**Work Paper PGECOREF109**

**Evaporator Fan Motors**

**Revision # 6**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Evaporator Fan Motors**

**Measure Codes R145, R176, RF004, RF005**

**PGECOREF109 R6 Evaporative Fan Motor**

PG&E is using the SCE work paper Work Paper SCE13RN011 ex-ante values for PG&E measure codes R145, R176, RF004 and RF005.

The measure mapping is as follows:

PG&E Measure code R145 = SCE Solution Code RF-60192

PG&E Measure code R176 = SCE Solution Code RF- 89850

PG&E Measure code RF004 = SCE Solution Code RF- 65986

PG&E Measure code RF005 = SCE Solution Code RF- 89766

**Work Paper SCE13RN011**

**Revision 2**

**Southern California Edison Company**

**Evaporator Fan Motors**

# At-a-Glance Summary

|  |  |
| --- | --- |
| ****Applicable Measure Codes:**** | RF-60192  RF-65986  RF-73198  RF-78433  RF-89766  RF-89850 |
| **Measure Description:** | Install new electronically commutated permanent magnet (ECM) motors on low and medium temperature display cases, and walk-in coolers and freezers. |
| **Base Case Description:** | Existing shaded pole (SHP) evaporator fan motors on low and medium temperature display cases; existing shaded pole or permanent split capacitor (PSC) evaporator fan motors on walk-in coolers and freezers. |
| **Energy Impact Common Units:** | Display cases: per (linear) ft  Walk-in coolers/freezers: per motor |
| **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):** | Source: DEER 2014-EUL-table-update-2014-02-05  15 years |
| **Measure Application Type:** | Retrofit (RET) |
| **Net-to-Gross Ratios:** | Source: DEER2011\_NTGR\_2012-05-16.xls  0.6 |
| **Important Comments:** | Major changes for Revision 1 include: added the savings evaluation with eQuest simulation for the walk-in measures; updated the work paper based on DEER 2014 code update; updated eQuest prototype from MASControl version 3.00.20. Also, updated the eQuest model weather files per DEER2014 CZ2010 weather data files.  Solution codes associated with walk-in coolers/freezers are included only for PG&E climate zones and territory only.  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 |
| SCE13RN011  Revision 0 | No | 05/29/2012 | Yin Yin Wu/BASE Energy, Inc.  Chris Fernandez/BASE Energy, Inc. | This is the original work paper for the bridge cycle 2013-2014 |
| Alfredo Gutierrez/SCE | Added the conversion factor of 0.667 motors per linear foot in section 4.2 |
| SCE13RN011  Revision 1 | Yes | 07/08/2012 | Yin Yin Wu/BASE Energy, Inc. | - Added the savings evaluation for the walk-in measures  - Updated the work paper based on DEER 2014 code update  - Used the updated eQuest prototype from MASControl version 3.00.20  - Updated the eQuest model weather files per DEER2014 CZ2010 weather data files  - Work paper updated for reporting period, effective 07/01/14-12/31/14 |
| SCE13RN011  Revision 2 | Yes | 5/9/2016 | Yin Yin Wu, P.E./  BASE Energy, Inc.  Mark Ritchie, P.E./  BASE Energy, Inc. | -Updated measure case cost using WO017 [E] instead of DEER2008.  -Updated report format per the most recent Statewide Work Paper Template. |

# 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 work paper details the replacement of shaded pole (SHP) and permanent split capacitor (PSC) evaporator fan motors with new electronically commutated permanent magnet (ECM) motors on low and medium temperature display cases, and walk-in coolers and freezers. Table 1 below shows the measures evaluated for this work paper.

