**Work Paper PGECOLTG111**

**Nonresidential Upstream CFL**

**Revision 8**

**Pacific Gas & Electric Company**

**Customer Energy Efficiency Department**

**Nonresidential Upstream Compact Fluorescent Lighting**

**Measure Codes L093-L096, L0160 – L0233, L0239 – L0241, L0261, L0275-L0276, L0321-L0334**

# At a Glance Summary

|  |  |
| --- | --- |
| **Applicable Measure Codes:** | L093-L096, L0160 – L0233, L0239 – L0241, L0261, L0275-L0276, L0321-L0334 |
| **Measure Description:** | The nonresidential upstream compact fluorescent lamps (CFL) program encourages commercial customers to replace their existing incandescent lamps and fixtures with more efficient compact fluorescent lighting. |
| **Energy Impact Common Units:** | The energy impact common unit for this measure is per lamp (bulb), per torchiere, or per fixture. |
| **Base Case Description:** | The base case wattage is based on the updated wattage reduction ratio.  Source:  2016 DEER.  2015 Uncertain Measures Update |
| **Base Case Energy Consumption:** | Various. Refer to .xlsx file attached |
| **Measure Energy Consumption:** | Various. Refer to .xlsx file attached |
| **Energy Savings (Base Case – Measure)** | Various. Refer to .xlsx file attached |
| **Costs Common Units:** | Various. Refer to .xlsx file attached  The cost common unit for this measure is per lamp (bulb), per torchiere, or per fixture. |
| **Base Case Equipment Cost ($/unit):** | Various. Refer to .xlsx file attached |
| **Measure Equipment Cost ($/unit):** | Various. Refer to .xlsx file attached |
| **Measure Incremental Cost ($/unit):** | Various. Refer to .xlsx file attached  Source:  2016 DEER. |
| **Effective Useful Life (years):** | |  |  |  | | --- | --- | --- | | **EUL\_ID** | **Measure Type** | **EUL years** | | ILtg-CFL-Com | CFL Lamps (10,000 hour lamp life) | 4.69 | | OLtg-CFL | CFL Lamps (10,000 hour lamp life) | 2.44 | | ILtg-CFLfix-Com | Interior CFL Fixtures or Torchieres | 12 | | OLtg-CFLfix-Dusk-to-Dawn | Exterior CFL Fixtures or Torchieres | 15 | |
| **Program Type:** | ROB |
| **Net-to-Gross Ratios:** | NonRes-sAll-mCFL, NTG= 0.54  Com-Default>2yrs, NTG = 0.6  Source: 2014 DEER.  CFL fixture and torchiere NTG not specified, so the NTG “default” value of 0.6 was used |
| **Important Comments:** | The Res/NonRes 94/6 upstream split will be applied in MDSS (based on the 2006-2008Upstream lighting program evaluation). PG&E proposes to update the Res/NonRes split to 93/7 (based on the 2010 – 2012 Upstream Lighting Impact Evaluation) for 1/1/2016 and is in the process of getting approval from ED.  The corresponding residential Upstream CFL measures have the same measure codes as the nonresidential Upstream CFL measures but have different impact, cost, EUL, and NTG values. |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision #** | **Date** | **Description** | **Author (Company)** |
| Revision 0 | 01/31/08 | Non-Residential Upstream Screw-In CFL PGECOLTG107 R0.doc | Ed Mah, Jim Wyatt, PG&E |
| Revision 1 | 06/30/09 | Non-Residential Upstream Screw-In CFL PGECOLTG111 R1.doc | Jenny Roecks |
| Revision 2 | 1/14/10 | Non-Residential Upstream Screw-In CFL PGECOLTG111 R2\_v1.doc | Jenny Roecks |
| Revision 3 | 03/15/11 | Non-Residential Upstream Screw-In CFL PGECOLTG107 R3.doc | Jenny Roecks/Alina Zohrabian |
| Revision 4 | 6/30/11 | Non-Residential Upstream Screw-In CFL PGECOLTG111 R4.doc | Jenny Roecks and Alina Zohrabian |
| Revision 5 | 8/9/11 | Non-Residential Upstream Screw-In CFL PGECOLTG111 R5.doc | Jenny Roecks and Alina Zohrabian |
| Revision 6 | 5/25/12 | Non-Residential Upstream Screw-In CFL PGECOLTG111 R6.doc  This version includes all the new DEER 2011 values.  NTG, ISR, EUL, WRR, HOU, IE | Alina Zohrabian |
| Revision 6 | 8/28/12 | The “Com” building type is the weighted up value from DEER building types. For Vintage AV is changed to EX and For Climate Zone All is changed to IOU | Alina Zohrabian (PG&E) |
| Revision 7 | 5/13/14 | Only a few savings value changed for measures that were not in READI tool or DEER documentation (Commercial exterior Lamps) and now the savings align with the lighting Retrofit disposition, December 14, 2013. For updated savings values, see file PGECOLTG111 R7.xlsx. | Alina Zohrabian (PG&E) |
| Revision 8 | 1/1/16 | Updated base case description, base case cost, measure cost, WWR, hours of operation, EUL, CDF per DEER2016. Removed torchiere fixtures. | Linda Wan (PG&E)/ Alina Zohrabian (PG&E)/Tai Voong (PG&E) |

