**Work Paper PGE3PREF120**

**SCT Control: Multiplex**

**Revision # 2**

**Pacific Gas & Electric Company**

**EnergySmart Grocer**

**Refrigeration Case SCT Control**

**Measure Codes R115, R116, R117, R118, R122, R123**

**EnergySmart Grocer, PECI**

# At-a-Glance Summary

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Applicable Measure Codes:** | **R115** | **R116** | **R117** | **R118** | **R122** | **R123** |
| **Measure Description:** | Ambient following SCT setpoint, 70°F minimum | Ambient following SCT setpoint, 70°F minimum, variable-spd condenser fan | Floating SCT controlled to 70°F | Floating SCT controlled to 70°F | Wetbulb following SCT setpoint, 70°F minimum | Wetbulb following SCT setpoint, 70°F minimum, variable-spd condenser fan |
| **Energy Impact Common Units:** | design cool tons | design cool tons | design cool tons | design cool tons | design cool tons | design cool tons |
| **Base Case Description:** | Source: DEER 2008  Standard air-cooled multiplex system, SCT control temp by vintage | Source: DEER 2008  Standard air-cooled multiplex system, SCT controlled temp by vintage | Source: DEER 2008  Standard evap-cooled multiplex system, SCT control temp by vintage | Source: DEER 2008  Standard air-cooled multiplex system, SCT control temp by vintage | Source: DEER 2008  Standard evap-cooled multiplex system, SCT control temp by vintage | Source: DEER 2008 Standard evap-cooled multiplex system, SCT control temp by vintage |
| **Base Case Energy Consumption:** | Source: DEER 2008 generated through MAS Control V3.00.19  The base case energy consumption varies by climate zone and vintage. | Source: DEER 2008 generated through MAS Control V3.00.19  The base case energy consumption varies by climate zone and vintage. | Source: DEER 2008 generated through MAS Control V3.00.19  The base case energy consumption varies by climate zone and vintage. | Source: DEER 2008 generated through MAS Control V3.00.19  The base case energy consumption varies by climate zone and vintage. | Source: DEER 2008 generated through MAS Control V3.00.19  The base case energy consumption varies by climate zone and vintage. | Source: DEER 2008 generated through MAS Control V3.00.19  The base case energy consumption varies by climate zone and vintage. |
| **Measure Energy Consumption:** | Source: DEER 2008 generated through MAS Control V3.00.19  The energy efficient measure energy consumption varies by climate zone and vintage. | Source: DEER 2008 generated through MAS Control V3.00.19  The energy efficient measure energy consumption varies by climate zone and vintage. | Source DEER 2008 generated through MAS Control V3.00.19  The energy efficient measure energy consumption varies by climate zone and vintage. | Source: DEER 2008 generated through MAS Control V3.00.19  The energy efficient measure energy consumption varies by climate zone and vintage. | Source: DEER 2008 generated through MAS Control V3.00.19  The energy efficient measure energy consumption varies by climate zone and vintage. | Source DEER 2008 generated through MAS Control V3.00.19  The energy efficient measure energy consumption varies by climate zone and vintage. |
| **Energy Savings (Base Case – Measure)** | Source: DEER 2008 generated through MAS Control V3.00.19  The energy savings varies by climate zone and vintage. | Source: DEER 2008 generated through MAS Control V3.00.19  The energy savings varies by climate zone and vintage. | Source: DEER 2008 generated through MAS Control V3.00.19  The energy savings varies by climate zone and vintage. | Source: DEER 2008 generated through MAS Control V3.00.19  The energy savings varies by climate zone and vintage. | Source: DEER 2008 generated through MAS Control V3.00.19  The energy savings varies by climate zone and vintage. | Source: DEER 2008 generated through MAS Control V3.00.19  The energy savings varies by climate zone and vintage. |
| **Costs Common Units:** | design cool tons | design cool tons | design cool tons | design cool tons | design cool tons | design cool tons |
| **Base Case Equipment Cost ($/unit):** | Source: DEER 2008  $0.00 | Source: DEER 2008  $0.00 | Source: DEER 2008  $0.00 | Source: DEER 2008  $0.00 | Source: DEER 2008  $0.00 | Source: DEER 2008  $0.00 |
| **Measure Equipment Cost ($/unit):** | Source: DEER 2008  $11.19 | Source: DEER 2008  $328.18 | Source: DEER 2008  $0.00 | Source: DEER 2008  $0.00 | Source: DEER 2008  $6.86 | Source: DEER 2008  $144.13 |
| **Gross Measure Cost ($/unit)** | Source: DEER 2008  $51.70 | Source: DEER 2008  $420.23 | Source: DEER 2008  $29.46 | Source: DEER 2008  $29.46 | Source: DEER 2008  $50.46 | Source: DEER 2008  $239.41 |
| **Measure Incremental Cost ($/unit):** | Source: DEER 2008  $51.70 | Source: DEER 2008  $420.23 | Source: DEER 2008  $29.46 | Source: DEER 2008  $29.46 | Source: DEER 2008  $50.46 | Source: DEER 2008  $239.41 |
| **Effective Useful Life (years):** | Source: DEER 2008  15 Years | Source: DEER 2008  15 Years | Source: DEER 2008  15 Years | Source: DEER 2008  15 Years | Source: DEER 2008  15 Years | Source: DEER 2008  15 Years |
| **Measure Application Type:** | Retrofit Addition (REA) | Retrofit Addition (REA) | Retrofit Addition (REA) | Retrofit Addition (REA) | Retrofit Addition (REA) | Early Retirement (ER) |
| **Net-to-Gross Ratios:** | Source: DEER 2011 v4.00  0.60 | Source: DEER 2011 v4.00  0.60 | Source: DEER 2011 v4.00  0.60 | Source: DEER 2011 v4.00  0.60 | Source: DEER 2011 v4.00  0.60 | Source: DEER 2011 v4.00  0.60 |
| **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** | 04/7/2008 | Original work paper | Dennis Krieger  (PECI Engineering) |
| **Revision 1** | 6/7/2012 | Updated to PG&E 2013-2014 format  Update cost data to reflect DEER 2008  Update EUL to reflect DEER 2008 | Laura Konstin  (EnergySmart Grocer) |
| **Revision 2** | 5/15/2014 | Updated calculations with 2009 weather data | Brian Owens  (PECI Engineering) |

