**Work Paper PGECOREF104**

**New Display Cases with Doors**

**Revision #5**

**Pacific Gas & Electric Company**

**Customer Energy Solutions Department**

New Refrigeration Display Cases with Doors

**Measure Codes R4 and R5**

# 

# May 20, 2014

# At-a-Glance Summary

|  |  |  |  |
| --- | --- | --- | --- |
| **Applicable Measure Codes:** | **R4** | **R5** |  |
| **Measure Description:** | New Refrigeration Display Cases with Doors – Low Temperature (R4) and New Refrigeration Display Cases with Doors – Medium Temperature (R5). | | |
| **Energy Impact Common Units:** | Linear Feet of Case | | |
| **Base Case Description:** | Source: DOE2.2R Model  Existing open vertical low-temperature (LT) and medium-temperature (MT) display cases. | | |
| **Base Case Energy Consumption:** | Source: DOE2.2R Model  The total baseline energy use consists of the direct energy use of the refrigerated case (evaporator fans, lights, and anti-sweat heater) and energy consumption of the refrigeration compressors and condensers to meet the system loads. The direct energy use of the case remains constant while the refrigeration energy consumption varies by climate zone. | | |
| **Measure Energy Consumption:** | Source: DOE2.2R Model  In the post-retrofit case the refrigerated cases are equipped with low energy glass doors, high-efficiency fans, lights and anti-sweat heaters (ASH). The increased efficiency of the fans and lights results in a decrease in direct energy consumption. There is a decrease in refrigeration energy consumption from reduction in air infiltration and from interactive effects that vary by climate zone. | | |
| **Energy Savings (Base Case-Measure)** | Source: DOE2.2R Model  The energy savings vary by climate zone. | | |

|  |  |
| --- | --- |
| **Costs Common Units:** | Linear Feet of Case |
| **Base Case Equipment Cost ($/Unit):** | Source: Department of Energy Rulemaking for Commercial Refrigeration Equipment Energy Conservation Standards, Chapter 8: Life-Cycle Cost and Payback Period Analysis:  R4: ROB - $1,043.38/linear-ft  R5: ROB - $800.15/linear-ft |
| **Measure Equipment Cost ($/Unit):** | Source: Department of Energy Rulemaking for Commercial Refrigeration Equipment Energy Conservation Standards, Chapter 8: Life-Cycle Cost and Payback Period Analysis  R4: $1,254.65/linear-ft  R5: $1,122.11/linear-ft |
| **Gross Measure Cost ($/Unit):** | Source:  Measure ID – Transaction Type – Gross Measure Case Cost  R4: ROB – $211.27/linear-ft  R5: ROB – $321.95/linear-ft |
| **Measure Incremental Cost ($/Unit):** | Source: Department of Energy Rulemaking for Commercial Refrigeration Equipment Energy Conservation Standards, Chapter 8: Life-Cycle Cost and Payback Period Analysis  Measure ID – Transaction Type – Gross Measure Case Cost  R4: ROB – $211.27/linear-ft  R5: ROB – $321.95/linear-ft |
| **Effective Useful Life (years):** | Source: DEER 2008, D03-207  Measure ID – Transaction Type – EUL (years)  R4: ROB – 12  R5: ROB – 12 |
| **Program Type:** | Replace on Burnout (ROB) only. |
| **Net-to-Gross Ratios:** | Source: Nonresidential Default, not listed in DEER. 0.6 |
| **Important Comments:** | Includes interactive effects with refrigeration systems and with the HVAC system. |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Developed From** | **10/15/2007** | **New Low and Medium Temperature Display Cases with Doors WPSCNRRN0008 (re.1.2007).** | **Southern California Edison** |
| **Revision 0** | **04/16/08** | **New Refrigeration Display Cases with Doors PGECOREF104 R0.doc** | **Sanjiy Deynani, P.E. (kW Engineering, Inc.)** |
| **Revision 1** | **05/29/2009** | **Updated NTG and IMC to match DEER2008. Minor editorial changes.** | **Michele Friedrich (PG&E)** |
| **Revision 1** | **11/10/09** | **Added OTR to Climate Zone and Vintage Type in AT-A-Glance table.** | **Andrew Wieszczyk (PG&E)** |
| **Revision 2** | **3/8/2010** | **Updated NTG** | **Andrew Wieszczyk (PG&E)** |
| **Revision 3** | **8/10/2011** | **Incorporated ED recommendations provided for Attachment A work papers.** | **Edwin Huestis (PG&E)** |
| **Revision 4** | **05/11/2012** | **Adopted SCE Work Paper SCE13RN008.** | **Yin Yin Wu/BASE Energy, Inc.**  **Chris Fernandez/BASE Energy, Inc.** |
| **Revision 5** | **5/20/2014** | **Incorporated 2012 Federal Code Updates for Refrigerated Case Baselines.** | **Jason Ochs, EIT (PECI)**  **Jim Wyatt, (PG&E)** |

