), the California Appliance Efficiency Regulations (Title 20), and NEC.

The installation of a manually set time-delay fan controller requires the invoice and/or installation contract that verifies the equipment was installed by a qualified HVAC contractor.

Eligible Building Types and Vintages

This measure is applicable for existing residential single family, multifamily, and double-wide mobile home buildings of any vintage.

Eligible Climate Zones

This measure is applicable in all California climate zones; note however that this measure will not produce savings in climate zone 01.

Program Exclusions

A fan controller used for solely optimizing and improving heating efficiency including those for gas furnaces is not eligible.

The baseline air conditioning system cannot be equipped with a hardware based built-in delay controller.

Data Collection Requirements

Data requirements are to be determined.

Use Category

HVAC

Electric Savings (kWh)

The unit energy savings (UES) of this measure are based upon baseline energy use determined using DEER2020 prototypes.[[2]](#footnote-2) The UES was calculated as a function of the baseline energy use and the part load ratio (PLR); the functional relationship was determined as the result of an Emerging Technologies (ET) Program study conducted by Southern California Edison (SCE) in 2012 (“SCE ET Study”).[[3]](#footnote-3)

The SCE ET Study tested a nominal 3-ton split air-conditioning unit in a laboratory setting. The test unit was equipped with an air-cooled condenser and a single-speed compressor; this combination of components is representative of one of the most common configurations of air-conditioning units found in residential applications. The measure evaluation portion of the testing included the installation of the two types of commercially available add-on fan controllers. The two fan controllers allowed the fans to run after the compressor was shut off; one ran for a prescribed period and the other had a built-in logic to delay shut off for a period of time based upon the compressor run time. The study results suggest that electric energy savings potential varied as a function of PLRs of the cooling systems.

The SCE ET Study was limited to estimating cooling savings and did not evaluate gas and/or electric (heat pump) heating savings.

The DEER Measure ID and associated Statewide Measure Offering ID and description are provided below.

Measure Offering IDs and DEER Energy Impact IDs

| **Statewide Measure Offering ID** | **DEER Energy Impact ID** | **Measure Offering Description** |
| --- | --- | --- |
| SWHC038A | RE-HV-ResAC-lt45kBtuh-15S | Fan Controller for Residential Air Conditioners |

The step-by-step calculation methodology to estimate the electric energy savings and peak demand reduction for a residential air conditioner with a fan controller is provided below.*[[4]](#footnote-4)*

1. The DEER Prototypes were downloaded for all eligible residential building types (see below) for each of the 16 California climate zones from MASControl3 (released on September 30, 2018).
2. This measure is applicable to all building vintages. However, the analysis for this measure only included vintage 2007 (for single family and multifamily) and vintages 2006 to 2014 (“M06”) for double-wide mobile homes, which are median of vintages considered.
3. As discussed in “Code Requirements”, the air conditioning (AC) unit efficiency requirement is SEER 14.0. To be conservative in the energy savings analysis, an efficiency rating of SEER 15.0 was used to establish the baseline energy usage for this measure. Additional modifications were made to the DEER prototypes to reflect code or industry standard practice. The table below summarizes the modified parameters in DEER prototypes.

DEER Prototypes Modified Parameters

| **Parameters** | **eQuest Keyword** | **Modified Value** | **Notes** |
| --- | --- | --- | --- |
| Cooling Electric Input Ratio | COOLING-EIR | 0.2322 (SEER15) | One SEER rating above Title 20 2019 code requirements |
| Fan Design kW/cfm | SUPPLY-KW/FLOW | 0.000580 | Title-24 2019 requirement |
| Temperature Setpoints | COOL-TEMP-SCH | DEER2020 thermostat (including all 5 schedules) options for SFm and DMo.  For MFm (Morning 75.2oF, Day 75.0 oF, Evening 74.8 oF and Night 75.4 oF) | No modification on SFm and DMo.  MFm schedule based on the study[[5]](#footnote-5) instituted by SCE |

1. The DEER2020 thermostat options, the five thermostat schedules, were considered for single family and double-wide mobile homes and the thermostat-weighted savings were calculated (as discussed later in the calculations).