Table 1 Base, Standard and Measure Cases

|  |  |
| --- | --- |
| Case | Description of Typical Scenario |
| **Measure #1: RF-60192** | |
| Measure | Display Case Cooler Evaporator Fan ECM Motor replacing Shaded Pole Motor |
| Existing Condition | Display Case Cooler Evaporator Fan Shaded Pole Motor |
| Code/Standard | N/A |
| Industry Standard Practice | N/A |
| **Measure #2: RF-65986** | |
| Measure | Walk-in Cooler Evaporator Fan ECM Motor replacing Shaded Pole Motor |
| Existing Condition | Walk-in Cooler Evaporator Fan Shaded Pole Motor |
| Code/Standard | Walk-in Cooler Evaporator Fan ECM Motor |
| Industry Standard Practice | N/A |
| **Measure #3: RF-73198** | |
| Measure | Walk-in Cooler Evaporator Fan ECM Motor replacing Permanent Split Capacitor (PSC) Motor |
| Existing Condition | Walk-in Cooler Evaporator Fan Permanent Split Capacitor (PSC) Motor |
| Code/Standard | Walk-in Cooler Evaporator Fan ECM Motor |
| Industry Standard Practice | N/A |
| **Measure #4: RF-78433** | |
| Measure | Walk-in Freezer Evaporator Fan ECM Motor replacing Permanent Split Capacitor (PSC) Motor |
| Existing Condition | Walk-in Freezer Evaporator Fan Permanent Split Capacitor (PSC) Motor |
| Code/Standard | Walk-in Freezer Evaporator Fan ECM Motor |
| Industry Standard Practice | N/A |
| **Measure #5: RF-89766** | |
| Measure | Walk-in Freezer Evaporator Fan ECM Motor replacing Shaded Pole Motor |
| Existing Condition | Walk-in Freezer Evaporator Fan Shaded Pole Motor |
| Code/Standard | Walk-in Freezer Evaporator Fan ECM Motor |
| Industry Standard Practice | N/A |

(Continued on the next page.)

Table 1 Base, Standard and Measure Cases (Continued)

|  |  |
| --- | --- |
| Case | Description of Typical Scenario |
| **Measure #6: RF-89850** | |
| Measure | Display Case Freezer Evaporator Fan ECM Motor replacing Shaded Pole Motor |
| Existing Condition | Display Case Freezer Evaporator Fan Shaded Pole Motor |
| Code/Standard | N/A |
| Industry Standard Practice | N/A |

Table 2 Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measure Codes | | | | Measure Name |
| SCG | SDG&E | SCE | PG&E |
|  |  | RF-60192 | R145 | Display Case Cooler Evaporator Fan ECM Motor replacing Shaded Pole Motor |
|  |  | RF-65986 | RF004 | Walk-in Cooler Evaporator Fan ECM Motor replacing Shaded Pole Motor |
|  |  | RF-73198 |  | Walk-in Cooler Evaporator Fan ECM Motor replacing Permanent Split Capacitor (PSC) Motor |
|  |  | RF-78433 |  | Walk-in Freezer Evaporator Fan ECM Motor replacing Permanent Split Capacitor (PSC) Motor |
|  |  | RF-89766 | RF005 | Walk-in Freezer Evaporator Fan ECM Motor replacing Shaded Pole Motor |
|  |  | RF-89850 | R176 | Display Case Freezer Evaporator Fan ECM Motor replacing Shaded Pole Motor |

Note: Please note that solution codes associated with walk-in coolers/freezers are included only for PG&E climate zones and territory only.

**Eligibility Requirements**

These measures are applicable when replacing an existing standard efficiency shaded pole or permanent split capacitor evaporator fan motor with an electronically commutated permanent magnet (ECM) motor in refrigerated display cases and walk-in coolers/freezers. The evaporator fan motor shaft output is typically rated between 6 Watts and 373 Watts (1/2 hp). Shaded-pole motors are to be replaced by ECMs on display cases. Shaded pole or permanent split capacitor motors are to be replaced by ECMs on walk-in coolers/freezers. These measures cannot be used in conjunction with the Evaporator Fan Controller measure.

These measures are applicable to refrigerated display cases and walk-in coolers/freezers that are found in a variety of building types: schools, groceries, restaurants, lodging, hospitals, and others. However, these measures are predominantly implemented in grocery stores and restaurants. These measures are applicable to climate zones within both Southern California Edison and Pacific Gas and Electric service territory.

