**Work Paper PGECOLTG107**

**Residential Upstream CFL**

**Revision 8**

**Pacific Gas & Electric Company**

**Customer Energy Efficiency Department**

**Residential Upstream Compact Fluorescent Lighting**

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

**L0321-L0334**

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# At a Glance Summary

|  |  |
| --- | --- |
| **Applicable Measure Codes:** | L093-L096, L0160 – L0233, L0239 – L0241, L0261, L0275-L0276 , L0321-L0334 |
| **Measure Description:** | The residential upstream compact fluorescent lamps (CFL) program encourages residential customers to replace their existing incandescent lamps and fixtures with more efficient compact fluorescent lighting. |
| **Energy Impact Common Units:** | per lamp (bulb) or per fixture. |
| **Base Case Description:** | The base case wattage is based on the DEER wattage reduction ratio.  Source:  2016 DEER. |
| **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 |
| **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 |
| **Effective Useful Life (years):** | |  |  |  | | --- | --- | --- | | **EUL ID** | **Measure Type** | **DEER EUL (years)** | | ILtg-CFL-Res | CFL Interior Lamps (10,000 hrs) | 3.5 | | OLtg-CFL | CFL Exterior Lamps (10,000 hrs) | 3.5 | | ILtg-CFLfix-Res | CFL Interior Fixtures | 16 | | OLtg-CFLfix | CFL Exterior Fixtures | 16 |   Source: 2016 DEER |
| **Program Type:** | ROB |
| **Net-to-Gross Ratios:** | |  |  |  | | --- | --- | --- | | **NTGR ID** | **Used for** | **NTGR value** | | Res-sAll-mCFL-up | Screw-in CFL | 0.9 | | Res-Default>2 | Fixtures | 0.55 |   Source: 2016 DEER  CFL fixture NTG not specified, so the NTG “default” value of 0.55 was used |
| **Important Comments:** | The Res/NonRes 94/6 upstream split will be applied in MDSS (based on 2006-2008 Upstream 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 nonresidential Upstream CFL measures have the same measure codes as the residential Upstream CFL measures but have different impact, EUL, and NTG values. |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision #** | **Date** | **Description** | **Author (Company)** |
| Revision 0 | 01/31/08 | Residential Upstream Screw-In CFL PGECOLTG107 R0.doc | Ed Mah, Jim Wyatt, PG&E |
| Revision 1 | 06/30/09 | Residential Upstream Screw-In CFL PGECOLTG107 R1.doc | Jenny Roecks |
| Revision 2 | 1/14/10 | Residential Upstream Screw-In CFL PGECOLTG107 R2\_v1.doc | Jenny Roecks |
| Revision 3 | 3/15/11 | Residential Upstream Screw-In CFL PGECOLTG107 R3.doc | Alina Zohrabian/ Jenny Roecks |
| Revision 4 | 6/30/11 | Residential Upstream Screw-In CFL PGECOLTG107 R4.doc | Jenny Roecks and Alina Zohrabian |
| Revision 5 | 8/9/11 | Residential Upstream Screw-In CFL PGECOLTG107 R5.doc | Jenny Roecks and Alina Zohrabian |
| Revision 6 | 5/18/12 | Residential Upstream Screw-In CFL PGECOLTG107 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 “Res” 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 |
| Revision 7 | 5/12/14 | Only a few savings value changed for measures that were not in READI tool or DEER documentation (Exterior Fixtures) and now the savings align with the lighting Retrofit disposition, December 14, 2013. For updated savings values, see file PGECOLTG107 R7.xlsx. | Alina Zohrabian |
| Revision 8 | 1/1/2016 | Updated base case, WRR, base case cost, measure cost, hours of operation, EUL, and CDF for exterior lamps per DEER2016. Removed torchiere measures. | Linda Wan, PG&E / Alina Zohrabian, PG&E / Tai Voong, PG&E |

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# Section 1. General Measure & Baseline Data

## 1.1 Product Measure Description & Background

The residential 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 residential upstream compact fluorescent lamps (CFL) program encourages residential 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 work paper 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 lamps and defined by the 2016 DEER wattage reduction ratio (WRR). 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 residential applications. The 2016 DEER wattage reduction ratios are listed in the table below:

**Table 2 Wattage Reduction Ratios**

|  |  |  |  |
| --- | --- | --- | --- |
| **Interior or Exterior** | **Reflector or Non-Reflector** | **CFL Lamp or CFL Fixture** | **WRR** |
| Interior | Reflector | CFL Lamp | 2.86 |
| Interior | Non-reflector | CFL Lamp | 2.48 |
| Exterior | Any | CFL Lamp | 2.84 |
| Any | Any | CFL Fixture | 3.53 |

**Hours of Operation:**

Since this is an upstream residential program, the weighted building type, “Res,” was used. The hours of use, CDF, and interactive effects for interior CFL lamps remain the same as the 2014 DEER values. The interior CFL lamp hours of use are 541 hours per year. The exterior CFL lamp savings are calculated using the delta wattage methodology, annual operating hours of 1249 hours per year. The usage behavior exhibited towards CFL lamps is assumed to be the same towards CFL fixtures.

