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MEASURE CHARACTERIZATION

Fan Controller for Air Conditioner, Residential

https://www.caetrm.com/measure/SWHC029/03/

USE CATEGORY
HC - HVAC

COMMITTED
October 28, 2022 6:08 PM

STATUS
CPUC Approved

EFFECTIVE START DATE
January 1, 2024

VERSION
SWHC029-03

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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. Depending upon the length of the fan delay time, additional savings can be recovered through latent cooling due to evaporation of moisture on the coil.

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 a set amount of time after the compressor has turned off. A fan controller with a built-in logic is an eligible technology. Fan controllers with a manually prescribed delay time are allowed only when installed and commissioned by an approved California (C-20) HVAC licensed contractor.

Southern California Edison (SCE) funded an Emerging Technologies (ET) Program study to evaluate the potential energy efficiency benefits associated with delaying the evaporator fan cycle off time. This measure package does not claim heating savings since this Emerging Technologies project specifically tested only for cooling savings.

Emerging Technologies

ETP FLAG (PROJECT NUMBER) (TEXT) R972	PROGRAM FUNDING YEAR (TEXT)
ET11SCE1130	2010-2012

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 operation and cycling to improve HVAC system efficiency.

Offering ID

STATEWIDE MEASURE OFFERING ID (TEXT)	MEASURE OFFERING DESCRIPTION (TEXT)
A	Fan controller for residential air conditioners

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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.

Base Case Descriptions

STATEWIDE MEASURE OFFERING ID (TEXT)	EXISTING DESCRIPTION (TEXT)	STANDARD DESCRIPTION (TEXT)
A	No fan controller for air conditioner	No fan controller for air conditioner

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 code requires split system air conditioners installed after January 1, 2015 to have a minimum SEER rating of 14.0. R1581

Applicable State and Federal Codes and Standards

CODE	APPLICABLE CODE REFERENCE	EFFECTIVE DATE
CA Appliance Efficiency Regulations – Title 20	None.	January 1, 2023
CA Building Energy Efficiency Standards – Title 24	None.	January 1, 2023
Federal Standards	None.	n/a

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	SECTOR	DELIVERY TYPE
AOE	Res	DnDeemDI
AOE	Res	DnDeemed

ELIGIBLE PRODUCTS

The installation of fan controller is only eligible in HVAC systems manufactured prior 2010. HVAC systems manufactured in 2010 and thereafter are expected to include some level of fan control delayed capability as indicated by a high level industry standard practice (ISP) effort supported as part of this measure package update. R3046

Both automated (logic-based) fan controllers and manually set time-delay fan controllers are eligible. For manual fan controllers, delay timer must be programmed to four minutes in order to maximize savings associated with the fan-delay, in accordance with the results of the SCE ET Study titled *Effects of Delaying Evaporator Fan Cycle Off Time for Residential Air-conditioning Units*. R972

The installation of a manually set time-delay fan controller requires the invoice and/or installation contract that verifies the equipment was installed by an approved California (C-20) HVAC licensed 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 the National Electrical Code (NEC).

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.

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 previously installed add-on retrofit fan-delay controller.

A fan controller installed with equipment with a manufactured date after January 1st, 2010.

Data Collection Requirements

The installation of a fan controller requires the manufactured date of the installed HVAC system that verifies the age of the equipment.

Electric Savings (kWh)

The unit energy savings (UES) of this measure are based upon baseline energy use determined using DEER2024 EnergyPlus prototypes. Energy impacts were taken directly from DEER2024 (version source: D24_E+_Res_v4) without modifications. The MeasureID and EnergyImpactID are both RE-ResAC-FanCtrls. 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"). R972

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 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.

The PLR for each hour was calculated as:

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PLR = Cooling Load (Btu/hr) / AC Cooling Capacity (Btu/hr)
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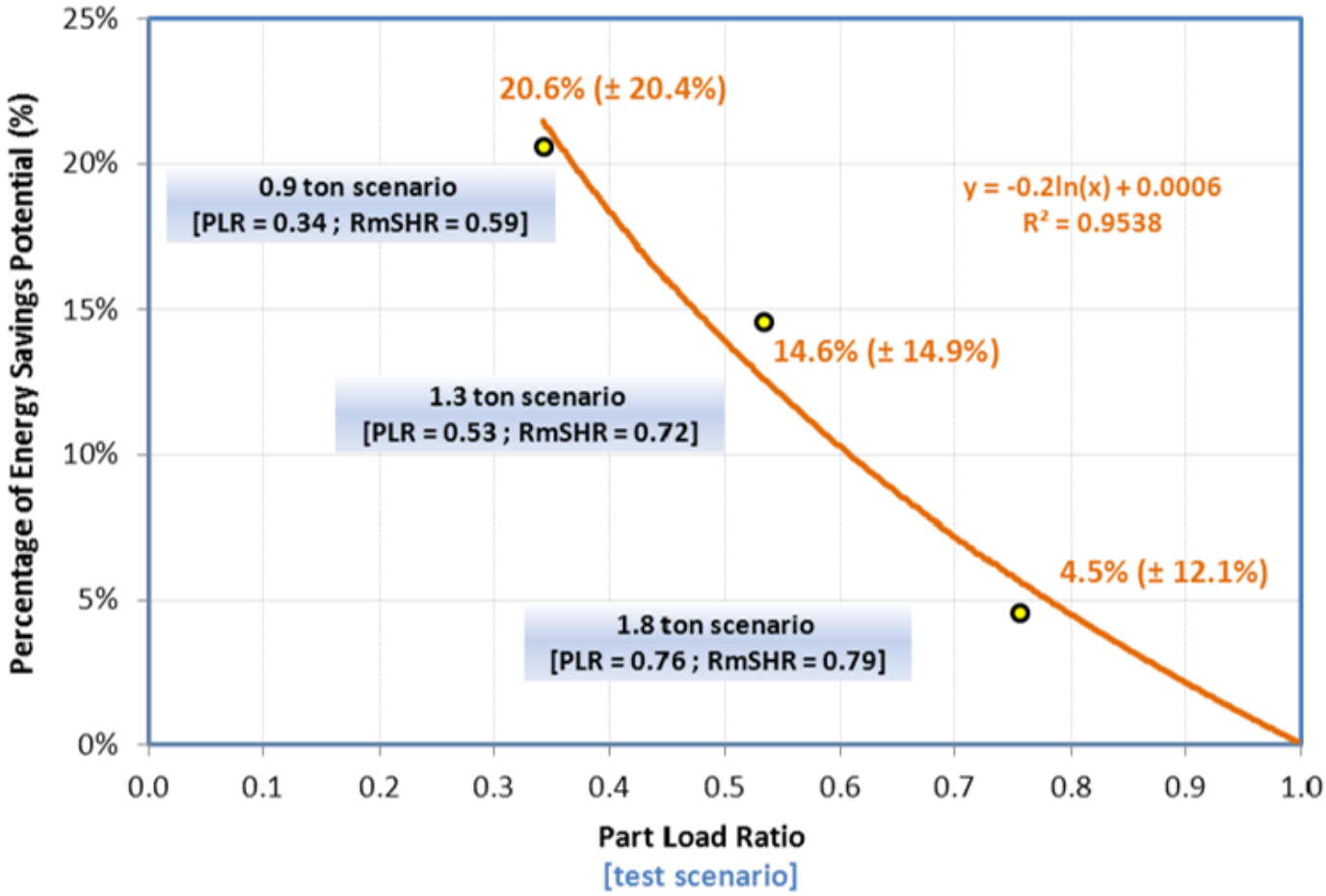
The following figure from the SCE ET Study plots the percentage of energy savings against the PLR. The logarithmic curve fit relation is listed on the top right of the figure below.



Energy Savings Potential as a Function of Part Load Ratios

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.

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AC Energy Savings (kWh) = Total Baseline AC Energy Usage (kWh) ×
                          (−0.2ln(PLR) + 0.0006)
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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.

Energy savings are normalized per square foot of building floor area.

Peak Electric Demand Reduction (kW)

Demand reduction impacts were taken directly from DEER2024 without modification. Demand savings are normalized per square foot of building floor area.

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 6 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." R1270 (Page 34-35) This approach provides a reasonable RUL estimate without requiring any prior knowledge about the age of the equipment being replaced. R181 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. R236 (Page 13)

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. It is expected that once the host equipment is replaced, the fan controller will not carry over to the new AC system. The EUL of a residential AC system has been adopted prior to 2005 and is documented in the Energy Efficiency Policy Manual. R104 (Page 17) 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. R356 R987 R705 R965 R682 R186 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. R104 (Page 17)

Effective Useful Life and Remaining Useful Life

EFFECTIVE USEFUL LIFE ID	EUL DESCRIPTION (TEXT)	SECTOR (TEXT)	EUL YEARS (YR)	START DATE (TEXT)	EXPIRE DATE (TEXT)
HV-ResAC	**High Efficiency Air Conditioner (package and split systems)**	**Res**	**15.00**	**2013-01-01**	

