**Work Paper PGECOREF106**

**Evaporator Fan Controller Walk-In**

**Revision # 6**

**Pacific Gas & Electric Company**

**Customer Energy Solutions Department**

**Evaporator Fan Controller for Walk-in Coolers and Freezers**

**Measure Code R53**

**PGECOREF106 R6 Evaporator Fan Controller**

**PG&E is using the SCE work paper values for this measure. Revision 5 updated to the Ex Ante format.**

**PG&E measure code R53 = SCE Solution Code RF-37766**

**Here is the methodology applied to refrigeration work papers:   
  
Use MASControl v3.00.20 to generate a DEER Grocery prototype for multiple climate zones, vintage "14" (year 2014-2015), no HVAC, no Tstat, CAv (Customer Average) case. Select a TechID that is not "GrocRefg." The output should be an eQUEST model that has T24 2013-compliant envelope, lighting, and HVAC systems, and a T24 2005-compliant refrigeration system. Create the measure case by editing the CAv model. Simulate the CAv and measure cases, using the CTZ2010 weather files.**

**Work Paper SCE13RN025**

**Revision 2**

**Southern California Edison Company**

**Walk-in Cooler Evaporative Fan Cycling Control or VFD Control**

# At-a-Glance Summary

|  |  |
| --- | --- |
| ****Applicable Measure Codes:**** | PG&E measure code R53 = SCE Solution Code RF-37766  RF-NEW01 |
| **Measure Description:** | Add fan cycling controls or VFD controls to walk-in evaporator units |
| **Base Case Description:** | Evaporator fan runs continuously |
| **Energy Impact Common Units:** | Per unit |
| **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):** | DEER14: 16 years |
| **Measure Application Type:** | Retrofit Add-On (REA) |
| **Net-to-Gross Ratios:** | DEER14: 0.6 |
| **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 |
| SCE13RN025.0 | No | 6/8/2012 | Thomas C. Tseng/SCE | Original workpaper for 2013 PC |
| SCE13RN025.1 | Yes | 6/9/2014 | Dhananjay Mangalekar, P.E. and Linda Wan, P.E./TRC Energy Services, Jason Wang/SCE | -Work paper updated for the reporting period, effective 7/1/14 – 12/31/14.  -All savings revised based on new eQUEST simulations.  -WP now has all climate zones except 7. No changes to building types.  -RF-NEW01 is a newly added solution code to this work paper. |
| SCE13RN025.2 | Yes | 5/18/2016 | Yin Yin Wu, P.E./  BASE Energy, Inc.  Mark Ritchie, P.E./  BASE Energy, Inc. | -Updated measure case cost using WO017 [A] instead of DEER2008.  -Updated report format per the most recent Statewide Work Paper Template.  -Section 1.4.2 *Codes and Standards Analysis* is updated to clarify that Title 24 does not apply to evaporator fan control of walk-ins. |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Rev | Party | Submittal Date | Comment Date | Comments | WP Developer Response |
|  |  |  |  | N/A |  |

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

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This measure is to add evaporator fan cycling or VFD controls to walk-in coolers or freezers.

The base case for the measure is an evaporator fan running continuously. There should not be an existing fan control in place.

Table 1 Base, Standard and Measure Cases

|  |  |
| --- | --- |
| Case | Description of Typical Scenario |
| **Measure #1: RF-37766** | |
| Measure | Walk-in Evaporator Fan Cycling Control replacing No Control |
| Existing Condition | Walk-in Evaporator Fan Without Control |
| Code/Standard | Walk-in Evaporator Fan Without Control |
| Industry Standard Practice | Walk-in Evaporator Fan Without Control |
| **Measure #2: RF-NEW01** | |
| Measure | Walk-in Evaporator Fan VFD Control replacing No Control |
| Existing Condition | Walk-in Evaporator Fan Without Control |
| Code/Standard | Walk-in Evaporator Fan Without Control |
| Industry Standard Practice | Walk-in Evaporator Fan Without Control |

