**Work Paper PGECOLTG163**

**LED Candelabra Replacements**

**Revision 7**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**LED Candelabra Replacements**

**Measure Codes L042, L043, LC108**

# At-A-Glance Summary

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Applicable Measure Codes:** | L042  (Res/Com) | L043  (MFM) | LC108  (Res/Com) | LC108  (MFM) |
| **Measure Description:** | LED Candelabra <3W | LED Candelabra <3W | LED Candelabra ≥3 to ≤5 | LED Candelabra ≥3 to ≤5 |
| **Energy Impact Common Units:** | Lamp. | | | |
| **Base Case Description:** | 35% LED, 5% CFL, and 60% Incandescent/Halogen.  Source: Disposition “2018ScrewInLampSavingsMethods-1March2018” | | | |
| **Base Case Energy Consumption:** | Various. Refer to .xlsx file attached, Source: PG&E Calculations. | | | |
| **Measure Energy Consumption:** | Various. Refer to .xlsx file attached, Source: PG&E Calculations. | | | |
| **Energy Savings (Base Case – Measure)** | Various. Refer to .xlsx file attached  Source: PG&E Calculations. | | | |
| **Costs Common Units:** | $ per lamp | | | |
| **Base Case Equipment Cost ($/unit):** | Refer to .xlsx file attached. Source: IOU consistent Cost Table | | | |
| **Measure Equipment Cost ($/unit):** | Refer to .xlsx file attached Source: IOU consistent Cost Table | | | |
| **Gross Measure Cost ($/unit)** | Refer to .xlsx file attached, Source: IOU consistent Cost Table | | | |
| **Measure Incremental Cost ($/unit):** | Refer to .xlsx file attached, Source: IOU consistent Cost Table | | | |
| **Effective Useful Life (years):** | Various. Refer to .xlsx file attached Source: PG&E Calculations. | | | |
| **Program Type:** | ROB | | | |
| **Net-to-Gross Ratios:** | |  |  |  | | --- | --- | --- | | **NTGR ID** | **Sector** | **NTGR** | | All-Ltg-ScrwInLED | Any | 0.91 |   Source: “2018ScrewInLampSavingsMethods-1March2018” | | | |
| **Important Comments:** | The new NTG of 0.91 was given in the 2018 Screw-in Lamp Disposition, Section 5. | | | |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision #** | **Date** | **Section by Section Description of Revisions** | **Author (Company)** |
| Revision 0 | 2/2/2012 | PGECOLTG163 R0 LED Candleabra.doc  Revised draft per PG&E comments | Marc Theobald (EMCOR Energy Services), Reviewed by Alina Zohrabian (PG&E) |
| Revision 1 | 2/2/2012 | PGECOLTG163 R1 LED Candleabra.doc  Revised based on Energy Division workpaper disposition for Integral LED replacement lamps (May 14-2012) | Alina Zohrabian (PG&E) |
| Revision 1 | 8/29/12 | The “Com” and "RES" building types are 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 2 | 7/13/13 | Revised Savings values per ED Workpaper Disposition for Lighting Retrofit, issue March, 2013. For updated savings values, see file PGECOLTG163 R2-Calcs.xlsx  For measure L042 PG&E used 2 watts for the measure wattage this went down to 1.8 watts. For measure L043 PG&E used 2 watts for the measure wattage this went down to 1.8 watts. | Alina Zohrabian (PG&E) |
| Revision 3 | 3/24/14 | Added DI values from (PGE3PLTG179) and Revised savings values per ED Workpaper Disposition for lighting Retrofit, December 14, 2013. For updated savings values, see file PGECOLTG163 R3.xlsx | Alina Zohrabian (PG&E) |
| Revision 4 | 1/1/2016 | Updated NTG, EUL, annual hours of operation, CDF, IE per DEER 2016. Costs have also been updated. | Linda Wan (PG&E)/Alina Zohrabian (PG&E) |
| Revision 5 | 11/18/2016 | Updated IE per DEER 2017 | Mini Damodaran (PG&E)/Alina Zohrabian (PG&E) |
| Revision 6 | 06/29/2017 | Updated NTG ID based on the 2017ScrewInLampDisposition | Henry Liu (PG&E) |
| Revision 7 | 4/27/2018 | Updated baseline technology % mix to 35% LED, 5% CFL, and 60% Incan and WRR = 4.61 based on “2018ScrewInLampSavingsMethods-1March2018” disposition.  Update NTG to new ID “All-Ltg-ScrwInLED”. Updated cost.  Effective 7/1/2018 per Disposition. | Randy Kwok (PG&E) |

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# Section 1. General Measure & Baseline Data

## 1.1 Product Measure Description & Background

This work paper details the replacement of a lumen equivalent candelabra lamps with LED candelabra lamps.