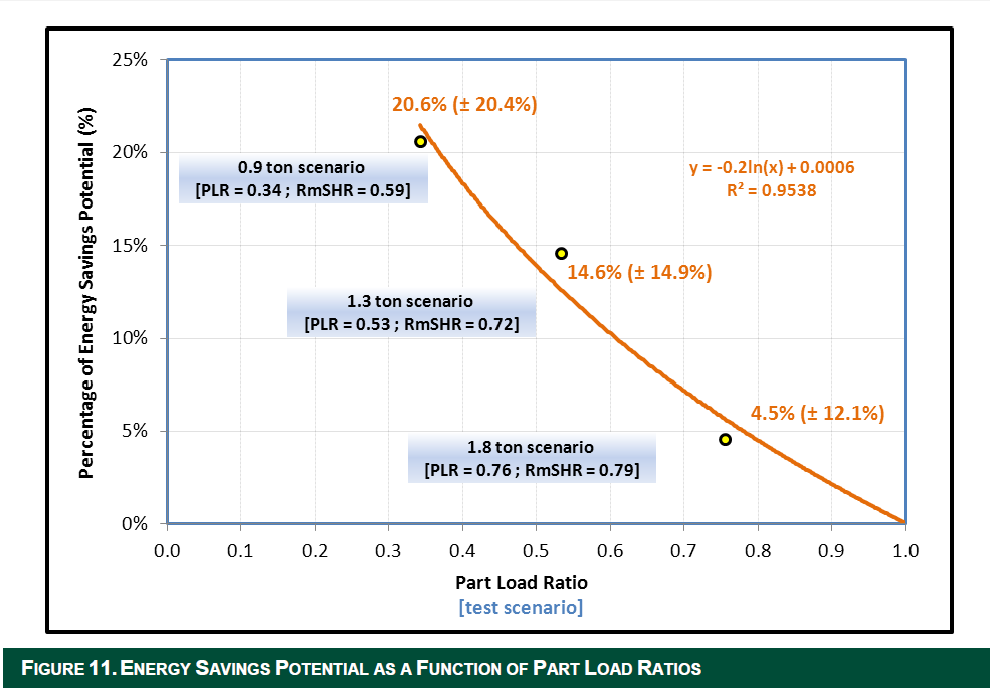
For multifamily, because of the large amount of data that needed to be processed, the five thermostat options was simplified and the average of cooling thermostat setpoints was used instead. This average was reported in a 2004 thermostat study conducted by Southern California Edison (SCE)[[6]](#footnote-6) for five regions (North Coast, South Coast, Central Valley, South Inland, and Desert) were used instead. The thermostat setpoints referenced in the 2004 thermostat study were based on Residential Appliance Saturation Survey (RASS) data.[[7]](#footnote-7)

1. Weather data files corresponding to CZ2010 were used to run the eQuest simulations. The baseline energy consumption was established using building energy simulation software eQuest v3.65 Built 7175(DOE2.3). Following each simulation, hourly report blocks were generated, and four hourly variables were captured from the eQuest simulations on an annual basis: Total Cooling Load (Btu/hr), Condensing Unit Energy (kWh), Supply (indoor) Fan Energy (kWh), and AC Total Cooling Capacity (Btu/hr).

An hourly report block was generated for each unit in a DEER prototype. For example, a double-wide mobile home simulation has two units and generates two hourly report blocks; a multifamily simulation has a total of 24 units and generates 24 hourly report blocks. The four circulation units in the multifamily building prototypes are not apartment units and were excluded from this measure analysis.

1. This measure is limited to cooling savings and excludes the evaluation of gas/electric heating savings. Therefore, only the supply fan energy specific to cooling purposes is incorporated in the total baseline AC energy usage. The following equation was used to compute the total baseline AC energy usage when the cooling load (Btu/hr) exists.

1. The approach to estimate the energy and demand saving potentials on the measure leverages the SCE ET Study that evaluated the feasibility and the potential electrical demand and energy savings due to fan delayed (cycle-off) periods for a central residential AC unit. Findings from the study suggest that electrical energy savings potential vary as a function of fan delayed periods and PLRs.
2. The PLR for each hour was calculated as:
3. The following figure from the SCE ET Study plots the percentage of energy savings against the PLR. The logarithmic curve fit relation is listed on the top right of the figure below.



1. Once the PLR was calculated , the equation below applies the logarithmic curve fit of percentage of energy savings versus PLR determined from laboratory testing. The value of the logarithmic curve fit is capped at 20.6% so that we are not applying the test results outside the range from SCE ET Study.