**Net-to-Gross Assumption:**

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

**Table 3 CFL Net-to-Gross**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **NTGR\_ID** | **Description** | **Used for** | **NTGR value** | **DEER Version**  **Version Source** |
| Res-sAll-mCFL-up | CFL-screw in, All. | Screw-in CFL | 0.9 | DEER2016  2016 v1 |
| Res-Default>2 | All other EEM with no evaluated NTGR; existing EEM with same delivery mechanism for more than 2 years | CFL Fixtures | 0.55 | DEER2014  D13 v1.0 |

The 2016 DEER did not address CFL fixture NTG. Therefore the 2014 DEER default Res value of 0.55 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 READI tool. The relevant IR values for the measures in this work paper are in the table below:

**Table 4 Installation Rate**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| PGE-Prop\_CFL\_0.67 | Propose: (0.73-Com, 0.67-Res) 2006-2008 EM&V-Upstream CFL: Res | Res | Any | Any | 0.67 |

**Effective and Remaining Useful Life:**

Based on the 2015 Uncertain Measures Update, the EUL for interior and exterior CFL lamps is 3.5 years. DEER 2014 listed EUL for CFL fixtures for residential application to be 16 years. The relevant EUL values for the measures in this work paper are listed in the table below:

**Table 5 Effective Useful Life**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **EUL\_ID** | **Description** | **CFL Type** | **EUL years** | **DEER Version**  **Version Source** |
| ILtg-CFL-Res | CFL Lamps - Indoor- Residential - 10,000 Rated Hours | CFL Lamps (10,000 hour lamp life) | 3.5 | DEER2016  2015 Uncertain Measures Update |
| OLtg-CFL | CFL Lamps - Outdoor- Residential - 10,000 Rated Hours | CFL Lamps (10,000 hour lamp life) | 3.5 | DEER2016  2015 Uncertain Measures Update |
| ILtg-CFLfix-Res | CFL Fixtures - Indoor - Residential | Interior CFL Fixtures | 16 | DEER2014  D08 v2.05 |
| OLtg-CFLfix | CFL Fixtures - Outdoor - Residential | Exterior CFL Fixtures | 16 | DEER2014  D08 v2.05 |

## 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 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 CFL Lamps and Fixtures**

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 CFL Lamps and Fixtures**

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 methodology follows 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 CFL Lamps and Fixtures**

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 CFL Lamps and Fixtures**

Exterior CFLs do not have any demand reduction savings.

## 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 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 [-0.135Therm/Unit-year] = (0.007\*2.48-0.007 KWatts/unit) x (541) x -0.024

**Exterior CFL Lamps and Fixtures**

Exterior CFLs 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 residential lighting 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 residential market sector and residential lighting. A DEER load shape for residential outdoor does not exist. There does exist a PG&E load shape for Commercial Outdoor Lighting, however, it was determined that this is not the best fit due to the use of timers or sensors typically used to control commercial outdoor lighting and hours of operation. Therefore, the closest load shape, PGE:DEER:Indoor\_CFL\_Ltg, was chosen.

Table Building Type and Load Shape

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| Residential - Indoor | PGE:DEER:Indoor\_CFL\_Ltg | RES |
| Residential - Outdoor | PGE:DEER:Indoor\_CFL\_Ltg | RES |

# 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, READI tool v2.3.0. Costs vary by lamp pack size and are a mix of 60% incandescent and 40% CFL as outlined in the 2015 Uncertain Measures Update. Single pack and weighted packs were captured for the base cases.

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

The 2016 DEER included compact fluorescent lamp cost values for interior and exterior non-reflector and reflector lamps. The READI Tool v 2.3.0 was used to access this information. Costs vary by lamp pack size. CFL single packs have a higher per lamp cost than multi-packs. Single pack and weighted packs were both captured for the measures in this work paper. In some cases the 2016 DEER cost values was interpolated or extrapolated for lamp wattages not addressed in 2016 DEER. See Section 4.3 for a detailed description of calculation methodology.

**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

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, READI Tool v 2.3.0. These costs represent any program delivery method. 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 Linear Regression of CFL Incremental Cost per Lamp in a Weighted Pack from 2016 DEER

Figure Linear Regression of CFL Incremental Cost per Lamp in a Single Pack from 2016 DEER

**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. CPUC Energy Division – Screw-in CFLs of all types DEER2015-2016\_CFLlighting\_UncertainMeasureUpdateDescription\_2015-05-19.pdf

   DEER2015-2016\_CFLlighting\_UncertainMeasureUpdateDetail\_2015-05-20.xlsx

   DEER2015-2016\_CFLExtLighting\_UncertainMeasureUpdateDetail\_2015-05-19.xlsx

   [from May 2015] [↑](#endnote-ref-2)
3. 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] [↑](#endnote-ref-3)
4. Calculation Excel Workbook [↑](#endnote-ref-4)
5. California LED Workpaper Update Study. Navigant Consulting. August 28, 2015. [↑](#endnote-ref-5)