Work Paper SCE13RN025

**Revision 2**

**Southern California Edison**

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

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | RF-37766, RF-90868 |
| **Measure Description** | Add fan cycling controls or VFD controls to walk-in evaporator units |
| **Base Case Description** | Evaporator fan runs continuously |
| **Units** | Per unit |
| **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** | DEER14: 16 years for EUL ID: GrocWlkIn-WevapFMtrCtrl |
| **Measure Installation Type** | Retrofit Add-On (REA) |
| **Net-to-Gross Ratio** | Com-Default>2yrs = 0.6 |
| **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 | 06/08/12 | Thomas C. Tseng/SCE | Original workpaper for 2013 PC |
| 1 | 06/09/14 | 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-90868 is a newly added solution code to this work paper. |
| 2 | 02/09/16 | Ajay Wadhera/Solaris | -New template update for 2016 program year  -WP effective from 1/1/2016 thru 12/31/2016  -No value modifications  -Removed SCE building types |

# 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

## 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.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Evaporator fan cycling or VFD controls to walk-in coolers or freezers |
| Existing Condition | No fan cycling |
| Code/Standard | N/A |
| Industry Standard Practice | N/A |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
|  |  | RF-37766 |  | Walk-in Cooler Evaporator Fan Cycling Control replacing No Control |
|  |  | RF-90868 |  | Walk-in Cooler Evaporator VFD Control replacing No Control |

**Implementation Requirements**

The measures in this work paper pertain to Grocery, 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.

## 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.

## Installation Types and Delivery Mechanisms

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.

**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 |

The delivery mechanisms are:

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

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. |
| Mid-Stream Programs | *See Mid-Stream Incentive in the Incentive Method Descriptions table.* |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| 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  Mid-Stream Buy Down | The program gives a financial incentive to a midstream market actor (distributor, vendor, or retailer) to encourage the promotion of efficient measures. Buy Down means that the incentive is required to be passed down to the end-use customer. |

## 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-90868 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-90868.

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.

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | Yes |
| Scaled DEER measure | No |
| DEER Base Case | Yes |
| DEER Measure Case | Yes |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | Yes |
| DEER Version | N/A |
| Reason for Deviation from DEER | DEER does not contain this type of measure. |
| 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** |
| 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 | Any | 0.6 |

**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)** |
| GrocWlkIn-WevapFMtrCtrl | Evaporator Fan Controller for Walk-In Coolers | Com | ComRefrig | 16 | 5.3 |

### 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.

Code Summary

|  |  |  |
| --- | --- | --- |
| **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

### 1.5.1 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.

## 1.6 Data Quality and Future Data Needs

N/A

# 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-90868 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 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** |
| Grocery | Refrigeration | NON\_RES |
| Restaurant – Fast Food | Refrigeration | NON\_RES |
| Restaurant – Sit-Down | Refrigeration | NON\_RES |
| Retail – Small | Refrigeration | NON\_RES |

# Section 4. 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 below.

Measure Costs

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Cost Case ID** | **Cost Case Description** | **Material Cost** | **Installation Labor Cost - Retrofit** | **FMC & 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 Full and Incremental Measure Cost

**Full and Incremental Measure Cost Equations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| 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

**Full and Incremental Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure** | **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| RF-37766 | REA | $161.75 | $161.75 | N/A |
| RF-90868 | REA | $345.25 | $345.25 | N/A |

# Attachments

1. 

1. 
2. 
3. 
4. 

# References



|  |  |
| --- | --- |
| [215] | Revised DEER Measure Cost Summary |
| [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 |