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# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

The nonresidential upstream compact fluorescent lighting program encourages manufacturers and distributors to increase the market share of higher efficiency compact fluorescent lamps (CFLs) and their associated fixtures by providing incentives to them that are then passed on to retail customers.  Education for manufacturers and distributors are provided through classes, workshops, and demonstrations.

## 1.2 Product Technical Description

The nonresidential upstream compact fluorescent lamps (CFL) program encourages commercial customers to replace their existing incandescent lamps and fixtures with more efficient compact fluorescent lighting.

## 1.3 Measure Application Type

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[[1]](#endnote-1)

Identifies the measure application type in the Measure Implemenation table in DEER2011.

|  |  |  |
| --- | --- | --- |
| **Code** | **Description** | **Comment** |
| *ER* | *Early retirement* | *measure applied while existing equipment still viable, or retrofit of existing equipment* |
| *ROB* | *Replace on Burnout* | *measure applied when existing equipment fails or maintenance requires replacement* |
| *NC* | *New Construction* | *measure applied during construction design phase as an alternative to a code-compliant standard design* |

All the measures within this workpaper are ROB.

## 1.4 Product Base Case and Measure Case Data

The base case for CFL lamps is a mixture of 60% incandescent and 40% compact fluorescent lamp and defined by the 2016 DEER wattage reduction ratio. The base case for CFL fixtures is defined by the 2014 DEER wattage reduction ratio. The 2016 and 2014 DEER use different wattage reduction ratio, delta watts, assumption for reflector, interior and exterior lamps and fixtures.

## 1.4.1 DEER Base Case and Measure Case Information

DEER includes a methodology for determining the relationship between base and measure wattages. These wattage reduction ratios are for non-residential applications. The wattage reduction ratios used in this work paper are listed in the table below:

Table Wattage Reduction Ratios

|  |  |  |
| --- | --- | --- |
| **Interior or Exterior** | **CFL Lamp or Fixture** | **WRR** |
| Any | Lamp | 3.57 |
| Any | Fixture | 3.53 |

Since this is an upstream non-residential program, the weighted building type, “Com,” was used.

**Hours of Operation:**

The annual hours of use, CDF, and HVAC interactive effects for CFL lamps and fixtures/torchieres follow the DEEER 2016 update. The interior CFL lamp annual hours of use is 2130 hours per year. The exterior CFL lamp savings are calculated using the 2016 DEER delta wattage methodology, in conjunction with the non-residential exterior CFL operating hours of 4100 hours per year.

**Net-to-Gross Assumption:**

The net-to-gross ratio for screw-in CFLs are obtained from the DEER READI tool and listed in the table below:

Table CFL Net-to-Gross

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **NTGR\_ID** | **Description** | **Used for** | **NTG value** | **DEER Version**  **Version Source** |
| NonRes-sAll-mCFL | CFL-screw in, All. | Screw in CFL | 0.54 | DEER2014  D13v1.0 |
| Com-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Fixture and Torchieres | 0.6 | DEER2014  D13v1.0 |

The 2016 DEER did not address CFL fixture or torchiere NTG. Therefore the 2011 DEER default Res value of 0.6 is used.

**Spillage Rate:**

Spillage rates are not tracked in work papers; they are tracked in an external document which will be supplied to the Commission Staff.