# Table of Contents

[At-a-Glance Summary ii](#_Toc386465481)

[Document Revision History iv](#_Toc386465482)

[Table of Contents v](#_Toc386465483)

[List of Tables vi](#_Toc386465484)

[Section 1. General Measure & Baseline Data 1](#_Toc386465485)

[1.1 Product Measure Description & Background 1](#_Toc386465486)

[1.2 Product Technical Description 2](#_Toc386465487)

[1.3 Measure Application Type 2](#_Toc386465488)

[1.4 Product Base Case and Measure Case Data 2](#_Toc386465489)

[1.4.1 DEER Differences Analysis 2](#_Toc386465490)

[1.4.2 Codes & Standards Requirements Base Case and Measure Information 4](#_Toc386465491)

[1.4.3 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information 5](#_Toc386465492)

[1.4.4 Assumptions and Calculations from other Sources – Base Case and Measure Case 5](#_Toc386465493)

[1.4.5 Time-of-Use Adjustment Factor 5](#_Toc386465494)

[1.4.6 Measure Effective Useful Life 6](#_Toc386465495)

[Section 2. Energy Savings & Demand Reduction Calculations 6](#_Toc386465496)

[2.1 Electric Energy Savings Estimation Methodologies 7](#_Toc386465497)

[2.2. Demand Reduction Estimation Methodologies 9](#_Toc386465498)

[2.3. Gas Energy Savings Estimation Methodologies 10](#_Toc386465499)

[Section 3. Load Shapes 10](#_Toc386465500)

[3.1 Base Case Load Shapes 10](#_Toc386465501)

[3.2 Measure Load Shapes 10](#_Toc386465502)

[Section 4. Base Case & Measure Costs 11](#_Toc386465503)

[4.1 Base Case Cost 11](#_Toc386465504)

[4.2 Measure Case Costs 11](#_Toc386465505)

[4.3 Gross Measure Cost 11](#_Toc386465506)

[4.4 Incremental Measure Cost 12](#_Toc386465507)

[Attachments 13](#_Toc386465508)

[References 14](#_Toc386465509)

# List of Tables

[Table 1 DEER Difference Summary 3](#_Toc386632084)

[Table 2 Net-to-Gross Ratio 4](#_Toc386632085)

[Table 3 DEER08 EUL Value/Methodology 6](#_Toc386632086)

[Table 4 Baseline by Measure Application Type 6](#_Toc386632087)

[Table 5 Summary of Modeled Medium Temperature Vertical Display Cases 8](#_Toc386632088)

[Table 6 Summary of Modeled Low Temperature Vertical Display Cases 8](#_Toc386632089)

[Table 7 Hour Specifications for Peak Demand Calculations 9](#_Toc386632090)

[Table 7 Hour Specifications for Peak Demand Calculations 10](#_Toc386632091)

[Table 8 Summary of Base Case Costs 11](#_Toc386632092)

[Table 9 Summary of Measure Case Costs 11](#_Toc386632093)

[Table 10 Summary of Section 4 Costs 12](#_Toc386632094)

# Section 1. General Measure & Baseline Data

## 1.1 Product Measure Description & Background

**Measure Description**

This work paper discusses the replacement of existing open vertical (or multi-deck) low-temperature (LT) and medium-temperature (MT) display cases with new reach-in glass door display cases. These types of display cases can be found in small and medium-to-large size grocery stores. Medium-temperature refrigerated display cases are used to stock dairy, deli, fish and meat. Low-temperature refrigerated display cases are used to stock frozen food and ice cream.

