



COMMERCIAL REFRIGERATION
MEDIUM-TEMPERATURE OPEN DISPLAY CASE
RETROFIT
SWCR020-01

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MEASURE NAME

Medium-Temperature Open Display Case Retrofit

STATEWIDE MEASURE ID

SWCR020-01

TECHNOLOGY SUMMARY

This measure replaces an existing open standard efficiency medium temperature refrigerated display case with a new open high efficiency medium-temperature 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.

MEASURE CASE DESCRIPTION

The measure case is defined as a medium-temperature, open, vertical refrigerated display case with a high efficiency evaporator coil. This measure is applicable to replace an existing medium-temperature, open, vertical refrigerated display case with a new case of the same style that exceeds federal energy standards using a high efficiency evaporator coil.

Measure Case Specification

Statewide Measure Offering ID	Measure Offering Description
SWCR020A	Medium temp open vertical refrigerated display case with a high efficiency evaporator coil

BASE CASE DESCRIPTION

The base case is defined as standard efficiency open vertical case.

CODE REQUIREMENTS

Applicable state and federal codes for this measure are specified below.

Applicable State and Federal Codes and Standards

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20	None	n/a
CA Building Energy Efficiency Standards – Title 24	None	n/a
Federal Standards – Code of Federal Regulations (2012)	10 CFR 431.66	March 28, 2014

Both the base case and measure equipment must comply with the Code of Federal Regulations, Title 10 section 431.66 (2012). The standard established a maximum daily energy consumption (MDEC) as follows, when tested in compliance with ARI Standard 1200-2006:

$$MDEC = 0.82 \times TDA \text{ (ft}^2\text{)} + 4.07 \text{ kWh/day.}$$

The standard does not prescribe requirements for specific case components (evaporator motors, case lighting, insulation, evaporator coil, air curtain).

This measure is not governed by California standards. Section 1605.3 of the California Appliance Efficiency Regulations (Title 20), pertains new appliances sold or offered for sale in California but does not apply to medium-temperature vertical open refrigerated display cases.

This measure does not fall under the California Building Energy Efficiency Standards (Title 24). Section 126 of the 2016 version of Title 24 applies to refrigeration systems in refrigerated warehouses but does not apply to display equipment found in retail food establishments.

NORMALIZING UNIT

Linear feet (Len-ft)

PROGRAM REQUIREMENTS

Measure Implementation Eligibility

All combinations of measure application type, delivery type, and sector that are established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial incentives or other services) is targeted. This table also designates the broad market sector(s) that are applicable for this measure.

Note that some of the implementation combinations below may not be allowed for some measure offerings by all program administrators.

Implementation Eligibility

Measure Application Type	Delivery Type	Sector
Normal replacement	DnDeemed	Com

Eligible Products

The medium-temperature display case must meet or exceed specifications and efficiency requirements in the Measure Case Description and Code Requirements through the use of a high efficiency evaporator coil.

The new display case must replace an existing medium-temperature, open, vertical refrigerated display case of the same style

The manufacturer spec sheet for the new display case must be submitted to the Program for review to confirm eligibility.

Eligible Building Types and Vintages

This measure is applicable in any existing commercial building type.

Eligible Climate Zones

This measure is applicable in all California climate zones.

PROGRAM EXCLUSIONS

None.

DATA COLLECTION REQUIREMENTS

Data collection requirements are to be determined.

USE CATEGORY

Commercial refrigeration (ComRefrig)

ELECTRIC SAVINGS (kWh)

The electric unit energy savings (UES) from this measure result primarily from a reduction in cooling load associated with a more efficient evaporator coil. Note that the estimated energy and demand impacts account only for the energy consumed by the refrigeration system compressor and condenser. The display case auxiliary loads (evaporator fans and lighting) are excluded from the analysis because they are not impacted by the measure.