**Installation Rate:**

The Installation Rate (IR) value was obtained using the DEER 2016 READI tool. The relevant IR values for the measures in this work paper are in the table below:

Table Installation Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| PGE-Prop\_CFL\_0.73 | Propose: (0.73-Com, 0.67-Res) 2006-2008 EM&V-Upstream CFL: Res | Com | Any | Any | 0.73 |

**Effective Useful Life:**

The 2016 DEER lists the EUL for CFL lamps in the READI tool based on 10,000 hours of lamp life.

The EUL for lamps is calculated based on the formula below:

EUL = 10,000/(interior (2130) or exterior (4100) hours of operation)

DEER 2016, READI Tool has EUL for CFL fixtures listed as 15 years for cross-cutting applications, which can still apply for commercial building types. Torchiere EUL is assumed to be the same as fixtures. The relevant EUL values for the measures in this work paper are listed in the table below:

Table CFL Effective Useful Life

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **EUL\_ID** | **Description** | **CFL Type** | **EUL years** | **DEER Version**  **Version Source** |
| ILtg-CFL-Com | CFL Lamps – Indoor- Commercial – 10,000 Rated Hours | CFL Lamps (10,000 hour lamp life) | 4.69 | DEER2016  2015 Uncertain Measures Update |
| OLtg-CFL | Outdoor CFL Lamps - 10,000 Hour | CFL Lamps (10,000 hour lamp life) | 2.44 | DEER2014  D08 v2.05 |
| ILtg-CFLfix-Com | CFL Fixtures – Indoor - Commercial | Interior CFL Fixtures or Torchieres | 12 | DEER2014  D08 v2.05 |
| OLtg-CFLfix-Dusk-to-Dawn | CFL Fixtures - Outdoor – Dusk to Dawn Operation | Exterior CFL Fixtures or Torchieres | 15 | DEER2014  Lighting Disposition |

## 

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

**Title 24:** These measures do not fall under Title 24 [2013] Non-Residential Building Energy Efficiency Standards.

**Title 20:** California Title 20 [2015] lists the federal standards for incandescent reflector lamps.

**Federal Standards:** Federally-regulated incandescent reflector lamps must meet a minimum average lamp efficacy level as shown in the table below. Because the measures in this workpaper and the corresponding base case incandescent reflector wattages are governed by DEER methodology, the Title 20 efficacy requirements were not used to dictate the base and measure cases for this workpaper.

Table 6. Standards for Federally-Regulated Incandescent Reflector Lamps

|  |  |
| --- | --- |
| Nominal Lamp Wattage | Minimum Average Lamp Efficacy (LPW) |
| 40 – 50 | 10.5 |
| 51 – 66 | 11.0 |
| 67 - 85 | 12.5 |
| 86 – 115 | 14.0 |
| 116 -155 | 14.5 |
| 156 - 205 | 15.0 |

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

These measures are in DEER and the methodology and results from DEER are used for this work paper.

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

The calculation in this work paper follows the 2016 DEER and 2015 Uncertain Measures Update[[2]](#endnote-2) as well as the 2014 DEER and Lighting Disposition from December 14, 2013[[3]](#endnote-3).

# Section 2. Calculation Methods

## 2.1 Electric Energy Savings Estimation Methodologies

The methodology for calculating energy savings follows DEER 2016. Please refer to the Excel calculation workbook for more information[[4]](#endnote-4).

**Interior CFLs**

The annual energy savings is calculated based on the formula below:



An example calculation is presented below for measure code L0160 (CFL 7 Watt Int Bare Spiral 1 Pk).



**Exterior CFLs**

Exterior CFLs do not affect the internal load and therefore do not produce any “interactive effects” with the space conditioning systems. The exterior CFL savings were calculated using the 2016 DEER delta wattage methodology in conjunction with the non-residential exterior CFL operating hours of 4100 hours per year, provided by 2014 DEER.

The annual energy savings for exterior fixtures are calculated based on the formula below:



An example calculation is presented below for measure code L0231 (CFL 23 Watt Ext Fixture).



## 2.2. Demand Reduction Estimation Methodologies

The demand savings estimation methodology followed the same methodology in DEER 2016 for measure delta wattage. The values for coincident demand factor and HVAC demand interactive effect factors are based on the 2015 Uncertain Measures Update. Please refer to the Excel calculation workbook for more information4.

**Interior CFLs**

The equation below illustrates the peak demand reduction estimation method used:



An example calculation is presented below for measure code L0160 (CFL 7 Watt Int Bare Spiral 1 Pk)



**Exterior CFLs**

Exterior fixtures are assumed to operate during off-peak hours, so the demand impacts are assumed to be zero.