**Express Requirements**

To qualify for the incentive, the following requirements must be met:

* The existing equipment is a standard efficiency shaded-pole or permanent split capacitor evaporator fan motor of refrigerated display cases or walk-in coolers/freezers.
* The shaded-pole or permanent split capacitor motors are being replaced by ECMs.

**Pacific Gas and Electric**

Requirements:

* Installation address must have a commercial electric account with PG&E.
* Must replace existing standard efficiency shaded-pole or permanent split capacitor evaporator fan motors in refrigerated display cases and walk-in coolers.
* Shaded-pole motors must be replaced by Electronically Commutated Motors (ECM).
* Permanent split capacitor motors must be replaced by Electronically Commutated Motors (ECM).

Exclusions:

* Cannot be used in conjunction with the “Evaporative Fan Controller for Walk-In Coolers and Freezers” rebate.

## 1.2 Technical Description

Display cases are common in grocery stores, convenience stores and other businesses with coolers and freezers.  Medium-temperature display cases are typically used to stock dairy, deli, fish and meat. Low-temperature display cases are typically used to stock frozen food and ice cream. The temperature inside medium and low temperature display cases can range from +10°F to +35°F and -25°F to -15°F, respectively [A]. Many older and some newer display cases and walk-in coolers/freezers with low-efficiency shaded pole or permanent split capacitor evaporator fan motors qualify for high-efficiency, electronically commutated motor (ECM) retrofits.   Evaporator fan motors are found within refrigerated display cases and walk-in coolers/freezers.

High efficiency motors, with lower energy (heat) losses, reduce both electrical energy consumption of the evaporator fans and the internal cooling load required by the cases. ECM motors operate efficiently over a wide range of speeds. ECM motors optimize airflow while minimizing energy use and waste heat. Several California contractors offer ECM retrofits for refrigerated display cases. Some manufacturers now offer ECM motors in lieu of shaded pole motors, or have standardized their equipment to include ECM motors in their refrigerated display cases and walk-in coolers/freezers.

## 1.3 Installation Types and Delivery Mechanisms

This work paper addresses retrofit (RET) installations of new electronically commutated evaporator fan motors. The delivery method is Financial Support - Down Stream Incentive – Deemed.

**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

This specific measure is included in the Database for Energy Efficient Resources (DEER 05) Measure D03-203 High-efficiency display fan motors. Measure D03-203 replaces display fan shaded pole motors (SHP) with electronically commutated permanent magnet motors (ECM). Measure D03-203 combines both low and medium temperature display cases and obtains an energy savings for replacing SHP motors with ECM motors. Measure D03-203 is available for vintages before 2005. The main difference between the DEER analysis and the analysis evaluated in this work paper is that the energy savings of low temperature display cases and medium temperature display cases are separated, and the weather file is updated using DEER2014 weather file. Also, the savings is evaluated for vintage 2014 in this work paper.

The Database for Energy Efficient Resources (DEER05) does not address the replacement of shaded pole (SHP) and permanent split capacitor (PSC) evaporator fan motors with new electronically commutated permanent magnet (ECM) motors in walk-in coolers and freezers. DEER does include measure D03-202 which addresses the replacement of SHP fan motors with PSC fan motors on walk-in coolers/freezers for vintages before 2005. This differs from the measures of this work paper.

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 | DEER14 |
| Reason for Deviation from DEER | DEER combines both low and medium temperature display cases. Savings in this workpaper separates the energy savings of low and medium temperature display cases. |
| DEER Measure IDs Used | D03-203 |

**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 versioning on the installation rate table. To address appropriate selection of the installation rate the date of the workpaper 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 8 Installation Rate

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

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

**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.

Table 9 DEER14 EUL Value/Methodology

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| EUL ID | Description | Sector | UseCategory | EUL (Years) | RUL (Years) |
| GrocDisp-FEvapFanMtr | High Efficiency Evaporator Fan Motors | Com | ComRefrig | 15 | 5 |
| GrocWlkIn-WEvapFanMtr | High Efficiency Evaporator Fan Motors | Com | ComRefrig | 15 | 5 |

### 1.4.2 Codes and Standards Analysis

***Display Cases:*** California’s Title 20 Appliance Efficiency Standards do not regulate refrigerated display cases [D]. EPAct 2005 [132] required the Department of Energy to develop energy efficiency standards for many types of commercial refrigeration equipment, including display cases. The regulatory language was adopted in 2009 [B], and will be applicable to all display cases manufactured after January 1, 2012. The standard does not specifically regulate evaporator fan motor efficiency, instead looking at overall performance of the display case.

