**Work Paper PGE3PREF128**

**Medium Temp Open Case Retrofit**

**Revision 2**

**PECI**

**EnergySmart Grocer**

**Medium Temperature Open Case Retrofit**

**Measure Code RA02**

**PECI EnergySmart Grocer**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Applicable Measure Codes:** | **RA02** |
| **Measure Description:** | Install a medium temp open vertical refrigerated display case with a high efficiency evaporator coil |
| **Energy Impact Common Units:** | Len-ft |
| **Base Case Description:** | Source: Manufacturer Specifications  Code-compliant medium temp, open vertical refrigerated display case with a standard evaporator coil. |
| **Base Case Energy Consumption:** | Source: Calculation  834.9 kWh/unit |
| **Measure Energy Consumption:** | Source: Calculation  688.7 kWh/unit |
| **Energy Savings (Base Case – Measure)** | Source: Calculation  146.2 kWh/unit |
| **Costs Common Units:** | Length of display case (Len-ft) |
| **Base Case Equipment Cost ($/unit):** | Source: US DOE Rulemaking Analysis  $550.92 |
| **Measure Equipment Cost ($/unit):** | Source: Equipment Vendors  $592.87 |
| **Full Measure Cost ($/unit)** | Source: Calculation  $41.95 |
| **Measure Incremental Cost ($/unit):** | Source: Calculation  $41.95 |
| **Effective Useful Life (years):** | Source: DEER D03-207  12 years |
| **Measure Application Type:** | Replace on burnout (ROB) |
| **Net-to-Gross Ratios:** | Source: DEER2011\_NTGR\_2012-05-16  0.60 (Default Value) |
| **Important Comments:** |  |

# Work Paper Approvals

The following Manager(s) approved this workpaper through the PG&E Electronic Data Routing System under Routing Requisition # \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |
| --- |
|  |
| **Grant Brohard**  Manager, Technical Product Support |
| **Carolyn Weiner**  Principal, CES Products and Programs |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision #** | **Date** | **Section by Section Description of Revisions** | **Author (Company)** |
| **Revision 0** | 07/23/2009 | Original work paper | James Anthony  (PECI Engineering) |
| **Revision 1** | 6/13/2012 | Updated to PG&E 2013-2014 format  Updated base case to reflect federal code  Updated calculations to reflect new base case  Updated measure and base case costs to reflect code compliant cases | Eric Mullendore  (PECI Engineering) |
| **Revision 2** | 5/20/14 | Updated workpaper format | John Rosendo, PECI |

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# Section 1. General Measure & Baseline Data

This work paper documents the rationale for the “Medium Temperature Open Vertical Case, Standard to High Efficiency” measure as part of Pacific Gas & Electronic Company’s Customer Energy Efficiency Program.

***Catalog Description –***

RA02: This measure is applicable to the replacement of an existing medium temperature open vertical refrigerated display case with a new case of the same style that exceeds federal energy standards through the use of a high efficiency evaporator coil.

## 1.1 Product Measure Description & Background

***Program Restrictions and Guidelines***

***Terms and Conditions:***

**Requirements**

* Must replace an existing medium temperature open vertical refrigerated display case with a new case of the same style that exceeds federal energy standards through the use of a high efficiency evaporator coil.

**Additional details**

* Spec sheet for new cases must be submitted to the Program for review to confirm eligibility

***Market Applicability:***

This measure is applicable to medium temp open vertical refrigerated display cases, which are found primarily in grocery stores and also in other food retail establishments.

## 1.2 Product Technical Description

This measure replaces an existing open standard efficiency medium temperature refrigerated display case with a new open high efficiency medium refrigerated display case. The savings result from the use of an evaporator coil that exceeds the minimum efficiency required to meet federal display case standards. Cases with a high efficiency evaporator coil are designed to keep the product at the desired temperature while reducing the amount of heat that the refrigeration system needs to reject. Additionally, the efficient evaporator coil allows the suction temperature to be 3 °F higher than that required for a standard evaporator coil. The higher suction temperature results in an increase in compressor efficiency.

The refrigeration system serving the display case load is generally remote (i.e. external) to the display case.

## 1.3 Measure Application Types

The delivery method for this measure is downstream prescriptive rebate.