# 2.3. Gas Energy Impact Estimation Methodologies

The gas savings methodology follows the same methodology in DEER 2016. Please refer to the Excel calculation workbook for more information4.

**Interior CFL Lamps**

The values for therm interactive effects factor are based on DEER 2016. The following formula is used to calculate the therm savings.

Gas Savings [Therm/Unit-year] = (∆KWatts/unit) x (annual hours of use) x Gas Interactive Effects

An example calculation is presented below for measure code L0160 (CFL 7 Watt Int Bare Spiral 1 Pk)

Gas Savings [-0.266 Therm/Unit-year] = (0.007\*3.57 -0.007 kWatts/unit) x (2130) x -0.0070

**Exterior CFL Fixtures**

Exterior fixtures do not affect the internal load of the residence and therefore do not produce any “interactive effects” with the space conditioning systems, so the therm impacts are assumed to be zero.

# Section 3. Load Shapes

Load Shapes are an important part of the life-cycle cost analysis of any energy efficiency program portfolio. The net benefits associated with a measure are based on the amount of energy saved and the avoided cost per unit of energy saved. For electricity, the avoided cost varies hourly over an entire year. Thus, the net benefits calculation for a measure requires both the total annual energy savings (kWh) of the measure and the distribution of that savings over the year. The distribution of savings over the year is represented by the measure’s load shape. The measure’s load shape indicates what fraction of annual energy savings occurs in each time period of the year. An hourly load shape indicates what fraction of annual savings occurs for each hour of the year. A Time-of-Use (TOU) load shape indicates what fraction occurs within five or six broad time-of-use periods, typically defined by a specific utility rate tariff. Formally, a load shape is a set of fractions summing to unity, one fraction for each hour or for each TOU period. Multiplying the measure load shape with the hourly avoided cost stream determines the average avoided cost per kWh for use in the life cycle cost analysis that determines a measure’s Total Resource Cost (TRC) benefit.

## 3.1 Base Case Load Shapes

The base case load shape would be expected to follow a typical nonresidential end use load shape.

## 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 would be the preferred load shape for use in the net benefits calculations.

The measure load shape for this measure is determined by the E3 calculator based on the applicable non-residential market sector and non-residential lighting.

Table Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| Commercial - Indoor | PGE:DEER:COM:Indoor\_CFL\_Ltg | NON\_RES |
| Commercial - Outdoor | PGE:2 = Commercial Outdoor Lighting | COMMERCIAL |

# Section 4. Base Case & Measure Costs

A joint effort was made between SCE and PG&E to update base case and measure costs for DEER 2016 affected measures.

## 4.1 Base Cases Costs

**CFL Lamps**

Base case costs were taken from the 2016 DEER cost tables from the READI Tool for any delivery type. Nonresidential CFL costs were not included in 2016 DEER, so the residential CFL costs were assumed to be representative of nonresidential costs. Costs vary by lamp pack size and are a mix of 60% incandescent and 40% CFL as outlined in the 2015 Uncertain Measures Update.

**CFL Fixtures**

The technique of web scraping (aka web harvesting, web crawling, web data extraction) was used to gather pricing information from the Home Depot website for base case costs. The methodology used for measure costs applies to base case costs. See Section 4.2 for the methodology. The base case costs are reduced by 30% as suggested by the Navigant LED Study5. The 30% reduction factor is “to account for the difference between online and typical purchase price” (page 1-3).

## 4.2 Measure Costs

**CFL Lamps**

CFL measure costs were also taken from the 2016 DEER cost tables from the READI Tool.  Nonresidential CFL costs were not included in 2016 DEER, so the residential CFL costs were assumed to be representative of nonresidential costs. In some cases the 2016 DEER cost values was interpolated or extrapolated for lamp wattages not addressed in 2016 DEER. Costs vary by lamp pack size. CFL single packs have a higher per lamp cost than multi-packs.

**CFL Fixtures**

The same technique of web scraping was used to gather pricing information from the Home Depot website for measure case costs. First, a small sample of products was examined between different online retailers to determine the need to include items from various retailers and the discrepancy between pricing. Please refer to the Competitive Pricing tab in the cost spreadsheet. Due to the competitive pricing of the same fixture from different retailers, only Home Depot data was examined in detail.