***Walk-ins:*** California’s Title 20 Appliance Efficiency Standards does regulate the efficiency of evaporator fans in newly constructed walk-in coolers and freezers manufactured on or after January 1, 2009 [D]. Since replacing the existing evaporator fan shaded pole (SHP) and permanent split capacitor (PSC) motors with electronically commutated permanent magnet (ECM) motors for walk-in coolers and walk-in freezers is considered as retrofit (RET),the first baseline savings is above existing equipment efficiency. Therefore, walk-in coolers and freezers with low-efficiency, shaded pole or permanent split capacitor, evaporator fan motors still qualify for high-efficiency, electronically commutated motor (ECM) retrofits.

***Walk-In Coolers and Walk-In Freezers.***

*Walk-in coolers and walk-in freezers manufactured on or after January 1, 2009 shall:*

*For evaporator fan motors of under one horsepower and less than 460 volts, use:*

*1. electronically commutated motors (brushless direct current motors); or*

*2. 3-phase motors;*

Table 10 Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 20 (2014) | Section 1605.1(a)(4)(E)(1) Refrigerators, Refrigerator-Freezers, and Freezers | May, 2014 |
| Title 24 (2013) | N/A | N/A |

## 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 following assumptions were made for the calculations of this work paper:

* The building simulation models were generated for a Grocery Store with multiplex-compressor systems for the refrigeration display cases. Single-compressor systems are less efficient than multiplex-compressor systems. According to the DEER Report [26], single-compressor systems were typically designed prior to 1980. To be conservative, it is assumed that the generated energy savings of this work paper will also be applied to display cases with single-compressor systems.
* This work paper is applied to display cases located inside a space which has space heating and space cooling. The unit energy savings is represented per linear-foot of the display case. The resulting savings involve savings of evaporator fan power reduction and refrigeration load reduction. The building simulation models were generated for a Grocery Store. Since the heat gain of a display case mainly depends on the temperature maintained for the display case and the surrounding space temperature, it is assumed that the building types would not have significant impact on the energy savings. Thus, the resulted savings of Grocery Store is applied to all other building types considered in this work paper.

The display cases and walk-ins are applicable to, but not limited to, grocery stores. ECM motors are more efficient than SHP and PSC motors. According to a commercial refrigeration study report by U.S. Department of Energy [128], typical SHP fan motor efficiencies range between about 15% to 38%, while typical PSC fan motor efficiencies range between about 40% to 70%, and typical ECM fan motor efficiencies range between about 71% to 83% for rated shaft output between 6-watt and 373-watt (1/2 hp). Therefore, replacing the evaporator fan SHP and PSC motors with ECM motors will reduce the evaporator fan energy consumption as well as the refrigeration cooling load for cooling the heat rejected by the motors, resulting in electrical energy savings.

The measures of this work paper are weather sensitive. The building energy simulation tool eQuest was used to determine the annual impacts. The built-in DEER building prototypes, generated by MASControl v3.00.20 of grocery store, were used for simulations. The DEER building prototypes consider multiplex-compressor systems as the refrigeration type.

**Display Cases** (RF-60192, RF-89850)

The 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study final Report [26] has included the measure of High Efficiency Display Fan Motors (ID D03-203). Please refer to the DEER Report Section 6 for details of DEER Building Prototypes generated by eQuest (a graphical interface to DOE-2.2), Section 7.3 for general description of grocery refrigeration measures, and Page 7-73 for detailed descriptions of this measure. The DEER measure ID D03-203 utilizes SHP motors as the baseline and ECM motors as the measure for display cases, which include both low temperature and medium temperature display cases all together.