The result from the equation above represents the AC energy savings for each hour. This number is summed for all hours of the year to obtain the total annual energy savings. Each zone has a separate split AC-system based on how the DEER prototypes are modeled and results are obtained for each zone.

Reiterating, there are two systems (N-S, E-W orientations) in double-wide mobile homes, four systems in single-family homes (single-story, two-story, two orientations), and 24 systems in multifamily homes (two-story buildings with 14 units, two orientations). The results obtained for each of the building units are averaged to obtain one representative savings number per building type. This averaged savings value is the kWh/year saved per unit for each respective building type and climate zone.

1. For single family and double-wide mobile homes, the savings from the above step were obtained for each of the five thermostat options. Using the DEER2020 residential thermostat weights[[8]](#footnote-8) available from MASControl3, weighted savings were calculated for these building types.
2. Demand reduction was calculated are evaluated using ex-ante DEER2020 peak demand definition and procedures. As per step 10, the hourly values of AC energy savings were available for 8,760 hours. Demand reduction was calculated by averaging the total AC energy savings between the peak period of 4:00 p.m. to 9:00 p.m. during the specific summer weekday periods respective to each climate zone.[[9]](#footnote-9) This is repeated for each zone and all the obtained peak demand reduction values are averaged resulting in one kW reduction value for each building type and climate zone.

Peak Electric Demand Reduction (kW)

Peak demand reduction was determined using the approach presented in Electric Savings.

Gas Savings (Therms)

Not applicable

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.”[[10]](#footnote-10) This approach provides a reasonable RUL estimate without the requiring any a prior knowledge about the age of the equipment being replaced.[[11]](#footnote-11) 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. [[12]](#footnote-12)

The EUL and RUL specified for this measure are specified below. Note that the EUL adopted for this measure is based upon the RUL of the host equipment, a residential air conditioning (AC) system. Specifically, the EUL of the fan controller measure is capped at one-third of the EUL of a residential AC system. The EUL of a residential AC system has been adopted prior to 2005 and is documented in the Energy Efficiency Policy Manual.[[13]](#footnote-13) A subsequent review in 2008 of various California retention studies found the estimated life of a residential AC system to range from 11 years to 20 years.[[14]](#footnote-14) The EUL adopted for this measure was determined to be reasonable.

The EUL and RUL specified for the fan delay (cycle off) controller are presented below.

Effective Useful Life and Remaining Useful Life

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value (years)** | **Source** |
| EUL (yrs) – host | 15.0 | California Public Utilities Commission (CPUC), Energy Division.  2003. *Energy Efficiency Policy Manual v 2.0.* Page 17. |
| EUL (yrs) – measure | 5.0 | 1/3 of host EUL |
| RUL (yrs) – measure | n/a | - |

Base Case Material Cost ($/unit)

Insofar as a fan controller for a residential air conditioning unit is add-on equipment, there is no base case material cost as the measure is being added onto the existing host equipment. The base case material cost is equal to $0.

Measure Case Material Cost ($/unit)

The measure equipment material cost was calculated as the average of costs obtained from two manufacturers of commercially available logic-based fan controller.[[15]](#footnote-15)

Base Case Labor Cost ($/unit)

Insofar as a fan controller for a residential air conditioning unit is add-on equipment, there is no base case material cost as the measure is being added onto the existing host equipment. The base case labor cost is equal to $0.

Measure Case Labor Cost ($/unit)

The measure labor cost was determined from 2018 RSMeans Electrical Cost Data; labor cost inputs are provided below*.* The hourly labor rate, obtained from RSMeans Electrical Cost Data, is associated with a low-voltage controller. [[16]](#footnote-16)

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. This GSIA rate is the current “default” rate specified for measures for which an alternative GSIA has not been estimated and approved.

Gross Savings Installation Adjustment Rate

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value** | **Source** |
| GSIA | 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 inputs and methods 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 / Used for Workpaper** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | Yes |
| DEER Version | DEER 2020 |
| Reason for Deviation from DEER | The measure does not exist in DEER. DEER Prototypes are used and modified to determine the baseline. |
| DEER Measure IDs Used | N/A |
| NTG | Source: DEER2014. The NTG of 0.55 is associated with NTG ID: *Res-Default>2yrs* |
| GSIA | Source: DEER. The GSIA of 1.0 is associated with GSIA ID: *Def-GSIA* |
| EUL/RUL | Source: DEER014. The value of 5 years using EULHOST/3; EULHOST is 15 years based on EUL\_ID: *HV-ResAC* |