Effective Useful Life and Remaining Useful Life – Host

HOST EUL ID	EUL DESCRIPTION (TEXT)	SECTOR (TEXT)	RUL YEARS (YR)	START DATE (TEXT)	EXPIRE DATE (TEXT)
HV-ResAC	**High Efficiency Air Conditioner (package and split systems)**	**Res**	**5.00**	**2013-01-01**	

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 based on the average of a survey of 'time delay relay' products on Grainger, the online retailer. R3042 Costs were normalized to square footage through eTRM calculations based on the measure area for each building type and climate zone provided in the DEER Energy Impact tables.

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 labor 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 based on RS Means 2022. The labor category used was residential electrician and installation was assumed to take one hour. R3042 Costs were normalized to square footage through eTRM calculations based on the measure area for each building type and climate zone provided in the DEER Energy Impact tables.

Net-to-Gross

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 value is based on recommendations included in the 2019 Residential HVAC Impact Evaluation study conducted by DNV GL. R3048 The recommended NTG of 0.88 was adopted by the California Public Utilities Commission in DEER *Resolution E-5152* for program year 2023. R1503 (Page A-31 Table A-5-1)

Net to Gross Ratio

NET TO GROSS RATIO ID	NTG DESCRIPTION (TEXT)	NTG ELECTRIC (RATIO)	NTG GAS (RATIO)	START DATE (TEXT)	EXPIRE DATE (TEXT)
Res-sAll-mHVAC-FanCtrl	**Residential fan motor control to delay turning off fan subsequent to heating/cooling cycle**	**0.8800**	**0.8800**	**2023-01-01**	

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. R1270

Gross Savings Installation Adjustments - Default

GSIA ID	GSIA (RATIO) R1270
Def-GSIA	**1.0000**

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
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 EnergyPlus Prototypes	Yes
DEER Version	DEER2024
Reason for Deviation from DEER	N/A
DEER Measure IDs Used	RE-ResAC-FanCtrls

References

R104 California Public Utilities Commission (CPUC), Energy Division. 2003. *Energy Efficiency Policy Manual v 2.0.* **Download** (PDF, 159.0 KB)

R1270 California Public Utilities Commission (CPUC), Energy Division. 2020. *Energy Efficiency Policy Manual Version 6.* April. Page 34-35. **Download** (PDF, 1.1 MB)

R1503 California Public Utilities Commission (CPUC). 2021. *Resolution E-5152.* August 6. **Download** (PDF, 1.7 MB)

R1581 California Energy Commission (CEC). 2021. *California Code of Regulations Title 20. Public Utilities and Energy.* CEC-140-2021-002. Revised July 2021. **Download** (PDF, 5.9 MB)

R181 Kema, Inc. 2008. "Summary of EUL-RUL Analysis for the April 2008 Update to DEER." Memorandum submitted to Itron, Inc.
Download (DOC, 37.0 KB)

R186 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).
Download (PDF, 354.2 KB)

R236 California Public Utilities Commission (CPUC). 2016. *Resolution E-4807.* December 16. **Download** (PDF, 1.4 MB)

R3042 Southern California Edison (SCE). 2022. "SWHC029-03_Cost_References.xlsx." **Download** (XLSX, 19.3 KB)

R3043 .

R3046 Southern California Edison (SCE). 2021. "SWHC029-03 Fan Controller for Residential Air Conditioners - Industry Standard Practice (ISP)." December. **Download** (DOCX, 33.6 KB)

R3048 DNV GL. 2021. *Impact Evaluation Report Residential HVAC Sector - Program Year 2019, EM&V Group A.* Prepared for the California Public Utilities Commission (CPUC). CALMAC ID: CPU0229.01. May 2021.
Download (PDF, 4.0 MB)

R356 California Public Utilities Commission (CPUC), Energy Division. 2008. “EUL_Summary_10-1-08.xls.” **Download** (XLS, 116.0 KB)

R682 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. **Download** (PDF, 2.6 MB)

R705 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.
Download (PDF, 1.1 MB)

R965 San Diego Gas & Electric (SDG&E). 2006. 1*996 Residential New Construction Program Ninth Year Retention Evaluation*. March.
Download (PDF, 78.5 KB)

R972 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.
Download (PDF, 1.6 MB)

R987 Pacific Gas and 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.
Download (PDF, 496.6 KB)