**Program Restrictions and Guidelines**

**Terms and Conditions**:

* Installation address must have a commercial electric account with PG&E.
* Must replace an existing, open multi-deck display case with a new reach-in unit with doors, Electronically Commutated Motor (ECM) evaporator fan(s), and LED lighting.
* Medium temperature cases must have no heat in the door. Heat is allowed in the frames of medium temperature cases. Low temperature door and frame heaters combined may not consume more than 50 W/ft of case length.
* New case length must be less than or equal to the original case length.
* This measure is only for cases served by a remote refrigeration system.
* Rebate is based on linear footage of new display case.
* Exclusions: Specialty deli cases, custom coolers/freezers and walk-in boxes with reach-in doors do not qualify. Refurbished cases are excluded unless compliant with 2012 Federal Efficiency Standards.
* Salvage, disposal or photographic records of replaced equipment should be part of program application requirements when early replacement or open-to-closed case conversion savings are being utilized to ensure the correct baseline is assumed for these measures.
* Display case replacements that are part of large-scale store remodels and any new construction projects should be revised to be custom measures. Large-scale remodels are defined as any project involving 50% of the linear feet of refrigerated casework or 32 linear feet of casework replacements, whichever is less.

**Market applicability:**

These measures are applicable for supermarkets and grocery stores containing stand-alone and/or multiplex compressor racks providing refrigeration to remote display cases and walk-ins. More specifically, this applies to supermarkets and grocery stores with both medium-temperature and low-temperature open multi-deck refrigeration cases.

**Type of Transaction**:

This measure is applicable for the Replace on Burnout (ROB) scenario.

## 1.2 Product Technical Description

Low-temperature (LT) display cases are used to merchandise frozen food and ice cream. Medium-temperature (MT) display cases are used to merchandise dairy, deli, fish and meat products. This workpaper defines the evaporator temperature in low-temperature cases as maintained between -40°F and 0°F; this workpaper defines evaporator temperature in medium-temperature refrigeration equipment as maintained between 0°F and 35°F.

The main benefit of replacing open multi-deck cases with new enclosed multi-deck cases is the reduction in total cooling load due to reduced air infiltration. The infiltration load refers to the entrainment of warm and moist air from the sales area into the refrigerated space. The infiltration load accounts for more than 80% of the total cooling load of a multi-deck display case.[[1]](#endnote-2) Therefore, any reduction in infiltration load can reduce refrigeration compressor power demand and energy usage significantly. It should be noted that installing cases with glass doors will likely result in an increase in anti-sweat heater (ASH) load.

The energy savings and cost figures are calculated per linear foot of case. Calculations for all climate zones in PG&E’s service territory have been performed for grocery store applications.

## 1.3 Measure Application Type

The DEER Measure Cost Data Users Guide, version 2.01, defines the terms as follows:

* Replace on Burnout (ROB) – Replacing a technology at the end of its useful life.

A replace on burnout implementation would signify that the open multi-deck case is at the end of its useful life. For the ROB iterations of the measure, the energy savings were calculated by comparing the new reach-in multi-deck to a code compliant open multi-deck baseline.

## 1.4 Product Base Case and Measure Case Data

### 1.4.1 DEER Differences Analysis

The DEER 2005 measure does an excellent job of modeling the energy savings for replacing an open multi-deck case with a new reach-in multi-deck case of a 2005 vintage. However, the energy efficiency level of a new reach-in multi-deck case today surpasses that of a standard case in 2005. Reach-in cases being installed by grocers now include LED lighting, doors and frames with no anti-sweat heat, and ECM motors. Some of these high efficiency components are now required by Federal Appliance Standards. As expected, most of the energy savings modeled for this measure are the result of the added doors. Acting as an infiltration barrier, there is a subsequent decrease in the infiltration load. The magnitude of infiltration reduction in the DEER measure aligns directly with the analysis found in recent studies.[[2]](#endnote-3) The DEER 2005 measure however, does not accurately reflect modern case component technology and efficiency.