**Table 2 Measures and Codes**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measure Codes | | | | Measure Name |
| SCG | SDG&E | SCE | PG&E |
|  |  | RF-37766 | R53 | Walk-in Evaporator Fan Cycling Control |
|  |  | RF-NEW01 |  | Walk-in Evaporator Fan VFD Control |

**Implementation Requirements**

The measures in this work paper pertain to Grocery, Food Store, Restaurant – Fast Food, Restaurant – Sit Down, and Retail – Small building types in all SCE and PGE climate zones (1-16, except 7).

**Eligibility Requirements**

The following base case conditions must be met:

* The existing evaporator fan must run continuously at full speed, with the exception of defrost cycles.
* The evaporator fan load at full speed operation is at least 1/20 horsepower.
* The evaporator fan motor is single phase.
* The evaporator uses off-cycle or time-off defrost.
* The compressor does not run all the time.

The following measure case conditions must be met:

* Controls must reduce fan power by at least 75% when the compressor cycles off.
* VFD controls can reduce fan speed to a minimum of 30%.

Documentation requirements collect actual costs from invoices.

## 1.2 Technical Description

An evaporator fan controller is defined as a device or system that reduces airflow across an evaporator in walk-in coolers and freezers when there is no refrigerant flow through the evaporator i.e., when the compressor is in an off-cycle; or when the controller receives a signal from the thermostat to stop the flow of refrigerant, i.e., turns the compressor off. The energy savings is typically accomplished by reducing the speed of the fan motors by at least 75% during the compressor off-cycle (fan cycling control) or reducing the fan motor speed to a minimum of 30% (VFD control). The controller reduces air flow rather than turning fans off completely when the compressor is not operating because a minimum airflow may be required to provide defrosting and prevent the air in the cooler from stratifying into layers of higher and lower temperatures.

A typical evaporator unit in a walk-in cooler contains one or more small fans with fractional horsepower motors that are operating continuously. To qualify for rebates, the motor must be at least 1/20 horsepower. A fan controller saves energy by reducing the fan usage and by reducing the refrigeration load resulting from the fan’s waste heat.

## 1.3 Installation Types and Delivery Mechanisms

This work paper addresses Retrofit Add-on (REA) installations for new evaporator fan controls on walk-ins. This is a subtype of RET that is specifically for adding a piece of equipment to existing equipment to make the overall equipment more efficient.

The delivery mechanisms are:

* Financial Support - Down-Stream Incentive - Deemed.
* Midstream Programs / Mid-Stream Incentive

**Table 3 Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Installation Type | Savings | | Life | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Replace on Burnout (ROB) | Above Code or Standard | N/A | EUL | N/A |
| New Construction (NEW/NC) | Above Code or Standard | N/A | EUL | N/A |
| Retrofit or Early Replacement (RET/ER) | Above Customer Existing | Above Code or Standard | RUL | EUL-RUL |
| Retrofit First Baseline Only (REF) | Above Customer Existing | N/A | EUL | N/A |
| 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.

**Table 4 Delivery Method Descriptions**

|  |  |
| --- | --- |
| Delivery Method | Description |
| Appliance Turn-in and Recycling | The program motivates customers, through financial incentives, to recycle appliances that are functional but inefficient. This prevents the continued use of those appliances, by both the current owner and potential future owners. |
| Audit/Information/Testing Services | The program performs a free assessment of a customer’s facility and provides the customer with information and guidance on energy efficiency opportunities. |
| Commissioning and Retrocommissioning | The program modifies or repairs existing equipment to ensure that it works as intended. |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |
| Innovative Design | The program funds new ideas that meet reasonable scientific scrutiny for potential energy savings. These innovative measures typically have small market penetration (less than 5%) or are targeted toward relatively unreached market segments. |
| New Construction | The program offers financial incentives and/or design assistance to customers involved with new building construction. This is intended is to motivate customer to exceed Title 24 building energy efficiency requirements (residential or nonresidential). |
| Partnership | The program implements projects through a partnership between the utility and an institutional, government, or community-based organization. |
| Performance Based | The program offers financial incentives that vary based on the energy efficiency performance of specific projects. |
| Up-Stream Programs | See Up-Stream Incentive and Up-Stream Buy Down in the Incentive Method table. |

