**Work Paper WPSDGENRRN0011**

**Revision 2**

**San Diego Gas & Electric**

**Energy Efficiency Engineering**

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

**At-a-Glance Summary**

|  |  |
| --- | --- |
| Applicable Measure Codes: | R-K1, R-K2 |
| 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 Ex-Ante Database |
| Gross Measure Cost ($/unit) | Refer to Ex-Ante Database |
| Measure Incremental Cost ($/unit): | Refer to Ex-Ante Database |
| Effective Useful Life (ID): | GrocWlkIn-WevapFMtrCtrl |
| Measure Application Type: | Retrofit – Add-On (REA) |
| Net-to-Gross Ratios (ID): | Com-Default>2yrs |
| Important Comments: | **This work paper document does not contain a data set in conformance with the 4/1/14 CPUC Ex Ante Database Specification; SDG&E will provide that data set separately.** |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision # | MM/DD/YY | Author/Affiliation | Summary of Changes |
| 0 | 08/30/2012 | Max Twogood (SDG&E) | Adopted from PGE workpaper: “PGECOREF106 R3 Evap Fan Controller Walk in.doc.” Applicable measure code changed to SDG&E’s EEBR program measure code for walk-in freezer evap. fan controls. NTG values for Direct Install removed, as this is not an SDG&E DI measure. |
| 1.0 | 10/08/2013 | Charles Harmstead (SDG&E) | Revised Energy and Demand savings for SDGE CZ using DEER 2005 |
| 2.0 | 08/26/2014 | Kyle Dunn (MWE2) | - Adopted SCE Workpaper SCE13RN025.1 Walk-in Cooler Evaporative Fan Cycling Control or VFD Contr, updated June 09, 2014  - Savings values based on eQUEST simulations for all climate zones  - Updated EUL\_ID  - Updated NTG  - Added GSIA  - Updated load shapes |

# Section 1. General Measure & Baseline Data

## 1.1 Measure & Delivery Description

### 1.1a Measure Description

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

|  |  |
| --- | --- |
| Product Code | Measure name |
| R-K1, R-K2 | Walk-in Cooler Evaporator Fan Cycling Control replacing No Control |
| N/A | Walk-in Cooler Evaporator VFD Control replacing No Control |

### 1.1b Delivery and Incentive Mechanism

Note: See Appendix A for a comparison of the application types used by and incorporated into SDG&E 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.

### 1.1c Measure Requirements

***Terms and Conditions***

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.

***Market Applicability***

The measures in this work paper pertain to Grocery, Food Store, Restaurant – Fast Food, Restaurant – Sit Down, and Retail – Small building types in all SDG&E climate zones.

### 1.1d 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.

## 1.2 DEER Differences Analysis

Solution code R-K1 and R-K2 were formerly a DEER 2005 measure with measure ID D03-936. This particular measure is no longer in DEER 2014. As a result, new simulation models using MASControl and eQUEST were generated to calculate the energy savings for the measures included in this work paper, which now includes VFD control.

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 | No |
| 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 |

## 1.3 Code 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 3 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 Measure Effective Useful Life

Refer to the Ex-Ante Database for the EUL values.

Table 4 DEER14 EUL Value/Methodology

|  |  |  |  |
| --- | --- | --- | --- |
| EUL\_ID | Market | Enduse | Measure |
| GrocWlkIn-WevapFMtrCtrl | Commercial | Refrigeration | Evaporator Fan Cycling Controller for Walk-In Coolers |

## 1.5 Net-to-Gross Ratios for Different Program Strategies

Refer to the Ex-Ante Database for the NTG values.

Table 5 Net-to-Gross Ratio

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

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

## 1.6 Time-of-Use Adjustment Factor

As directed by the CPUC in decision 06-06-063 dated June 29, 2006, time-of-use (TOU) adjustment factors are to be applied for residential A/C and commercial A/C (packaged and split-system direct-expansion cooling) measures only. Since this is not an A/C measure, the TOU adjustment factor is 0. Additionally, if a measure is assigned a DEER08 load shape, i.e. the load shape starts with “DEER:” the TOU assigned to that measure should also be zero.

Table 6 TOU Summary Table

|  |  |
| --- | --- |
| Measure | % |
| Walk-in Cooler Evaporator Fan Cycling Control | 0 |

# Section 2. Energy Savings & Demand Reduction Calculations

## 2.1 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. The adopted SCE work paper did not include baseline or measure case models for Climate Zone 7. Savings values were obtained for this Climate Zone by modifying the weather file for the prototype, cycling, and VFD models from the adopted work paper.

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: 6, 7, 8, 10, 14, 15
* 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:

* 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
* 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 1 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 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.

For a complete list of savings please refer to the Ex-Ante Database.

## 2.2 Gas Energy Savings Estimation Methodologies

Gas savings were also estimated using the results of the eQUEST simulations and are included in the Ex-Ante database.

## 2.3 Installation Rate

The installation rate (IR) is identified in ex-ante database. This value is obtained from the support table available in READi. Currently there is no versioning 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 7** below.

Table 7 Installation Rate

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

## 2.4 Spillage Rate

Spillage rate will also be applied to measures however the values will not be tracked in the work papers. The spillage rate will be tracked in an external table to be supplied to the Energy Division.

## 2.5 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 8 READi Tech IDs

|  |  |
| --- | --- |
| READi Field Name | Values included in this work paper |
| Measure Case UseCategory | ComRefrig |
| Measure Case UseSubCats | Storage |
| Measure Case TechGroups | Ref-Storage |
| Measure Case TechTypes | TempSensor |
| Base Case TechGroups | Ref-Storage |
| Base Case TechTypes | TempSensor |

# 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 SDG:01-ALC-AllCommercial-Refrig

shape. See Table 9 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 9 Building Types and Load Shapes

|  |  |
| --- | --- |
| Building Type | Load Shape |
| Grocery | SDG:01-ALC-AllCommercial-Refrig |
| Restaurant – Fast Food | SDG:01-ALC-AllCommercial-Refrig |
| Restaurant – Sit-Down | SDG:01-ALC-AllCommercial-Refrig |
| Retail – Small | SDG:01-ALC-AllCommercial-Refrig |

# 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 2. 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. RS Means was used for the labor cost of installing a VFD (Attachment 3). For the material cost and labor cost per unit please refer to the Ex-Ante Database.

## 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.

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. The IMC is the same for both measures.

# Attachments

1.



2. 

3. 

# References



|  |  |
| --- | --- |
| [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 – SDG&E/ED Application Types

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| SDG&E 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 |