Power densities for lighting, ASH, and fans in the DEER measure do not reflect those that are currently installed and compliant with the 2012 Federal Efficiency Standards. In the current DEER measure the lighting and ASH power densities actually increase from the baseline and result in an energy penalty. The logic behind the penalty is sound; in 2005 when the measure was initially created, additional fluorescent case lights were installed to keep the product illuminated and heat was run through the doors and frames to prevent condensation and frost build up. Since then, and in large part driven by the Federal Standards, LED lighting has become economically viable in new cases resulting in better illumination of products while at the same time using approximately the same, if not less, power. Anti-sweat heat (ASH) can also be essentially eliminated through the use of more advanced doors and frames. Each of these components directly draws power as well as indirectly interacts with compressor power consumption by contributing heat to the refrigerated space.

This workpaper is based on adjusting the DEER grocery prototype model. In order to more accurately assess the energy savings of each measure, humidity controls congruent with the current grocery store market segment were implemented into the baseline model.[[3]](#endnote-4) Medium temperature case baselines were updated with values to represent a 2012 Federal Code compliant open multi-deck case. Medium temperature reach-in cases were modeled to represent cases with LED lighting, ECM evaporator fan motors, and doors without anti-sweat heat. Low temperature open refrigerated display case baselines were updated with values to represent a 2012 Federal Code complaint open multi-deck case. Low temperature reach-in cases were modeled to represent cases with LED lighting, EC evaporator fan motors, and doors with low anti-sweat heat power. See Table 1 for a summary of the differences.

Table 1 DEER Difference Summary

|  |  |
| --- | --- |
| Modified DEER Methodology | Yes |
| Scaled DEER Measure | No |
| Deviation from DEER | Medium temperature baseline was adjusted to reflect 2012 Federal Standards. Also, DEER does not include retrofitting old vertical low-temperature display cases with low-temperature display cases with glass doors. |
| DEER Version / Run ID | DEER 05 / D03-207 |

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

**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 vertical open refrigerated display cases.[[4]](#endnote-5)

**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.[[5]](#endnote-6)

**Federal Standards:**

Both the base case and measure equipment described in this workpaper comply with Federal Standard 10CFR § 431.66 (2012). Any case that receives an incentive based on this workpaper should also comply with this standard. It establishes a maximum daily energy consumption for the equipment class of 0.22 × TDA -Total Display Area (ft2) + 1.95 kWh/day for medium temperature display cases with doors and 0.56 + TDA (ft2) + 2.61 kWh/day for low temperature display cases with doors when tested in compliance with ARI Standard 1200-2006. For vertical open multi-deck cases, Federal Standards prescribe a maximum energy consumption of 0.82 × TDA (ft2) + 4.07 kWh/day for medium temperature applications and 2.27 × TDA (ft2) + 6.85 kWh/day for low temperature applications. The standard does not prescribe requirements for specific case components (evaporator fan motors, case lighting, insulation, evaporator coil, air curtain).[[6]](#endnote-7)

**Net to Gross Value:**

The NTG value was obtained from the “DEER2011\_2012-05-16.xls” (See Attachment C) on the DEER website as required by Version 4 of the California Public Utilities Commission (CPUC) Energy Efficiency Policy Manual. The relevant NTGR for this measure is shown in Table 2 below.

Table 2 Net-to-Gross Ratio

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NTGR\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID | NTG\* |
| Com-Default>2yr | 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.

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

Numerous studies have been conducted on the energy savings associated with the measures described in this paper. One commonly cited study conducted by researchers at Southern California Edison’s Research and Thermal Test Center found that after retrofitting doors to an open display case the cooling load attributable to infiltration was reduced by 68%. This conclusion was based on lab testing conducted with static ambient temperature and humidity levels.[[7]](#endnote-8)

Another report based on lab testing concluded that the cooling load of open cases decreased 66% versus cases without doors or night covers and 53% when compared to an open case with night covers in place at night. The same report discussed the results of a field trial that measured savings of 26% for the store’s entire refrigeration system when several medium and low temperature cases were retrofitted with doors. Though this study focuses on a door retrofit the principles of load reduction are the same.[[8]](#endnote-9) Case replacements as described in this workpaper also include component upgrades for lighting and motors.