The Measure Application Type for this measure is Replace on Burnout. The DEER Measure Cost Data Users Guide found on [www.deeresources.com](http://www.deeresources.com) under *DEER2011 Database Format* hyperlink, DEER2011 for 13-14, spreadsheet *SPTdata\_format-V0.97.xls*, defines the terms as follows:

Table 1 Measure Application Type

*Identifies the measure application type in the Measure Implementation table in DEER2011.*

|  |  |  |
| --- | --- | --- |
| **Code** | **Description** | **Comment** |
| ROB | Replace on Burnout | *measure applied when existing equipment fails or maintenance requires replacement* |

The existing refrigerated display case is considered to have reached the end of its useful life because the simple payback period for a retrofit version of the measure would exceed that generally acceptable for this market segment.

## 1.4 Product Base Case and Measure Case Data

### 1.4.1 DEER Base Case and Measure Case Information

The 2011 DEER v4.01 data include the Net to Gross applicable to this measure.

The 2008 DEER v2.05 data include the equipment useful life (EUL) applicable to this measure.

The DEER 2014 data does not contain the demand, electric, gas energy savings, equipment unit costs, or equipment incremental costs for this measure.

Table 2 DEER Net-to-Gross Ratios

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **DEER Spreadsheet** | |
| Program Approach | NTG | File name | Cell Number |
| EnergySmart Grocer | 0.60 | DEER2011\_NTGR\_2012-05-16 | T56 |

**Effective Useful Life / Remaining Useful Life:**

The Effective Useful Life was estimated based on the EUL applied to similar equipment in DEER 2005.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Building type** | **Bldg Vintage** | **Climate Zone** | **EUL (yrs)** | **RUL (yrs)** | **DEER Version** | **Impact ID** |
| **GRO** | **ALL** | **ALL** | **12** | **N/A** | **2005 v2.01** | **D03-207** |

### 1.4.2 Codes & Standards Requirements Base Case and Measure Information

The measure in this work paper is not governed by either state or federal codes and standards.

***Title 20:***

This measure does not fall under Title 20 of the California Energy Regulations. Title 20, Section 1605.3 covers new appliances sold or offered for sale in California, but does not apply to medium temperature vertical open refrigerated display cases.

***Title 24:***

This measure does not fall under Title 24 of the California Energy Regulations. Section 126 of the current standard (2008) applies to refrigeration systems in refrigerated warehouses but does not apply to display equipment found in retail food establishments. The proposed 2013 revisions to the standard includes a provision in section 126 for the control of refrigerated display case lighting but otherwise does not address this equipment class.

***Federal Standards:***

Both the base case and measure equipment described in this workpaper must comply with 10CFR § 431.66 (2012). The standard establishes a maximum daily energy consumption for the equipment class of 0.82 × TDA (ft2) + 4.07 kWh/day when tested in compliance with ARI Standard 1200-2006. The standard does not prescribe requirements for specific case components (evaporator motors, case lighting, insulation, evaporator coil, air curtain).

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

The base case equipment and installation cost information were taken from the US Department of Energy’s cost-effectiveness analysis used to develop the current federal standards for refrigerated display cases. The DOE report estimated that a 12’ code compliant medium temperature open vertical refrigerated display case would cost a retailer $6,611 for the equipment and $1,960 for installation.[[1]](#endnote-1)

### 1.4.4 Assumptions and Calculations from other sources—Base and Measure Cases

The values for the average annual and peak EER of the refrigeration system were sourced from the 2010 ASHRAE Handbook for Refrigeration. Figure 24 in Section 15.14 displays the typical range of EER in a retail food store. For medium temp systems it ranges from 8 Btu/W-h for meat cases to 11 Btu/W-h for produce cases. A conservative value of 10 Btu/W-h was used as the average annual EER. The EER during the peak demand period is reduced to 9 Btu/W-h as a result of hotter ambient conditions.

Both the average annual EER and peak EER are improved in the efficient case a result of increased suction temperature. According to “Industrial Refrigeration Best Practices Guide” prepared by Cascade Energy Engineering with support from Northwest Energy Efficiency Alliance (NEEA), each degree in suction temperature increase results in between a 1% and 2% gain in refrigeration system efficiency. A value of 1.5%/oF was used in the calculations.

The value of Full Load Hours (FLH) are derived from hourly reports from parametric DOE2.2r modeled peak refrigeration load, and the total annual suction load. The FLH value shown represents the average across the many different refrigeration system types and climate zones that apply to this measure. See file “Explanation of FLH for PG&E & CPUC.doc” in Appendix C for details.