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# Section 1. General Measure & Baseline Data

This workpaper details DEER measure D03-221, D03-222, D03-223, D03-224, D03-225, and D03-226.

|  |  |  |
| --- | --- | --- |
| **Measure Code** | **DEER Measure / Impact ID** | **Description** |
| R117 | D03-221 | SCT controlled to 70°F for air cooled system (Itron, 7-87) |
| R118 | D03-222 | SCT controlled to 70°F for evap-cooled multiplex system (Itron, 7-87) |
| R115 | D03-223 | The base case is an air-cooled multiplex, vintage dependent, and having a fixed condensing setpoint per vintage. The EEM is the addition of an drybulb-following condensing setpoint, with a 12°F temperature difference (TD) between ambient and setpoint. (Itron, 7-88) |
| R122 | D03-224 | The base case is an evaporative-cooled multiplex, vintage dependent, and having a fixed condensing setpoint per vintage. The EEM is the addition of a wetbulb following condensing setpoint, with a 17°F TD between wetbulb and setpoint. (Itron, 7-89) |
| R116 | D03-225 | The base case is an air-cooled multiplex, vintage dependent, and having a fixed condensing setpoint per vintage. The EEM is the addition of an drybulb-following condensing setpoint, with a 12°F TD between ambient and setpoint. In addition, the fans are controlled using a variable-speed drive. (Itron, 7-89) |
| R123 | D03-226 | The base case is an evaporative-cooled multiplex system, vintage dependent, and having a fixed condensing setpoint per vintage. The EEM is the addition of a wetbulb following condensing setpoint, with a 17°F TD between wetbulb and setpoint. In addition, the base-case two-speed fan is replaced with variable-speed. (Itron, 7-90) |

## 1.1 Product Measure Description & Background

***Program Restrictions and Guidelines***

***Terms and Conditions:***

**Requirements:**

**For Measures R117 and R118:**

* Must reduce fixed head pressure setpoint of an existing multiplex system to a fixed setpoint of 70F° SCT or lower.

**Exclusions:**

* Cannot be used in conjunction with measures that already incorporate floating head pressure controls.

**For Measures R115, R116, R122, R123:**

* Add controls to float head pressure down to a lower pressure when conditions permit, i.e., changes control from fixed set point to floating set point.
* Measure applicable only to refrigeration systems having multiplex compressor systems with existing control of saturated condensing temperature (SCT) at fixed set point.
* New SCT set-point must be ambient following by controlling condenser fans with variable- speed drives or by staging condenser fans.
* For air-cooled condensers the SCT must be controlled to follow ambient + 12°F TD or less
* For evaporative-cooled condensers, SCT must be controlled to follow ambient wetbulb + 17°F TD or less.
* Minimum SCT set-point must be set to 70°F or less
* If back-flood controls are present, set-point must be set to 68°F or less.

**Additional Details:**

* Cannot be used in conjunction with measures that already incorporate floating head pressure controls
* To qualify for rebate, new hardware must be installed. Projects that only reprogram a controller are not eligible for this rebate.