The UES is calculated as the difference between the baseline and measure case unit energy consumption (UEC). The UEC (baseline or measure case) is a function of the annual heat load rejected by the

refrigeration system, the annual compressor full-load hours, and the average energy efficiency ratio (EER).¹

$$UES_{kWh} = UEC_{base} - UEC_{measure}$$

$$UEC = \frac{Load \times FLH}{EER_{base} \times 1000 \left(\frac{kW}{W}\right)}$$

UEC_{base or measure} = Annual electrical energy consumption (UEC) of the display case refrigeration system compressors and condensers dedicated to removing the heat load. (kWh/len-ft)

Load_{base or measure} = 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. (Btu/hr/ len-ft)

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

EER_{base} = Annual average energy efficiency ratio (EER) of the refrigeration system. (Btu/hr/Watt-hr)

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 The higher suction temperature increases the efficiency of the refrigeration system compressors.

The average EER of the measure case was calculated as a function of the baseline EER and a compressor efficiency factor, which accounts for improved compressor efficiency that results from maintaining a higher suction temperature. The measure case EER was calculated as the following:

$$EER_{measure} = EER_{base} \times CompEffFactor$$

CompEffFactor = Compressor efficiency factor, which accounts for improved compressor efficiency that results from maintaining a higher suction temperature.

The inputs for the calculation of the base case and measure case UEC are provided and explained below.

UEC Calculation Inputs

Variable	Value	Source
Base Case Load (Btu/hr/ft)	1,439	Pacific Gas & Electric Company (PG&E). (n.d.) "SWCR020-01 Open to HE Open Case Calcs.xlsx." See "Calculations" tab, Table 2.
Efficient Case Load (Btu/hr/ft)	1,240	Pacific Gas & Electric Company (PG&E). (n.d.) "SWCR020-01 Open to HE Open Case Calcs.xlsx." See "Calculations" tab, Table 3.

¹ Pacific Gas & Electric Company (PG&E). (n.d.) "SWCR020-01 Open to HE Open Case Calcs.xlsx."

² Pacific Gas & Electric Company (PG&E). (n.d.). "SWCR020-01 Spec Sheets.zip."

Variable	Value	Source
Refrigeration System Full Load Hours	5,803	DOE2.2R Modeling
Annual Average Base EER (Btuh/W)	10.00	American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE). 2010. 2010 ASHRAE Handbook – Refrigeration. Atlanta (GA): ASHRAE.
Annual Average Efficient EER (Btuh/W)	10.60	Cascade Energy. (n.d.) <i>Industrial Refrigeration Best Practices Guide</i> . 3 rd Ed.
Annual Average Base EER (Btuh/W)	9.00	American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE). 2010. 2010 ASHRAE Handbook – Refrigeration. Atlanta (GA): ASHRAE.
Annual Average Efficient EER (Btuh/W)	9.54	Cascade Energy. (n.d.) <i>Industrial Refrigeration Best Practices Guide</i> . 3 rd Ed.
Compressor Efficiency Factor	1.06	Assumes a 1.5% per °F increase of the suction temperature (See below).

The values for the average annual and peak EER of the refrigeration system were sourced from the 2010 ASHRAE Handbook for Refrigeration.³ Figure 24 in Section 15.14 of the ASHRAE Handbook displays the typical range of EER in a retail food store. For medium-temperature systems the EER 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 for this analysis. 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 the *Industrial Refrigeration Best Practices Guide* prepared by Cascade Energy,⁴ each degree in suction temperature increase results in between a 1% and 2% gain in refrigeration system efficiency. A value of 1.5% per °F increase was used in the calculations.

Full load hours (FLH) were derived from hourly reports from parametric DOE2.2r modeled peak refrigeration load, and the total annual suction load. The FLH value represents the average across the many different refrigeration system types and climate zones that apply to this measure.⁵

Design cooling loads for the efficient and base case equipment were developed using manufacturer case specifications.

PEAK ELECTRIC DEMAND REDUCTION (kW)

Peak demand reduction was calculated as the difference between the baseline peak demand and the measure case peak demand. The peak demand (baseline or measure case) is a function of the annual heat load rejected by the refrigeration system, the annual compressor full-load hours, and the average energy efficiency ratio (EER).

³ American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE). 2010. 2010 ASHRAE Handbook – Refrigeration. Atlanta (GA): ASHRAE.