**Table 5 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. |
| Mid-Stream Incentive | The program gives a financial incentive to a midstream market actor, such as a retailer or contractor, to encourage the promotion of efficient measures. The incentive may or may not be passed on to the end-use customer. |
| Up-Stream Incentive | The program gives a financial incentive to an upstream market actor, such as a manufacturer or distributor, to encourage the manufacture, provision, or distribution of an efficient measure. The incentive may or may not be passed on to the end-use customer. |
| Up-Stream Buy Down | The program gives a financial incentive to an upstream market actor, such as a manufacturer or distributor, with specific requirements to pass down the incentive to the end use customer. Such an incentive buys-down the cost of an efficient measure for the end-use customer by at least the amount of the financial incentive. |
| Giveaway | The program provides customers with energy efficiency equipment or services for free. |
| Exchange/Replacement | The utility program holds events where customers can trade functional equipment for similar but more energy efficient equipment, free of charge. |
| On-bill Finance/Loan | The program offers financing for the cost an efficient measure as part of the utility bill. This can be an add-on option to an existing program or can serve as an organizing principle for its own program. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

Solution code RF-37766 was formerly a DEER 2005 measure with measure ID D03-936. This particular measure is no longer in DEER 2014. Solution code RF-NEW01 is a newly added measure for this work paper. As a result, new simulation models using MASControl and eQUEST were generated to calculate the energy savings for solution code RF-37766 and RF-NEW01.

The Grocery DEER prototype building was used to calculate savings, which are shared by Food Store, Fast Food Restaurant, Sit Down Restaurant, and Small Retail. The walk-in coolers usually have the same characteristics irrespective of building type.

Table 6 DEER Difference Summary

|  |  |
| --- | --- |
| DEER Item | Used for Workpaper? |
| Modified DEER methodology | Yes |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | No |
| DEER eQUEST Prototypes | Yes |
| DEER Version | N/A |
| Reason for Deviation from DEER | DEER 2014 does not contain this type of measure. |
| DEER Measure IDs Used | N/A |

**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 7 below.

Table 7 Net-to-Gross Ratio

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NTGR\_ID\* | Description\* | Sector\* | BldgType\* | Measure Delivery\* | NTG\* |
| Com-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Com | Any | All | 0.6 |

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

**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.

**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 final version on the installation rate table. To address appropriate selection of the installation rate the date of the work paper 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 8 below.

Table 7 Installation Rate

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

**Effective and Remaining Useful Life**

DEER14 update documentation provides EUL and RUL information to be used for the 2013-14 program cycle 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 8 below identifies the value/methodology used for the measures in this work paper.

Table 8 DEER14 EUL Value/Methodology

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| READi EUL ID | Description | Sector | UseCategory | EUL (Years) | RUL (Years) |
| GrocWlkIn-WevapFMtrCtrl | Evaporator Fan Cycling Controller for Walk-In Coolers | Any | ComRefrig | 16 | N/A |

### 1.4.2 Codes and Standards Analysis

Title 24 2013 [355] Section 120.6(a)3 provides the following requirements for new fan-powered evaporators for refrigerated warehouses:

|  |
| --- |
| Section 120.6  (a) Mandatory Requirements for Refrigerated Warehouses  Refrigerated Warehouses that are greater than or equal to 3,000 square feet shall meet the requirements of Subsections 1, 2, 3, 6 and 7 of Section 120.6(a).  Refrigerated Spaces that are less than 3,000 square feet shall meet the requirements of the Appliance Efficiency Regulations for walk-in coolers or freezers contained in the Appliance Efficiency Regulations (California Code of Regulations, Title 20, Sections 1601 through 1608). |

This Title 24 code does not apply to evaporator fan control of walk-ins and therefore does not affect the measures in this work paper.

