**Work Paper PGECOREF106**

**Evaporator Fan Controller Walk-In**

**Revision # 4**

**Pacific Gas & Electric Company**

**Customer Energy Solutions Department**

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

**Measure Code R53**

**PG&E is using the SCE work paper values for this measure.**

**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 Approvals**

The following Managers approved this work paper through the PG&E Electronic Data Routing System under Routing Requisition # 2014-54844

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|  |
| **Grant Brohard**  Manager, Engineering Services |
| **Carolyn Weiner**  Manager, Products |

**Work Paper SCE13RN025**

**Revision 1**

**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. |

# 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 of the measure is an evaporator fan running continuously. There should not be an existing fan control in place.

Table 1 Measure Names

|  |  |
| --- | --- |
| Solution Code | Measure name |
| RF-37766 | Walk-in Cooler Evaporator Fan Cycling Control replacing No Control |
| RF-NEW01 | Walk-in Cooler Evaporator VFD Control replacing No 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 Measure Application Type

Note: See Appendix A for a comparison of the application types used by and incorporated into SCE systems versus the application types available in the newest revision of DEER 2014. Appendix A will serve as a translation between the outputs of this work paper and application types used by READi.

The delivery mechanisms are:

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

The program type Retrofit Add-on (REA). 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.

## 1.4 Measure and Base Case Cost Effectiveness Data

### 1.4.1 DEER Measure and Base Case Analysis

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 2 DEER Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Modified DEER Methodology | Yes |
| Scaled DEER Measure | No |
| DEER Building Prototypes Used | Yes |
| Deviation from DEER | DEER 2014 does not contain this type of measure. |
| DEER Version | N/A |
| DEER Run ID and Measure Name (Sample) | 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 3 below.

Table 3 Net-to-Gross Ratio

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NTGR\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID | 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.

**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 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 work paper. For a full set of values associated with the measures in the work paper refer the Excel calculation template.

Table 5 READi Tech IDs

|  |  |
| --- | --- |
| READi Field Name | Values included in this work paper |
| Measure Case UseCategory | Commercial Refrigeration |
| Measure Case UseSubCats | Refrigerated Storage |
| Measure Case TechGroups | Grocery Refrigeration system |
| Measure Case TechTypes | Adjustable Speed Drive, Non-DEER |
| Base Case TechGroups | Grocery Refrigeration system |
| Base Case TechTypes | General Purpose |

### 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:

|  |
| --- |
|  |

This code does not apply to retrofit add-on measures 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 6 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 |

### 1.4.3 Non-DEER Study Review

According to the California Commercial End-Use Survey [424] pg 152, refrigeration is the third highest end use of electricity in commercial buildings, using 13.4% of total commercial building electrical consumption. This emphasizes the significant potential for energy-efficiency measures involving types of refrigeration.

### 1.4.4 Measure and Base Case Effective 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 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) |
| GrocWlkIn-WevapFMtrCtrl | Commercial | Refrigeration | Evaporator Fan Cycling Controller for Walk-In Coolers | 16 | N/A |

# Section 2. Energy Savings & Demand Reduction Calculations

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.

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 8 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 8 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. Base Case & Measure Costs

## 4.1 Base Case Cost

For REA measures, there are no base case costs.

## 4.2 Measure Case Cost

The DEER 2008 cost spreadsheet [215] contains material cost and labor cost for non-residential, commercial refrigeration evaporator fan cycling controllers for walk-in coolers. The cost is reported per motor.

The Grainger catalog was used to find the VFD cost. The material cost used is for a VFD on a ½ hp motor; see Attachment 4. It is typical for one VFD to control a bank of fans serving an evaporator coil. For this work paper, it is assumed that one VFD controls a bank of 4 fan motors, so the per unit cost is: $856.00 / 4 = $214.00. RS Means was used for the labor cost of installing a VFD (Attachment 5); $525.00 / 4 = $131.25. The material cost and labor cost per unit are shown in Table 10.

Table 9 Measure Costs

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cost Case ID | Cost Case Description | Material Cost | Installation Labor Cost - Retrofit | GMC & IMC | Normalizing Unit |
| None | Evaporator Fan Controller for Walk-In Coolers | $69.69 | $92.06 | $161.75 | Per Motor |
| None | VFD controller for Walk-In Coolers | $214.00 | $131.25 | $345.25 | Per Motor |

## 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 REA, gross measure cost (GMC) means the full cost of the measure to purchase and install.

For REA, GMC is represented by the equation below:

*GMC = Measure Equipment Cost + Measure Labor Cost*

In the case of REA, the customer is making a conscious 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.

Refer to Table 9 for the measure equipment and labor costs. The GMC is the same for both measures.

### 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. The incremental cost is only used to help determine program incentives.

For REA, there exists no base case measure comparison. For this reason, IMC is represented by the equation below for REA install types:

*IMC = Measure Equipment Cost + Measure Labor Cost*

As a result, the IMC is equal to the GMC. Refer to Table 9 for the measure equipment and labor costs. The IMC is the same for both measures.

# Attachments

1. 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 |

# 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 |