⁴ Cascade Energy. (n.d.) *Industrial Refrigeration Best Practices Guide*. 3rd Ed.

⁵ Anthony, J. (PECI). 2012. "Full Load Hours from GrocerSmart® Algorithms. June 5.

$$\Delta kW_{peak} = kW_{base} - kW_{measure}$$

$$kW_{base} = \frac{Load_{base}}{EER_{peak,base} \times 1000 \left(\frac{kW}{W}\right)}$$

The peak EER of the measure case was calculated as a function of the baseline peak EER and a compressor efficiency factor, which accounts for improved compressor efficiency that results from maintaining a higher suction temperature. The value of 1.045 assumes a 1.5% efficiency increase for each degree that the suction temperature increases. The measure case peak EER was calculated as the following:

$$EER_{measure,peak} = EER_{base,peak} \times CompEffFactor$$

GAS SAVINGS (Therms)

Not applicable.

LIFE CYCLE

Effective useful life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. Remaining useful life (RUL) is an estimate of the median number of years that a technology or piece of equipment replaced or altered by an energy efficiency program would have remained in service and operational had the program intervention not caused the replacement or alteration.

The methodology to calculate the RUL conforms with Version 5 of the Energy Efficiency Policy Manual, which recommends “one-third of the effective useful life in DEER as the remaining useful life until further study results are available to establish more accurate values.”⁶ This approach provides a reasonable RUL estimate without the requiring any a priori knowledge about the age of the equipment being replaced.⁷ Further, as per Resolution E-4807, the California Public Utilities Commission (CPUC) revised add-on measures so that the EUL of the measure is equal to the lower of the RUL of the modified system or equipment or the EUL of the add-on component.”⁸

The EUL and RUL specified below, are based upon estimated lifetime of the display case with doors. Note that RUL is only applicable for add-on equipment and accelerated replacement measures and is not applicable for this measure.

⁶ California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 32.

⁷ KEMA, Inc. 2008. "Summary of EUL-RUL Analysis for the April 2008 Update to DEER." Memorandum submitted to Itron, Inc.

⁸ California Public Utilities Commission (CPUC). 2016. *Resolution E-4807*. December 16. Page 13.

Effective Useful Life and Remaining Useful Life

Parameter	Value	Source
EUL (yrs)	12.0	California Public Utilities Commission (CPUC). 2014. "DEER2014-EUL-table-update_2014-02-05.xlsx."
RUL (yrs)	n/a	-

BASE CASE MATERIAL COST (\$/UNIT)

The base case equipment costs were retrieved from the U.S. Department of Energy (DOE) cost-effectiveness analysis used to develop the federal standards for refrigerated display cases. (See Table 8.2.9 in Chapter 8 of the Technical Support Documentation (TSD). Level 5 is equivalent to the standard that was adopted for this equipment class.) Because costs were presented per display case, values were normalized per linear foot of display case using the assumptions specified below. Costs were converted to 2019 values by applying an adjustment factor developed from the RSMeans historical cost index.⁹

Base Case Material Cost Inputs

Input	Value	Source
Baseline code-compliant display case (\$/case)	\$6,611	U.S. Department of Energy (DOE). 2014. <i>Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment. Commercial Refrigeration Equipment</i> . Washington DC: US Department of Energy.
Case length (len-ft)	12.0	
2019 cost conversion factor	1.19	Pacific Gas & Electric Company (PG&E). 2019. "SWCR020-01_Cost Updates.xlsx." See "Table 1" tab.

MEASURE CASE MATERIAL COST (\$/UNIT)

The measure equipment cost was derived from equipment costs obtained in 2018 from several refrigeration equipment vendors.¹⁰

Measure Case Material Cost Inputs

Input	Value	Source
Measure case display case (\$/case)	\$7,114.40	Pacific Gas & Electric Company (PG&E). (n.d.) "SWCR020-01 Open to HE Open Case Calcs.xlsx."
Case length (len-ft)	12.0	U.S. Department of Energy (DOE). 2014. <i>Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment. Commercial Refrigeration Equipment</i> . Washington DC: US Department of Energy.
2019 cost conversion factor	1.19	Pacific Gas & Electric Company (PG&E). 2019. "SWCR020-01_Cost Updates.xlsx." See "Table 1" tab.