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) paid for a research project (RP-1402) to compare energy and sales results of open multi-deck vs. reach-in case for medium temperature applications. The display cases tested held alcoholic beverages and dairy and were located in 2 stores in Kansas. The report summary showed an 18% reduction in energy, using calculated compressor savings and measured refrigeration load.[[9]](#endnote-10)

The State of California Air Resources Board has estimated that adding doors to all viable open vertical refrigerated display cases in the state would reduce energy consumption by more than 1,000 GWH, or 5% of the total energy consumption attributed to the grocery sector.[[10]](#endnote-11)

### 1.4.4 Assumptions and Calculations from other Sources – Base Case and Measure Case

The display case keyword assumptions in the models are derived from manufacturer specification. A summary of the manufacturers specifications can be found in Attachment A and copies of those specifications can be found in Attachment H. Section 2 provides further details

### 1.4.5 Time-of-Use Adjustment Factor

As 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. The TOU adjustment factor is 0.

### 

### 1.4.6 Measure Effective Useful Life

DEER11 documentation provides EUL (Estimated Useful Life) and RUL (Remaining Useful Life) information to be used for the 13-14 program cycle on 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 retrofits 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 DEER11 documentation, EUL\_Summary\_10-1-08.xls, was consulted. Table 3 below identifies the value/methodology used for the measures in this work paper.

Table 3 DEER08 EUL Value/Methodology

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Market | Enduse | Measure | EUL (Years) | RUL (Years) |
| Non-Residential | Refrigeration | Zero Heat Reach-in Glass Doors | 12 | N/A |

# Section 2. Energy Savings & Demand Reduction Calculations

Table 4 Baseline by Measure Application Type

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Measure Life Basis** | **First Baseline Period: Energy Savings Baseline** | **Second Baseline Period: Energy Savings Baseline** |
| ***ER* (early retirement)** | **EUL** | Customer Average Baseline | Code Baseline |
| ***ROB* (replace-on-burnout)** | **EUL** | Code Baseline | N/A |
| ***NC* (new construction)** | **RUL/EUL-RUL** | Code Baseline | N/A |

Notes:

* For ROB measures, First Baseline is the baseline for the full EUL. There is no second baseline.
* For ER measures, First Baseline Period is the period for the RUL(remaining useful life),defined by the CPUC as RUL=1/3 EUL. Second baseline period for ER is Code baseline for the period EUL-RUL.

## 2.1 Electric Energy Savings Estimation Methodologies

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

* The building simulation models were generated from the DEER measure analysis tool within eQUEST 3-61R. The DEER model simulates a grocery store with a multiplex-compressor system for the refrigerated display cases. Since single-compressor systems are generally slightly less efficient than multiplex-compressor systems, only multiplex systems have been analyzed as a conservative estimate of savings. 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 applies to display cases located within a space with heating, cooling, and humidity controls. The unit energy savings are represented per linear-foot of the display case. The building simulation models were generated for a grocery store. Since the heat gain to 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 resulting savings of the grocery store model is applied to all other building types considered in this work paper.

The energy savings and demand reduction for this workpaper are based on replacing the existing open vertical (multi-deck) low temperature and medium temperature display cases with reach-in glass door display cases. The display cases are generally applicable to, but not limited to, grocery stores. The baseline display cases were replaced with similar cases with glass doors. Based on industry practice, the medium temperature retrofit incorporated additional case lighting to improve product visibility. Due to the addition of the LED lights the overall case lighting power density for the medium temperature case was reduced. The low temperature baseline case included LED lighting and no change was made to the power density per foot. Replacing open display cases with reach-in glass door display cases will reduce the infiltration load significantly, resulting in savings on the refrigeration cooling load and space heating load.

The DEER measure ID D03-207 replaces existing medium temperature multi-deck cases with new cases having glass doors. For the measures described in the workpaper the new cases are assumed to have low anti-sweat heat (ASH) doors, ECM motors, and LED lighting. This is a change from the original DEER measure which did not take into account the lower ASH and LED lighting. Due to the lower ASH power requirement in the medium temperature cases, it was assumed that the ASH controls would be fixed in the measure.