The DEER building prototypes have built-in refrigeration display cases for low temperature and medium temperature display cases with evaporator fan SHP motors. The baseline models of DEER D03-203 are used as the baseline models for the measures included in this work paper. The evaporator fan ECM motor input power of low temperature display cases included in the DEER D03-203 model (DEER08 Measure ID of *D08-NE-GrocRefg-DispFixt-EvapFanMtr-AllTemp-HiEff*) are used in the measure model of the display case freezer (low temperature) measure. Similarly, the evaporator fan ECM motor input power of medium temperature display cases included in the DEER D03-203 model are used in the measure model of the display case cooler (medium temperature) measure. To be conservative, the eQuest models were simulated for vintage 2014. The built-in evaporator fan input power of both SHP motors and ECM motors are included in Table 11 below.

Table 11 Summary of Built-In Display Evaporator Fan Input Power from DEER Prototypes

|  |  |  |
| --- | --- | --- |
| **Fixture Type** | **SHP Motor**  **(Baseline)** | **ECM Motor**  **(Measure)** |
| Low Temperature Vertical Display Case with Transparent Doors | 0.055 kW/dr | 0.02475 kW/dr |
| Low Temperature Horizontal Open Display Case | 0.009 kW/ft | 0.00171 kW/ft |
| Medium Temperature Horizontal Open Display Case | 0.02667 kW/ft | 0.0125349 kW/ft |
| Medium Temperature Vertical Open Display Case | 0.01333 kW/ft\* | 0.0062651 kW/ft\* |
| 0.00975 kW/ft\* | 0.004485 kW/ft\* |
| Medium Temperature Vertical Display Case with Transparent Doors | 0.06667 kW/dr\*\* | 0.03 kW/dr |

\*Provided based on the display cases application of meat or other produce.

\*\* Estimated based on the ECM motor rating and the ECM/SHP ratio of the low temperature vertical display case with doors.

**Walk-Ins** (RF-65986, RF-73198, RF-78433, RF-89766)

The Database for Energy Efficient Resources (DEER05) does not address the replacement of shaded pole (SHP) and permanent split capacitor (PSC) evaporator fan motors with new electronically commutated permanent magnet (ECM) motors on walk-in coolers and freezers. DEER does contain measure D03-202 which addresses the replacement of SHP fan motors with PSC fan motors on walk-ins for vintages before 2005. This differs from the walk-in measures of this work paper. The walk-in evaporator fan input power provided in the D03-202 DEER models are used to modify the baseline models generated by MASControl v3.00.20. The ECM motor power modified in the measure models are estimated based on the SHP and PSC power input and the ECM/SHP or ECM/PSC efficiency ratios provided from a commercial refrigeration study report by U.S. Department of Energy [128]. To be conservative, the eQuest models were simulated for vintage 2014. The walk-in evaporator fan power inputs modified in the eQuest simulations are included in Table 12 below.

Table 12 Summary of Walk-In Evaporator Fan Input Power used in eQuest Simulation

|  |  |  |
| --- | --- | --- |
| **Walk-In Type** | **SHP/PSC Motor**  **(Baseline)\*** | **ECM Motor**  **(Measure)\*\*** |
| Walk-In Freezer | SHP Motor:  0.000169 kW/CFM | 0.0000761 kW/CFM  Est. per SHP power |
| PSC Motor:  0.00006084 kW/CFM | 0.0000507 kW/CFM  Est. per PSC power |
| Walk-In Cooler | SHP Motor:  0.000169 kW/CFM | 0.0000761 kW/CFM  Est. per SHP power |
| PSC Motor:  0.00008619 kW/CFM | 0.0000718 kW/CFM  Est. per PSC power |

\*Provided in build-in DEER prototype models.

\*\* Estimated based on the SHP or PSC power and the ECM/SHP or ECM/PSC efficiency ratio provided from a commercial refrigeration study report by U.S. Department of Energy [128], page 115, Table 5-3.