⁹ Pacific Gas & Electric Company (PG&E). 2019. "SWCR020-01_Cost Updates.xlsx."

¹⁰ Pacific Gas & Electric Company (PG&E). 2019. "SWCR020-01_Cost Updates.xlsx."

BASE CASE LABOR COST (\$/UNIT)

The base case labor cost were retrieved from the U.S. Department of Energy (DOE) cost-effectiveness analysis used to develop the federal standards for refrigerated display cases. (See Table 8.2.9 in Chapter 8 of the Technical Support Documentation (TSD). Level 5 is equivalent to the standard that was adopted for this equipment class.) Because costs from the TSD were presented per display case, values were normalized per linear foot of display case using the assumptions specified below. Costs were also converted to 2019 values by applying an adjustment factor developed from the RSMeans historical cost index.¹¹

MEASURE CASE LABOR COST (\$/UNIT)

The installation is assumed to be same for both base case and measure case display cases, See Base Case Labor Cost.

NET-TO-GROSS (NTG)

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention. These NTG values are based upon the average of all NTG ratios for all evaluated 2006 – 2008 commercial programs, as documented in the 2011 DEER Update Study conducted by Itron, Inc. These sector average NTGs (“default NTGs”) are applicable to all energy efficiency measures that have been offered through commercial sector programs for more than two years and for which impact evaluation results are not available.

Net-to-Gross Ratios

Parameter	Value	Source
NTG - commercial	0.60	Itron, Inc. 2011. <i>DEER Database 2011 Update Documentation</i> . Prepared for the California Public Utilities Commission. Page 15-4 Table 15-3.

GROSS SAVINGS INSTALLATION ADJUSTMENT (GSIA)

The gross savings installation adjustment (GSIA) rate represents the ratio of the number of verified installations of the measure to the number of claimed installations reported by the utility. This factor varies by end use, sector, technology, application, and delivery method. This GSIA rate is the current “default” rate specified for measures for which an alternative GSIA has not been estimated and approved.

¹¹ Pacific Gas & Electric Company (PG&E). 2019. “SWCR020-01_Cost Updates.xlsx.”

Gross Savings Installation Adjustment

Parameter	GSIA	Source
GSIA - Default	1.00	California Public Utilities Commission (CPUC), Energy Division. 2013. <i>Energy Efficiency Policy Manual Version 5</i> . Page 31.

NON-ENERGY IMPACTS

Non-energy benefits for this measure have not been quantified.

DEER DIFFERENCES ANALYSIS

This section provides a summary of inputs and methods based upon the Database of Energy Efficient Resources (DEER), and the rationale for inputs and methods that are not DEER-based.

DEER Difference Summary

DEER Item	Comment
Modified DEER methodology	No
Scaled DEER measure	No
DEER Base Case	No
DEER Measure Case	No
DEER Building Types	No
DEER Operating Hours	No
DEER eQUEST Prototypes	No
DEER Version	n/a
Reason for Deviation from DEER	DEER does not contain this measure.
DEER Measure IDs Used	n/a
NTG	Source: DEER. The value of 0.60 is associated with NTGR IDs: <i>Com-Default>2yrs</i>
GSIA	Source: DEER. The value of 1.0 is associated with GSIA ID: <i>Def-GSIA</i>
EUL/RUL	Source: DEER. The EUL value of 12 years is associated with EUL ID: <i>GrocDisp-FixtDoors</i>

REVISION HISTORY

Measure Characterization Revision History

Revision Number	Revision Complete Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision
01	05/23/2019	Adan Rosillo, PG&E	Draft of consolidated text for this statewide measure is based upon: PGE3PREF128, Revision 3 (January 1, 2016) Consensus reached among Cal TF members.
	06/07/2019	Jennifer Holmes, Cal TF Staff	Revisions for submittal of version 01.