Title 20 2014 [422] Section 1605.1(a)(4) provides the following requirements for walk-in coolers and freezers:



The requirement for ECM motors will apply to walk-ins manufactured on or after January 1, 2009.

Table 9 Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 24 (2013) | Section 120.6(a)3 | July 1, 2014 |
| Title 20 (2014) | Section 1605.1(a)(4) | January 1, 2009 |

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

This section is not applicable

## 1.6 Data Quality and Future Data Needs

This section is not applicable

# Section 2. Calculation Methodology

The measures in this work paper are not in DEER 2014, so the energy savings were determined through building simulation in eQUEST 3.65 Refrigeration. Only the Grocery building type was simulated, and its savings were used for other building types because walk-in coolers and freezers generally have the same characteristics regardless of building type.

Prototype generation

MASControl v3.00.20 was used to generate the DEER 2014 Grocery prototype files using the following parameters:

* Building Type: Grocery
* Climate Zones: 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16
* Vintage: “14” (years 2014-2015)
* HVAC Type: Blank (Default)
* Thermostat Options: Blank (Default)
* Case Options: CAv (Customer Average), C13 (Code 2013)
* Tech ID: “D08-NE-HVAC-airAC-SpltPkg-135to239kBtuh-10p8eer”

The C13 case model was used as the baseline for this work paper. The Energy Division advised that the prototype’s refrigeration systems were not updated after DEER 2005 and therefore may not reflect industry standard practice and/or code. Since a non-refrigeration Tech ID was selected, the HVAC system, building envelope, and other systems should be compliant with Title 24 2013 standards.

Simulation

In order to create the measure cases, the baseline eQUEST model was edited by changing the following parameters:

* RF-37766 Fan Cycling Control
  + Affected Systems: Freezer, Cooler
  + FAN-CONTROL = CYCLING
  + INDOOR-FAN-MODE = INTERMITTENT
  + MIN-FLOW-RATIO = 0.01
  + MIN-DUTY-CYCLE = 0.1
  + MAX-DUTY-CYCLE = 0.5
* RF-NEW01 VFD Control
  + Affected Systems: Freezer, Cooler
  + FAN-CONTROL = SPEED
  + INDOOR-FAN-MODE = CONTINUOUS (no change from baseline)
  + MIN-FLOW-RATIO = 0.3

The simulation results were tabulated, and savings were determined; see Attachment 2. See Attachment 3 for the eQUEST files used. For REA measures, the baseline is the customer existing equipment, which may be less energy efficient that the baseline model used in in this work paper. Therefore the savings are most likely conservative estimates.

Demand reduction: The DEER peak demand was calculated from the eQUEST hourly data by averaging the demand from 2pm to 5pm during the DEER peak period, which varies by climate zone as shown in Table 10 below.

|  |  |
| --- | --- |
|  | **Table 10. 2014 DEER Peak-Demand Periods** |

|  |  |  |  |
| --- | --- | --- | --- |
| Climate Zone | Dates | Climate Zone | Dates |
| CZ01 | Sep 16-18 | CZ09 | Sep 1-3 |
| CZ02 | Jul 8-10 | CZ10 | Sep 1-3 |
| CZ03 | Jul 8-10 | CZ11 | Jul 8-10 |
| CZ04 | Sep 1-3 | CZ12 | Jul 8-10 |
| CZ05 | Sep 8-10 | CZ13 | Jul 8-10 |
| CZ06 | Sep 1-3 | CZ14 | Aug 26-28 |
| CZ07 | Sep 1-3 | CZ15 | Aug 25-27 |
| CZ08 | Sep 1-3 | CZ16 | Jul 8-10 |

Per-unit savings: The Grocery prototype is defined as having 30 walk-in motors, so all savings were divided by 30 to determine per unit savings.