Although energy savings differ across the various climate zones due to changing system design parameters the two measures are not directly weather sensitive. The building energy simulation tool, eQUEST 3-61R, was used in determining the impact of the measure across all California climate zones. The built-in DEER grocery store prototype for vintage 2002-2005 was used for all simulations of the measure including both medium temperature and low temperature cases. The DEER grocery prototype considered multiplex-compressor systems as the refrigeration system type. The DEER building prototypes included refrigeration fixtures for both open multi-deck medium temperature cases and low temperature vertical display cases with doors. Since no refrigeration fixtures existed for low temperature open vertical display cases within the DEER grocery prototype, the baseline models were generated by modifying the similar low temperature vertical display cases with doors into low temperature open vertical display cases. Store relative humidity set point was also adjusted to 45% to match industry standard and more meaningfully simulate HVAC interactions[[11]](#endnote-12). The 2002 – 2005 vintage was the most recent vintage in the grocery building prototype that included open multideck display cases. It is also reasonable to expect that the newer refrigeration system in this vintage will yield conservative interactive effects and results may be applied to all vintages. A summary of changes for components of both the medium and low temperature vertical display cases in the baseline and measure models are included in Table 4 and Table 5 below.

Table 5 Summary of Modeled Medium Temperature Vertical Display Cases

|  |  |  |
| --- | --- | --- |
| Component | MOMD1 Values\*  (Baseline Model) | MRIMD2 Values\*  (Measure Model) |
| Evaporator Fan Power | 0.0147 (kW/ft) \* | 0.0150 (kW/dr) |
| Lighting Power | 0.0369 (kW/ft) \* | 0.02810 (kW/dr) |
| Anti-Sweat Power | 0.0000 (kW/ft) | 0.01783 (kW/dr) |
| Infiltration Load | 1058 (Btu/hr-ft) | 153.33 (Btu/hr-dr) |
| Conduction Load | 77.8 (Btu/hr-ft)\* | 273.33 (Btu/hr-dr) |
| Total Line-Up Length | 128 (ft) | 50 (doors) |

Table 6 Summary of Modeled Low Temperature Vertical Display Cases

|  |  |  |
| --- | --- | --- |
| Component | LOMD3 Values\*  (Baseline Model) | LRIMD4 Values\*  (Measure Model) |
| Evaporator Fan Power | 0.01788 (kW/ft) \* | 0.01976 (kW/dr) |
| Lighting Power | 0.0179 (kW/ft) \* | 0.0478 (kW/dr) |
| Anti-Sweat Power | 0.04525 (kW/ft) | 0.09568 (kW/dr) |
| Infiltration Load | 1550 (Btu/hr-ft) | 65.84 (Btu/hr-dr) |
| Conduction Load | 325 (Btu/hr-ft)\* | 600 (Btu/hr-dr) |
| Total Line-Up Length | 283 (ft) | 109 (doors) |

\* Values represent the average across cases. For specific keyword changes and values see attachment E “keyword changes”.

1 Medium Temperature Open Multi Deck

2Medium Temperature Reach in Multi Deck

3Low Temperature Open Multi Deck

4Low Temperature Reach in Multi Deck

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 calculated. The specific savings and hourly data for both the LT and MT measure can be seen in attachments F “LT Results” and G “MT Results” respectively. 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. Dividing the length of cases by the number of doors in the DEER grocery prototype yielded an approximate unit door length of 2.67 ft per door.

By utilizing eQUEST’s hourly report function, the average peak demand outputs were calculated based on the CPUC defined peak demand periods specific to each climate zone. The peak hours can be seen in Attachment I “DEER 2014 Peak Demand Hours by Climate Zone”. 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. All simulations were run using weather files adopted by the 2013 update of Title-24.