**eQuest Output Savings**

Once the base case and measure case model simulations were completed, the energy savings and demand reduction could be determined. Comparing the total energy consumption (electricity and natural gas) of both models, the total energy savings were determined. The unit energy savings, in kWh/yr-ft for electricity and therm/yr-ftfor natural gas, were calculated by dividing the total energy savings by the total line-up length of the display cases. Note that some built-in display cases were modeled per number of doors. According to the eQuest built-in models, each glass door is about 2.6 ft in length. Therefore, the number of doors was converted into feet by multiplying by 2.6. The unit energy savings, in kWh/yr-motor for electricity and therm/yr-motor for natural gas, were calculated by dividing the total energy savings by the total number of motors of the walk-ins.

The baseline and measure peak demands were averaged for the hourly demand outputs between 2 P.M. and 5 P.M. on the DEER peak days. Table 13 summarizes the 2014 DEER Peak-Demand periods for all climate zones. The measure results were subtracted from the baseline results to determine the demand reduction. Similar to the energy savings the unit demand reduction, in kW/ft, was calculated by dividing the total demand reduction by the total line-up length of the display cases. The unit demand reduction, in kW/motor, was calculated by dividing the total demand reduction by the total motors of the walk-ins.

Refer to Attachment B for the eQuest output savings summary, and Attachment C for the sample peak demand output of CZ01 for RF-89850.

|  |  |
| --- | --- |
|  | **Table 13. 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 |

# 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 14 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 14 Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| Building Type | E3 Alt. Building Type | Load Shape |
| Assembly | Assembly | Refrigeration |
| Grocery | Grocery\_Store | Refrigeration |
| Food Store | Food\_Store | Refrigeration |
| Restaurant - Fast-Food | Fast\_Food\_Restaurant | Refrigeration |
| Restaurant - Sit-Down | Sit\_Down\_Restaurant | Refrigeration |
| Retail - Multistory Large | Large\_Retail\_Store | Refrigeration |
| Retail - Single-Story Large | Large\_Retail\_Store | Refrigeration |
| Retail - Small | Small\_Retail\_Store | Refrigeration |

# Section 4. Costs

The measure case cost data is taken from the 2010-2012 WO017 Ex Ante Measure Cost Study Final Report [E]. The methodology from WO017 is used to develop the base case cost data.

## 4.1 Base Case Cost

Based on the methodology from WO017, the measure costs were obtained from various sources for motors at different sizes. Also, a contractor margin of 0.34 was added to the material cost. Considering the same method and using the same labor cost as WO017, the base case costs are obtained and summarized in the following. Refer to Attachment D for base case cost supporting documents.

**Display Cases** (RF-60192, RF-89850)

Shaded Pole Motor: The base case cost is estimated to be $71.01 per motor and the labor cost is $12 per motor.

According to the Department of Energy’s *Energy Conservation Standards for Commercial Refrigeration Equipment* [C], there is an average of 0.667 motors per linear foot of display case. This number was determined as follows:

Table 15 Motors Per Linear Foot of Display Case

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Fixture Type | No. of Fans | Power Consumption per Fan (W) | Total Power (kW) | Evaporator Fan (kW/ft) \* | Fixture Length (ft) | Motors/ft |
| Vertical Open – Reach In – Medium Temp | 6 | 45 | 0.27 | 0.0225 | 12 | 0.50 |
| Vertical Open – Reach In – Low Temp | 14 | 45 | 0.63 | 0.0525 | 12 | 1.167 |
| Horizontal Open – Reach In – Medium Temp | 4 | 45 | 0.18 | 0.015 | 12 | 0.333 |
| **Average** | | | | | | **0.667** |

\*Table D.2.8 DOE-2.2R Input Parameters for Modeled Display Cases

Hence,

Shaded Pole Motor:

**Walk-Ins** (RF-65986, RF-73198, RF-78433, RF-89766)

Shaded Pole Motor: The base case cost is estimated to be $163.90 per motor and the labor cost is $30 per motor. Hence, the total measure cost for walk-ins = $163.90 (material) + $30 (labor) = $193.9 per motor.