The design cooling load for the efficient and base case equipment were developed using manufacturer case specifications. See Appendices A and B for complete details.

The measure equipment cost was developed based on conversations with several refrigeration equipment vendors. Based on these conversations, the average cost for a 12’ medium temperature open vertical refrigerated display case with a high efficiency coil was $7,114.40.

### 1.4.5 Time-of-Use Adjustment Factor

We are required by CPUC decision 06-06-063 dated June 29, 2006 to apply time-of-use (TOU) adjustment factors on 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.

***1.5 Summary of Inputs for Savings Calculations***

The following table provides references to sections that document the inputs for calculation:

|  |  |  |
| --- | --- | --- |
| **Calculation Variable** | **Input Value** | **Source** |
| Base Case Load (Btu/hr/ft) | 1,439 | Manufacturer Specifications |
| Efficient Case Load (Btu/hr/ft) | 1,240 | Manufacturer Specifications |
| Refrigeration System Full Load Hours | 5,803 | DOE2.2R Modeling |
| Annual Average Base EER (Btuh/W) | 10 | 2010 ASHRAE Ref. Handbook |
| Annual Average Efficient EER (Btuh/W) | 10.45 | 2010 ASHRAE Ref. Handbook + NEEA Report |
| Annual Average Base EER (Btuh/W) | 9 | 2010 ASHRAE Ref. Handbook |
| Annual Average Efficient EER (Btuh/W) | 9.41 | 2010 ASHRAE Ref. Handbook + NEEA Report |

# Section 2. Calculation Methods

Table 3 Baseline by Measure Application Type

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Measure Life Basis** | **First Baseline Period: Energy Savings Baseline** | **Second Baseline Period: Energy Savings Baseline** |
| ***ROB* (replace-on-burnout)** | **EUL** | Code Baseline | N/A |

## 2.1 Electric Energy Savings Estimation Methodologies

The electrical savings from this measure result primarily from a reduction in cooling load associated with a more efficient evaporator coil. The energy and demand values presented account only for the energy consumed by the refrigeration system compressor and condenser. The display case’s auxiliary loads (evaporator fans and lighting) are ignored as they are not impacted by the measure.

Equation 1- Annual Electric Savings Equation



where kWhbase is found using the equation:

Equation 2- Base Case Annual Electric Energy Used

Where:

kWh base = Base case annual electrical energy consumption of the energy efficient case refrigeration system compressors and condensers dedicated to removing the heat load associated with the base case scenario. Units are kWh consumed annually / linear foot of display case.

Loadbase = Base case annual heat load that must be rejected by the refrigeration system. The load is created by the product within the refrigerated display case, heat infiltration from the sales space of the grocery store and auxiliary load. Units are Btu/hr/ linear foot of case.

FLH = Annual compressor system full-load hours. Units are hours.

EERbase = Base case annual average energy efficiency ratio of the refrigeration system. Units are in Btu/hr/Watt-hr.

kWhee (the energy efficient annual electric energy used) is found using **Equation 2** above, but with energy efficient values.

In addition to the reduced load associated with a more efficient evaporator coil, the suction temperature is on average 3 °F higher than the base case suction temperature.[[2]](#endnote-2) The higher suction temperature increases the efficiency of the refrigeration system compressors. The EERefficient was found using the equation:



Equation 3 – Average Annual EER for Efficient Case

Where,

1.045 = The factor which accounts for improved compressor efficiency that results from maintaining a higher suction temperature. The factor assumes a 1.5% efficiency increase for each degree of the suction temperature is increased.

## 2.2. Demand Reduction Estimation Methodologies

Peak demand electric energy reduction was found using the equation:

Equation 4 - Peak Demand Reduction



where kWbase is found using the equation:

Equation 5- Peak Demand in Base Case

kWee (the energy efficient annual electric energy used) is found using **Equation 5** above, but with energy efficient values. EERpeak,efficient was found using the equation:

Equation 6 – Peak EER for Efficient Case



## 2.3. Gas Energy Savings Estimation Methodologies

There is no gas energy savings associated with this measure.

# Section 3. Load Shapes

The PG&E E3 Calculator “Measure Electric End Use Shape” for both the base case load shape and measure load shape is Commercial Refrigeration.