A manual process of examining reasonable cost was conducted by viewing the scatterplot of all costs and its associated rated wattages and categorizing the items into a high, medium, or low cost bin. Note that in some cases where enough data was scraped, only Energy Star lamps and fixtures were considered in the measure case and CA Title 20 compliant lamps and fixtures were considered in the base case.

Item descriptions were also viewed to understand the reasoning of such high costs.  It was almost always found that items with high costs were associated with architectural features and/or specialty finishes.  As a result, items that fell into the high cost category was not used in the calculations of cost for the work papers because it does not appropriately reflect the approach most consumers would take to implement energy efficiency projects. Refer to the cost spreadsheet for detailed information. Furthermore, the latest EM&V Study from Navigant for LED costs uses the 25th percentile for the median price.[[5]](#endnote-5)

Using the low and medium cost data from Home Depot, the best-fit line or linear regression was used to determine the association between fixture wattages and cost. Please see the cost spreadsheet for the specific linear regression equation generated for the low cost and medium cost. Raw data points are also included in the spreadsheet.

For work paper purposes, the costs are an equal representation of the medium and low cost categories.  Therefore, the best representative association is the average of the trendline for medium cost and the trendline of the low cost. This process is not the same as a linear regression determined from the low and medium cost items combined.  Due to the quantity in the data sampling, the items associated with the low or medium cost would influence the linear regression.  For this reason, the best representative cost comes from the average of the linear regression from the medium cost and the linear regression from the cost.  This is how cost is propagated for all the technology categories.

As with base case costs, the measure costs are also reduced by 30%5 to account for the bulk wholesale pricing discrepancy.

## 4.3 Incremental & Full Measure Costs

**CFL Lamps**

The incremental measure equipment costs for the CFL lamp measures were taken from the 2016 DEER cost tables. These costs represent any program delivery method. Nonresidential CFL costs were not included in 2016 DEER, so the residential CFL costs were assumed to be representative of nonresidential costs. The incremental equipment cost is the difference in material cost between the CFL measure case and base case. This Upstream CFL program promotes a replace-on-burnout (ROB) strategy as opposed to an early retirement (ER) strategy. The ROB cost scenario utilizes incremental material cost only, while RET costs include full CFL measure costs (including installation). The ROB incremental material costs vary by lamp pack size. CFL single packs have a higher per lamp cost than multi-packs. The weighted pack from DEER was used when calculating multi-packs.

Cost data was provided for the following types of Upstream CFLs in 2016 DEER for various wattages but not all wattages addressed by PG&E’s Upstream CFL program: interior integral, exterior screw-in, interior reflector, and exterior reflector. Cost values for interior reflector were applied to specialty “reflector” lamp measure costs, and interior A-lamp costs were applied to “covered” lamp measures since the costs will be approximately the same for these lamp categories. The same wattages were covered for the single pack and multi-pack cost cases.

For bare spiral measures, 55 and 60 Watt costs were not provided. These costs were estimated by extrapolating the cost data. A linear regression was performed on the DEER fixture cost values to estimate cost as a function of wattage for lamps not addressed in DEER. The R2 is very close to “1.0”, indicating a reasonable trend line fit for this data and a good approximation of the cost. The incremental cost graphs are shown below for weighted pack and single pack:

Figure 1 Linear Regression of CFL Incremental cost per lamp in a weighted pack from DEER 2016

Figure 2 Linear Regression of CFL incremental cost per lamp in a single pack from DEER 2016

**CFL Fixtures**

The incremental cost for CFL fixtures is the difference between the base case costs and the measure costs. Please refer to the cost calculation spreadsheet for detailed incremental or full cost information.

# References

1. 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.* [↑](#endnote-ref-1)
2. 2015 Uncertain Measures Update – Database for Energy-Efficient Resources – DEER2015 Updates for Measures Removed from the ESPI Uncertain Measure List found on <http://www.deeresources.com/index.php/deer-versions/2015-uncertain-measures-update> [↑](#endnote-ref-2)
3. CPUC Energy Division -- CPUC Energy Division – Lighting Disposition 2013-2014\_LightingRetrofit\_Disposition-14December2013.Docx

   DEER 2012 Lighting 13-14 dispositions 2013-2014\_LightingRetrofit\_Disposition-14December2013.xlsx {from Dec. 2013] [from December 2013] [↑](#endnote-ref-3)
4. Calculation Excel workbook [↑](#endnote-ref-4)
5. California LED Workpaper Update Study. Navigant Consulting. August 28, 2015. [↑](#endnote-ref-5)