***Market Applicability:*** This is a retrofit measure for reprogramming fixed SCT controls on a multiplex system in the grocery sector in a downstream rebate program. The rebate encourages the grocer to add this technology to make their existing equipment more energy efficient.

This paper contains savings for the grocery building type, 5 building vintage categories and 9 California climate zones.

## 1.2 Product Technical Description

These DEER measures either reduce or float head pressure to lower SCTs when ambient conditions allow a reduction.

## 1.3 Measure Application Type

The delivery method for this measure is downstream prescriptive rebate.

The Measure Application Type for this measure is early retirement (ER).

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** |
| REA | Retrofit Addition | *measure applied while existing equipment still viable, or retrofit of existing equipment* |

## 1.4 Product Base Case and Measure Case Data

### 1.4.1 DEER Base Case and Measure Case Information

The 2005 DEER v2.01 data include: demand, electric and interactive gas energy savings. DEER 2008 data includes: equipment unit costs, equipment incremental costs, equipment useful life and Net-to-Gross values.

The original measures and energy models were created with DEER 2005. Measure information was updated in DEER 2008. The MAS Control tool that ran the batch simulations with the new 2014 T24 weather files appear to have pulled from the D08 version of the measure. We therefore cited the DEER 2008 measure with the update generated through most up to date version of MAS Control.

**Delta Wattage Assumption (ΔW):**

The EUL electric savings were generated using MASControl v3.00.19. They match the intended measures. For detailed information see MDSS excel file PGE3PREF120\_v2.

**Therms Savings Assumption (ΔTh):**

The EUL therm savings were generated using MASControl v3.00.19. They match the intended measures. For detailed information see MDSS excel file PGE3PREF120\_v2.

**Base Case Costs and Measure Case Costs:**

The Base Case, Measure Case and Incremental costs were downloaded from DEER directly; they match the intended measures for climate zones and building types and ages.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **Costs ($)** | | |  |  |
| **Building type** | **Bldg Vintage** | **Climate Zone** | **Base Case** | **Measure Case** | **IMC** | **DEER Version** | **Impact IDs** |
| **GRO** | **ALL** | **ALL** | **$0.00** | **$29.46** | **$29.46** | **DEER 2008** | **D03-221** |
| **GRO** | **ALL** | **ALL** | **$0.00** | **$29.46** | **$29.46** | **DEER 2008** | **D03-222** |
| **GRO** | **ALL** | **ALL** | **$0.00** | **$51.70** | **$51.70** | **DEER 2008** | **D03-223** |
| **GRO** | **ALL** | **ALL** | **$0.00** | **$50.46** | **$50.46** | **DEER 2008** | **D03-224** |
| **GRO** | **ALL** | **ALL** | **$0.00** | **$420.23** | **$420.23** | **DEER 2008** | **D03-225** |
| **GRO** | **ALL** | **ALL** | **$0.00** | **$239.41** | **$239.41** | **DEER 2008** | **D03-226** |

**Net-to-Gross Assumption:** 2011 DEER Update Report – Section 15 Table 15-3

Table 1 below summarizes all applicable DEER based Net-to-Gross ratios for programs that may be used by 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 estimates were downloaded from DEER directly. They match the intended measures for climate zones and building types and ages.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Building type** | **Bldg Vintage** | **Climate Zone** | **EUL (yrs)** | **RUL (yrs)** | **DEER Version** | **Impact IDs** |
| **GRO** | **ALL** | **ALL** | **15** | **N/A** | **DEER 2008** | **D03-221** |
| **GRO** | **ALL** | **ALL** | **15** | **N/A** | **DEER 2008** | **D03-222** |
| **GRO** | **ALL** | **ALL** | **15** | **N/A** | **DEER 2008** | **D03-223** |
| **GRO** | **ALL** | **ALL** | **15** | **N/A** | **DEER 2008** | **D03-224** |
| **GRO** | **ALL** | **ALL** | **15** | **N/A** | **DEER 2008** | **D03-225** |
| **GRO** | **ALL** | **ALL** | **15** | **N/A** | **DEER 2008** | **D03-226** |

### 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 24:*** There are no code changes. T24 p. 32 Section 100.0(a)2, code only required when building permit or permit renewal is needed.

***Federal Standards:*** This measure does not fall under Federal DOE or EPA Energy Regulations.

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

There are no EM&V reports used in this measure. Information on the base and measure condensers is found in the other sub-sections of 1.4

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

There are no further data or calculations provided for the support of the measures in this workpaper.

### 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. Additionally, if a measure is assigned a DEER08 load shape, i.e. the load shape starts with “DEER:” the TOU assigned to that measure should also be zero.

# Section 2. Calculation Methods

The savings for this measure is from DEER 2008 and generated from MASControl v3.00.19.