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 |  | SCE | Draft of consolidated text for this statewide measure is based upon:  SCE17HC052, Revision 0 (October 25, 2018)  Consensus reached by Cal TF.  Related workpapers are:  SCE15HC052, Revision 2 (March 16, 2016)  PGE3PHVC150, Revision 4 (September 19, 2016)  WPSDGREHC0024, Revision 2, short form (December 15, 2016)  PGE3PMOT102, Revision 1 (May 28, 2014) |
|  | 05/04/2019 | Akhilesh Endurthy Solaris-Technical | Updated using DEER 2020 Prototypes  Updated the DEER peak kW based on DEER2020/ E-4952  New Statewide workpaper template |
|  | 06/03/2019 | Jennifer Holmes,  Cal TF Staff | Revisions for submittal of version 01 |

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2. Southern California Edison (SCE). 2019. “SWHC029-01 Fan Controller-Calc Files.zip.” [↑](#footnote-ref-2)
3. Southern California Edison (SCE), Design and Engineering Services. 2012. *Effects of Delaying Evaporator Fan Cycle Off Time for Residential Air-conditioning Units.* ET11SCE1130. March 20. [↑](#footnote-ref-3)
4. Southern California Edison (SCE). 2019. “SWHC029-01 Fan Controller Savings Summary.xlsx”

   Southern California Edison (SCE). 2019. “SWHC029-01 Fan Controller-Calc Files.zip.” [↑](#footnote-ref-4)
5. Southern California Edison (SCE) and James J. Hirsch & Associates. 2004. *Programmable Thermostats Installed into Residential Buildings: Predicting Energy Saving Using Occupant Behavior & Simulation.* *Draft*. November 26. [↑](#footnote-ref-5)
6. Southern California Edison (SCE) and James J. Hirsch & Associates. 2004. *Programmable Thermostats Installed into Residential Buildings: Predicting Energy Saving Using Occupant Behavior & Simulation.* *Draft*. November 26. [↑](#footnote-ref-6)
7. KEMA-XENERGY, Itron, Inc., Roper, and ASW. 2004. California Statewide Residential Appliance Saturation Study. Prepared for the California Energy Commission. Contract No. 400-04-009.   [↑](#footnote-ref-7)
8. California Public Utilities Commission (CPUC), Energy Division. (n.d.) “DEER\_all\_Res\_weights\_tables.xlsx.” [↑](#footnote-ref-8)
9. California Public Utilities Commission (CPUC). 2018. Resolution E-4952. October 11. O.P 1. [↑](#footnote-ref-9)
10. California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 32. [↑](#footnote-ref-10)
11. KEMA, Inc. 2008. "Summary of EUL-RUL Analysis for the April 2008 Update to DEER." Memorandum submitted to Itron, Inc. [↑](#footnote-ref-11)
12. California Public Utilities Commission (CPUC). 2016. Resolution E-4807. December 16. Page 13.   [↑](#footnote-ref-12)
13. California Public Utilities Commission (CPUC), Energy Division.  2003. Energy Efficiency Policy Manual v 2.0. Page 17. [↑](#footnote-ref-13)
14. California Public Utilities Commission (CPUC), Energy Division. 2008. “EUL\_Summary\_10-1-08.xls.”

    Pacific Gas & Electric Company (PG&E). 2004. *Retention Study of Pacific Gas & Electric Company’s 1994 and 1995 Appliance Energy Efficiency Programs.* Study ID 384cR2. March 1.

    ADM Associates, Inc. 2004. Southern California Edison 1994 Residential Appliance Efficiency Incentive Program Ninth Year Retention Study CEC Study ID #546A. Prepared for Southern California Edison Company.

    San Diego Gas & Electric (SDG&E). 2006. *1996 Residential New Construction Program Ninth Year Retention Evaluation.* March.

    Pacific Gas and Electric Company (PG&E). 2006. Retention Study of Pacific Gas & Electric Company’s 1996 and 1997 Residential New Construction Energy Efficiency Programs. PG&E Study ID number: 386R2 CALMAC Study ID number: PGE0247.01.

    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-14)
15. Southern California Edison (SCE). 2019. “SWHC029-01 Cost References.xlsx.” [↑](#footnote-ref-15)
16. Southern California Edison (SCE). 2019. “SWHC029-01 Cost References.xlsx.” [↑](#footnote-ref-16)