## 3.1 Base Case Load Shapes

The base case load shape follows a typical commercial refrigeration load shape. This load shape closely follows outside temperatures, with the highest load associated with high outside temperatures and the smallest load associated with cooler outside temperatures. Figure 2 - Base Case Daily Load Profiles displays the load profile of a typical commercial refrigeration system over the course of a summer day.



Figure 2 - Base Case Daily Load Profiles

## 3.2 Measure Load Shapes

The measure load shape will resemble the base case load shape. The base case shapes are to be used in the cost avoidance calculation.

# Section 4. Base Case & Measure Costs

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Measure Life Basis** | **First Baseline Period Full Measure Cost (RUL)** | **Second Baseline Period Full Measure Cost (EUL – RUL)** |
| ***ROB(replace on burnout)*** | EUL | Calculated as Incremental Measure Cost | N/A |

## 4.1 Base Case(s) Costs

The following Measure Application Type is appropriate to this measure. The Base Case Costs are:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Measure Code*** | **Measure Application Type** | **Baseline** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Base Case Cost** |
| RA02 | ROB | Federal Code | $550.92 | $163.33 | $0 | $714.25 |

*All costs are noted as $ per measure unit*

## 4.2 Measure Case Costs

The following Measure Application Type is appropriate to this measure. The Measure Case Costs are:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Measure Code*** | **Measure Application Type** | **Baseline** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Measure Case Cost** |
| RA02 | ROB | Federal Code | $592.87 | $163.33 | $0 | $756.20 |

*All costs are noted as $ per measure unit*

## 4.3 Incremental & Full Measure Costs

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Full Measure Cost**  **(RUL Period/First Baseline)** | **Full Measure Cost**  **(EUL-RUL Period/ Second Baseline)** | **Incremental Measure Cost** |
| ROB | Measure Equipment Cost  – Base Case Equipment Cost | N/A | Measure Equipment Cost  – Base Case Equipment Cost |

### 4.3.1 Full Measure Cost

Full Measure Cost is the cost to install an energy efficient measure per the CPUC calculators. This definition implies a different meaning depending on the Measure Application Type.

This Measure Application Type is ROB, so the Full Measure Cost (FMC) is represented by the equation below:

FMC = Measure Equipment Cost + Measure Labor Cost) –

(Base Case Equipment Cost + Base Case Labor Cost)

\*Note: We assume that, unless stated otherwise, the measure case labor and base case labor are assumed to be the same value reducing the equation to the following:

FMC = Measure Equipment Cost – Base Case Equipment *Cost*

*FMC = $756.20 per len-ft - $714.25 per len-ft = $41.95 per len-ft*

\*Note: Various complicated price fluctuations are not addressed in this equation, such as future costs due to inflation in labor, future costs due to deflation in material cost, and other variables that cannot be accurately described at this time.

### 4.3.2 Incremental Measure Costs

Incremental Measure Cost is the premium cost to install an energy efficient measure over a standard efficiency measure or code baseline measure. While IMC has a straightforward definition depending on the Measure Application Type, the equation does vary.

This Measure Application Type is ROB so the Gross Measure Cost (GMC) is represented by the equation below:

IMC = (Measure Equipment Cost + Measure Labor Cost) –

(Base Case Equipment Cost + Base Case Labor Cost)

\*Note: Unless stated otherwise the measure case and base case labor costs are typically the same, reducing the equation to the following:

IMC = Measure Equipment Cost – Base Case Equipment Cost

*IMC = $756.20 per len-ft - $714.25 per len-ft = $41.95 per len-ft*

**Summary Table for Section 4**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure ID** | **Measure ApplicationType** | **Base Case Total Cost** | **Measure Case Total Cost** | **Full Measure Case Cost** | **Incremental Measure Cost** |
| RA02 | ROB | $714.25 | $756.20 | $41.95 | $41.95 |

# References

2004-2005 Database for Energy Efficiency Resources, Version 2.01, October 26, 2005, EEM D03-207 <http://eega.cpus.ca.gov/deer>.

1. Table 8.2.9 in Chapter 8 of the Technical Support Documentation. Level 5 is equivalent to the standard that was adopted for this equipment class. [↑](#endnote-ref-1)
2. See Appendix A for details. [↑](#endnote-ref-2)