# Section 3. Load Shapes

## 3.1 Base Case Load Shapes

The base case load shape, characterized by the PG&E 2009-2011 E3 Calculator, is “Commercial Refrigeration”.

## 3.2 Measure Load Shapes

The measure case load shape, characterized by the PG&E 2009-2011 E3 Calculator, is “Commercial Refrigeration.”

# 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)** |
| ***REA (retrofit add on)*** | EUL | Calculated as Full Gross Measure Cost | N/A |

## 4.1 Base Case(s) Costs

The following Measure Application Type is appropriate to these measures. The Base Case Costs are:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Measure Code*** | **Measure Application Type** | **Baseline** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Base Case Cost** |
| R118 | REA | Existing | $0 | $0 | $0 | $0 |
| R117 | REA | Existing | $0 | $0 | $0 | $0 |
| R115 | REA | Existing | $0 | $0 | $0 | $0 |
| R122 | REA | Existing | $0 | $0 | $0 | $0 |
| R116 | REA | Existing | $0 | $0 | $0 | $0 |
| R123 | REA | Existing | $0 | $0 | $0 | $0 |

*All costs are noted as $ per measure unit*

## 4.2 Measure Case Costs

The following Measure Application Type is appropriate to these measures. The Measure Case Costs are:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Measure Code*** | **Measure Application Type** | **Baseline** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Measure Case Cost** |
| R118 | REA | Existing | $0.00 | $29.46 | $0 | $29.46 |
| R117 | REA | Existing | $0.00 | $29.46 | $0 | $29.46 |
| R115 | REA | Existing | $11.19 | $40.51 | $0 | $51.70 |
| R122 | REA | Existing | $9.96 | $40.51 | $0 | $50.46 |
| R116 | REA | Existing | $328.18 | $92.06 | $0 | $420.23 |
| R123 | REA | Existing | $169.45 | $69.96 | $0 | $239.41 |

*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** |
| REA | 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 REA with a single baseline, so the Full Measure Cost (FMC) is represented by the equation below:

FMC = Measure Equipment Cost + Measure Labor Cost

FMC(R118) = $0.00/ ton + $29.46/ ton = $29.46/ ton

FMC(R117) = $0.00/ ton + $29.46/ ton = $29.46/ ton

FMC(R115) = $11.19/ ton + $40.51/ ton = $51.70/ ton

FMC(R122) = $9.96/ ton + $40.51/ ton = $50.46/ ton

FMC(R116) = $328.18/ ton + $92.06/ ton = $420.23/ ton

FMC(R123) = $169.45/ ton + $69.96/ ton = $239.41/ ton

### 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 Types is ER or REA. There is no base case to which to compare the measure, so the Incremental Measure Cost (IMC) is represented by the equation below:

IMC = Measure Equipment Cost + Measure Labor Cost

The table below provides the Incremental cost for R115, R116, R117, R118, R122 and R123.

**Summary Table for Section 4**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure ID** | **Measure Application Type** | **Base Case Total Cost** | **Measure Case Total Cost** | **Full Measure Case Cost** | **Incremental Measure Cost** |
| R118 | REA | **$0** | **$29.46** | **$29.46** | **$29.46** |
| R117 | REA | **$0** | **$29.46** | **$29.46** | **$29.46** |
| R115 | REA | **$0** | **$51.70** | **$51.70** | **$51.70** |
| R122 | REA | **$0** | **$50.46** | **$50.46** | **$50.46** |
| R116 | REA | **$0** | **$420.23** | **$420.23** | **$420.23** |
| R123 | REA | **$0** | **$239.41** | **$239.41** | **$239.41** |

# References:

2004-2005 Database for Energy Efficiency Resources, Version 2.01, October 26, 2005, EEM D03-227 http://eega.cpus.ca.gov/deer.

Itron, Inc. *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study: Final Report.* December 2005. (Pg 7-86 to 7-91)

DEER2005UpdateFinalReport\_ItronVersion.pdf (file archived in measure folder at PECI)

Proposed T24 Part 6-15 Day.pdf (file archived in measure folder at PECI)Naming Convention for Work paper Codes.

|  |  |  |
| --- | --- | --- |
| **End Use** | **Code** | **Number variations (see JAWB)** |
| Agriculture | AGR |  |
| All | ALL |  |
| Appliances (not food Service) | APP | Gas 10X Electric 20X |
| Building Shell | BLD |  |
| Computers | COM |  |
| Domestic Hot Water | DHW |  |
| Food Service | FST | Gas 10X Electric 20X |
| HVAC (including HVAC water heat) | HVC |  |
| Lighting | LTG |  |
| Motors | MOT |  |
| Process Loads (not HVAC or DHW | PRO |  |
| Pumping | PUM |  |
| Refrigeration | REF |  |