Permanent Split-Capacitor Motor: The base case cost is estimated to be $136.06 per motor and the labor cost is $30 per motor. Hence, the total measure cost for walk-ins = $136.06 (material) + $30 (labor) = $166.06 per motor.

## 4.2 Measure Case Cost

The measure case costs were taken from WO017, Measure 9 of Appendix C. WO017 evaluated the costs of installing ECM motors for walk-ins and display cases. These values are summarized below.

**Display Cases** (RF-60192, RF-89850)

WO017 included ECM motor costs from five different equipment for door and open upright display case fan motors. On average, the material cost is $122.41 per motor and the labor cost is $12 per motor. Considering the average of 0.667 motors per linear foot of display case, the total unit cost is calculated as:

**Walk-Ins** (RF-65986, RF-73198, RF-78433, RF-89766)

WO017 included ECM motor costs from four different equipment for walk-in fan motors. On average, the material cost is $226.25 per motor. The installation labor cost is $30 per motor. Hence, the total measure cost for walk-ins = $226.25 (material) + $30 (labor) = $256.25 per motor.

## 4.3 Full and Incremental Measure Cost

**Table 16 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 17 Full and Incremental Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measure | Installation Type | Incremental Measure Cost | Full Measure Cost | |
| **1st Baseline** | **2nd Baseline** |
| **RF-60192**: Display Case Cooler Evaporator Fan ECM Motor replacing Shaded Pole Motor | REF | $89.65 - $55.37 = $34.28/ft\* | $89.65/ft\* | N/A |
| **RF-65986**: Walk-in Cooler Evaporator Fan ECM Motor replacing Shaded Pole Motor | REF | $256.25 - $193.9 = $62.35/motor | $256.25/motor | N/A |
| **RF-73198**: Walk-in Cooler Evaporator Fan ECM Motor replacing Permanent Split Capacitor (PSC) Motor | REF | $256.25 - $166.06 = $90.19/motor | $256.25/motor | N/A |
| **RF-78433**: Walk-in Freezer Evaporator Fan ECM Motor replacing Permanent Split Capacitor (PSC) Motor | REF | $256.25 - $166.06 = $90.19/motor | $256.25/motor | N/A |
| **RF-89766**: Walk-in Freezer Evaporator Fan ECM Motor replacing Shaded Pole Motor | REF | $256.25 - $193.9 = $62.35/motor | $256.25/motor | N/A |
| **RF-89850**: Display Case Freezer Evaporator Fan ECM Motor replacing Shaded Pole Motor | REF | $89.65 - $55.37 = $34.28/ft\* | $89.65/ft\* | N/A |

\* According to the eQuest built-in models, each glass door is about 2.6 ft in length.

# Attachments

The attachments are stored separately and not embedded in the Word File.

1. Base Case Cost Supporting Document

# References

The Reference file is stored separately and not embedded in the Word Document

[26]

[31]

[128]

[132]

[213]

[215]

[351]

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

[A] ASHRAE 2006. Refrigeration Handbook. Atlanta, Georgia. pp. 46.2, Table 1.

[B] Energy Conservation Program for Commercial and Industrial Equipment:

Energy Conservation Standards for Commercial Ice-Cream Freezers; for Self-Contained Commercial Refrigerators, Commercial Freezers, and Commercial Refrigerator-Freezers without Doors; and for Remote Condensing Commercial Refrigerators, Commercial Freezers, and Commercial Refrigerator-Freezers. Federal Register. 10 CFR Part 431. January 9, 2009. <http://www1.eere.energy.gov/buildings/appliance_standards/commercial/refrig_equip_final_rule.html>

[C] DOE 2009a. Energy Conservation Standards for Commercial Refrigeration Equipment:

Technical Support Document, U.S. Department of Energy, January 2009,

http://www1.eere.energy.gov/buildings/appliance\_standards/commercial/refrig\_equip\_final\_rule.html.

[D] 2014 Appliance Efficiency Regulations (Title 20), CEC-400-2014-009-CMF (2014).

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