## 2.2. Demand Reduction Estimation Methodologies

eQUEST hourly reports were used to determine the peak demand values for the baseline and post-retrofit energy models. These hourly reports can be viewed in detail in attachments F and G. The difference between these two values is determined to be the peak demand savings for this measure. Demand savings include interactive effects between the refrigeration and HVAC system. The specific peak demand period was defined by the DEER 2014 Update and uses updated Title 24 Weather Files. This period was chosen based on the following criteria:

* Occurs between June 1st and September 30th
* Does not include weekends or holidays
* Has the highest value for
  + Average temperature over the three day period
  + The average temperature from noon to 6 p.m. over the three period
  + The peak temperature over the three day period

The following table illustrates the specific periods that were used for the hourly report calculations.

Table 7 Hour Specifications for Peak Demand Calculations

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| CZ | Start Month | Start Day | End Month | End Day | Start Hour | End Hour |
| 1 | 9 | 16 | 9 | 18 | 15 | 17 |
| 2 | 7 | 8 | 7 | 10 | 15 | 17 |
| 3 | 7 | 8 | 7 | 10 | 15 | 17 |
| 4 | 9 | 1 | 9 | 3 | 15 | 17 |
| 5 | 9 | 8 | 9 | 10 | 15 | 17 |
| 6 | 9 | 1 | 9 | 3 | 15 | 17 |
| 7 | 9 | 1 | 9 | 3 | 15 | 17 |
| 8 | 9 | 1 | 9 | 3 | 15 | 17 |
| 9 | 9 | 1 | 9 | 3 | 15 | 17 |
| 10 | 9 | 1 | 9 | 3 | 15 | 17 |

Table 7 Hour Specifications for Peak Demand Calculations

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| CZ | Start Month | Start Day | End Month | End Day | Start Hour | End Hour |
| 11 | 7 | 8 | 7 | 10 | 15 | 17 |
| 12 | 7 | 8 | 7 | 10 | 15 | 17 |
| 13 | 7 | 8 | 7 | 10 | 15 | 17 |
| 14 | 8 | 26 | 8 | 28 | 15 | 17 |
| 15 | 8 | 25 | 8 | 27 | 15 | 17 |
| 16 | 7 | 8 | 7 | 10 | 15 | 17 |

## 2.3. Gas Energy Savings Estimation Methodologies

Gas energy savings were determined from the baseline and post-retrofit eQUEST energy models in accord with the keyword changes elaborated on in section 2.1 and in Attachment E “Keyword Changes”. Because there is no code, the gas energy savings for this measure represents interactive effects of the refrigeration system with the HVAC system.

# Section 3. Load Shapes

## 3.1 Base Case Load Shapes

The base case load shape is expected to follow a typical “Refrigeration” load shape for this measure because the case lights, evaporator fans, ASH and the compressor operate continuously to maintain the case temperature.

## 3.2 Measure Load Shapes

For purposes of the net benefits estimates in the E3 calculator, what is required is the load shape that ideally represents the difference between the base equipment and the installed energy efficiency measure. This difference load profile is what is called the Measure Load Shape and is the preferred load shape for use in the net benefits calculations.

The E3 Calculator contains a fixed set of load shapes selections that are the combination of the hourly avoided costs and the load shape data that was available at the time of the tool’s creation. In the E3 Calculator, the load shape that most closely fits this measure is the "Refrigeration” load shape as the new cases also operate continuously.

# Section 4. Base Case & Measure Costs

Baseline and measure case costs were compiled using the Federal energy standards life cycle analysis data.[[12]](#endnote-13)

## 4.1 Base Case Cost

Table 8 Summary of Base Case Costs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Measure Code | Transaction | Baseline | Equipment Cost | Labor / Install Cost | Maintenance / Other Cost | Total Base Case Cost |
| R4 | ROB | Federal Code | $837.05 | $206.33 | $0.00 | $1,043.38 |
| R5 | ROB | Federal Code | $593.82 | $206.33 | $0.00 | $800.15 |

\*All costs noted as $ per measure unit

\*\*For Cost Data See Appendix B

## 4.2 Measure Case Costs

Table 9 Summary of Measure Case Costs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Measure Code | Transaction | Baseline | Equipment Cost | Labor / Install Cost | Maintenance / Other Cost | Total Base Case Cost |
| R4 | ROB | Federal Code | $1,048.32 | $206.33 | $0.00 | $1,254.65 |
| R5 | ROB | Federal Code | $915.77 | $206.33 | $0.00 | $1,122.11 |