A complete list of savings is in Attachment 1.

# 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 Refrigeration load shape. See Table 11 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 11 Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| Building Type | E3 Alt. Building Type | Load Shape |
| Grocery | NON\_RES | Refrigeration |
| Food Store | NON\_RES | Refrigeration |
| Restaurant – Fast Food | NON\_RES | Refrigeration |
| Restaurant – Sit-Down | NON\_RES | Refrigeration |
| Retail – Small | NON\_RES | Refrigeration |

# Section 4. Costs

Values and methodologies are taken from the 2010-2012 WO017 Ex Ante Measure Cost Study Final Report (WO017) [A] prepared by Itron for the California Public Utilities Commission.

## 4.1 Base Case Cost

For REA measures, there are no base case costs.

## 4.2 Measure Case Cost

The measure case costs were taken from WO017, Measure 5 of Appendix C. WO017 evaluated the costs of installing duty cycle or low speed controllers for small unit coolers with fans less than 1 hp and costs for variable speed controllers for large unit coolers with fans greater than 1 hp. Total cost includes cost for the fan controllers as well as other related electrical materials and installation costs such as wiring, conduit, electrical enclosure, backplate, circuit breakers, etc.

**Cycling Control** (RF-37766)

WO017 includes costs of a fan controller and new ECM motors. Since ECM motor retrofit is not part of this work paper, only the fan controller cost from WO017 will be used. In summary, the total material cost is $779 for four motors, including costs of a fan controller and incidental electrical installation materials. The total labor cost is $455 for four motors, including installation labor cost of a fan controller (estimated to be $225) and labor to program, test, and adjust. Hence, the total measure cost = $779/4 (material) + $455/4 (labor) = $194.75 (material) + $133.75 (labor) = $328.5 per motor.

**VFD Control** (RF-NEW01)

WO017 includes costs of a VFD and a new VFD-ready drop-in replacement motors. Since the existing motor may not be compatible with a VFD, replacement of a new motor is considered. Based on cost data from WO017, the total material cost is $9,696 for eight motors, including costs of a VFD-ready drop-in replacement motor, a VFD and various incidental electrical installation materials. The total labor cost is $5,345 for eight motors. Hence, the total measure cost = $9,696/8 (material) + $5,345/8 (labor) = $1,212 (material) + $668.12 (labor) = $1,880.12 per motor.

## 4.3 Full and Incremental Measure Cost

**Table 12 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

**Table 13 Full and Incremental Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measure | Installation Type | Incremental Measure Cost | Full Measure Cost | |
| **1st Baseline** | **2nd Baseline** |
| **Measure #1: RF-37766**  Walk-in Cooler Evaporator Fan Cycling Control replacing No Control | REA | $328.5/motor | $328.5/motor | N/A |
| **Measure #2: RF-NEW01**  Walk-in Cooler Evaporator VFD Control replacing No Control | REA | $1,880.12/motor | $1,880.12/motor | N/A |

# Attachments

The attachments are stored separately and not embedded in the Word Document

# References

The references are stored in a separate file and not embedded in this Word Document

|  |  |
| --- | --- |
| [31] | Load Shape Update Initiative - KEMA / JJ Hirsch and Assoc. / Itron Inc. - November 17, 2006 |
| [213] | EUL/RUL Values Provided through Excel Spreadsheet |
| [215] | Revised DEER Measure Cost Summary |
| [351] | Energy Efficiency Policy Manual-Version 5 |
| [355] | 2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (Title 24) |
| [422] | 2014 Appliance Efficiency Regulations (Title 20) |
| [424] | California Commercial End-Use Survey (CEUS) 2006 |

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

[A] “2010-2012 WO017 Ex Ante Measure Cost Study Final Report”, prepared for California Public Utilities Commission, prepared by Itron, Inc., May 27, 2014.