\*All costs noted as $ per measure unit

\*\*For Cost Data See Attachment B “Cost Information”

## 4.3 Gross Measure Cost

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

This measure transaction type includes: ROB, so the Gross Measure Cost (GMC) is represented by the equation below:

GMC = (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:

GMC = Measure Equipment Cost – Base Case Equipment Cost

GMCR4, ROB = $1,254.65 / ft - $800.15 / ft = **$211.27 / ft**

GMCR5, ROB = $1,122.10 / ft - $800.15 / ft = **$321.95 / ft**

\*Note: Various complicated price fluctuations are not addressed in these equations, 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.

## 4.4 Incremental Measure Cost

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 straight forward definition depending on the install type, the equation does vary.

This measure transaction type includes **ROB** only 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 labor and base case labor are assumed to be the same value reducing the equation to the following:

IMC = Measure Equipment Cost – Base Case Equipment Cost

Table 10 Summary of Section 4 Costs

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Measure ID | Transaction Type | Base Case Total Cost | Measure Case Total Cost | Gross Measure Case Cost | Incremental Measure Cost |
| R4 | ROB | $1,043.38 | $1,254.65 | $211.27 | $211.27 |
| R5 | ROB | $800.15 | $800.15 | $321.95 | $321.95 |

# Attachments

1. Case Specifications
2. Cost Information
3. DEER2011\_NTGR\_2012-05-16
4. Final Results
5. Keyword Changes
6. LT Results
7. MT Results
8. Refrigerated Case Specifications
9. DEER 2014 Peak Demand Hours by Climate Zone
10. PGECOREF104 R5 Display Cases with Doors Measure Summary

# References

1. ASHRAE Refrigeration Fundamentals Page 15.5 Figure 9 [↑](#endnote-ref-2)
2. Faramarzi, R., B. Coburn, R. Sarhadian, Rafik. 2002. Performance and Energy Impact of Installing Glass Doors on an Open Vertical Deli/Dairy Display Case. ASHRAE Transactions: Symposia p. 678 [↑](#endnote-ref-3)
3. Brian A. Fricke, Ph.D. and Vishal Sharma, Oak Ridge National Laboratory Oak Ridge, TN 12 Aug. 2011. Isolated Sub-Dehumidification Strategies in Large Supermarkets and Grocery Stores p. 36 - 37 [↑](#endnote-ref-4)
4. Title 20 2010 Appliance Efficiency Regulations [↑](#endnote-ref-5)
5. California Title 24 [↑](#endnote-ref-6)
6. Federal Energy Standards – Subpart C [↑](#endnote-ref-7)
7. Faramarzi, R., B. Coburn, R. Sarhadian, Rafik. 2002. Performance and Energy Impact of Installing Glass Doors on an Open Vertical Deli/Dairy Display Case. ASHRAE Transactions: Symposia p. 678 [↑](#endnote-ref-8)
8. Lindberg, U., M. Axell, P. Fahlen. 2010. Vertical Display Case Cabinets without and with Doors. Sustainability and Cold Chain Conference at Cambridge University, pp. 5-7 [↑](#endnote-ref-9)
9. Fricke, B.A. and B.R. Becker. 2009. “Comparison of Vertical Display Cases: Energy and Productivity Impacts of Glass Doors Versus Open Vertical Display Cases”, Final report to ASHRAE Technical Committee 10.7 [↑](#endnote-ref-10)
10. State of California Air Resources Board. 2009. Inventory of Direct and Indirect GHG Emissions from Stationary Air Conditioning and Refrigeration Sources, with Special Emphasis on Retail Food Refrigeration and Unitary Air Conditioning, CARB Agreement No. 06-325, p. 74 [↑](#endnote-ref-11)
11. Brian A. Fricke, Ph.D. and Vishal Sharma, Oak Ridge National Laboratory Oak Ridge, TN 12 Aug. 2011. Isolated Sub-Dehumidification Strategies in Large Supermarkets and Grocery Stores p. 36 – 37. [↑](#endnote-ref-12)
12. Federal Energy Standards – Life Cycle Cost and Payback Period Analysis [↑](#endnote-ref-13)