***Requirements:***

* Must replace a lumen equivalent candelabra lamp of higher wattage

Table 1 Measure Codes and Description

|  |  |
| --- | --- |
| **Measure Code** | **Description** |
| L042 | LED Candelabra <3W |
| L043 | LED Candelabra <3W MF |
| LC108 | LED Candelabra ≥3 to ≤5 |

***Program Restrictions and Guidelines***

The delivery method is Upstream/Midstream Programs for commercial customers and the Upstream Lighting Program for residential customers. For Multifamily customers, this product is also available through the downstream program.

In support of the transition to the California Energy Commission’s Voluntary California Quality Light-Emitting Diode (LED) Lamp Specification (CEC Spec), to qualify for a rebate in the program, the replacement LED lamps must fall into one of the categories shown in the table below. Only lamps that fully meet the CEC Spec will be supported in the Upstream Lighting Program after Dec 1, 2013.

Table 2 Lamp Specification

|  |  |
| --- | --- |
| **Residential: Upstream Lighting Program** | **Residential: Downstream & Direct Install Commercial: Midstream / Upstream & Direct Install** |
| Must meet CEC specification 3.1[[1]](#endnote-2) and Energy Star 2.0[[2]](#endnote-3) and be listed on both Energy Star and Modernized Appliance Efficiency Database System ([MAEDBS](https://cacertappliances.energy.ca.gov/Login.aspx)) databases.  The lamps in MAEDBS must be listed on the “State-regulated Light Emitting Diode Lamp” list[[3]](#endnote-4) as “Voluntarily Certified”. | Must be on the ENERGY STAR Qualified Products List. |

***Terms and Conditions:*** The customer must be a residential or commercial PG&E electric customer. Multifamily downstream is eligible.

***Market Applicability:*** The customer must be a residential or commercial PG&E electric customer.

Please refer to the table below for the applicable delivery types, building types, and application types.

Table 3 Delivery Method and Applicable Building Types

|  |  |  |
| --- | --- | --- |
| **Delivery Type** | **Applicable Building Types** | **Application Type** |
| Upstream | “Com,” “Res” | ROB |
| Direct Install | DEER Building Types | ROB |
| Downstream | DEER Building Types | ROB |

## 1.2 Product Technical Description

Light emitting diode (LED) sources have improved over the past decade making them an efficient and reliable lighting technology. Many LED products successfully replaced other lighting sources and made their way into the market. LED products continue to improve to be able to compete in any application.

## 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 4 Measure Application Type[[4]](#endnote-5)

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 most common base case wattages of the incandescent lamps are 15, 25 40, and 60 watts, based on analysis by EMCOR Energy Services (EES) determining typical replaced candelabra lamps. The base case wattages follow the DEER Wattage Reduction Ratio (WRR) methodology per the “2018ScrewInLampSavingsMethods-1March2018” disposition. The measure case is the associated LED wattage.

### 1.4.1 DEER Base Case and Measure Case Information

The Database for Energy Efficient Resources (DEER) contains measures for LED candelabra lamps using the WRR method. The base case wattage is calculated using the WRR of 4.61 per the “2018ScrewInLampSavingsMethods-1March2018” disposition. The measure case is the associated LED wattage.

**Hours of Operation**

The DEER 2017 hours of operation and interactive effects are used for savings calculations.

**Net-to-Gross Assumption**

The NTG values are based on “2018ScrewInLampSavingsMethods-1March2018” disposition. Table 5 below summarizes all applicable Net-to-Gross ratios for programs that may be used by this measure.

Table 5 Net-to-Gross Ratios

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Delivery Method** | **NTGR** |
| All-Ltg-ScrwInLED | All LED lamps and Can Retrofits | Any | Any | Any | 0.91 |

**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 IR values were obtained using the DEER READI tool. The relevant IR values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| Com-LED-PGE | Non-Res LED; Non-Upstream Program; Annual Installation Rate | Com | Any | NonUpStrm | 1 |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1 |

**Effective Useful Life / Remaining Useful Life**

Although the minimum lamp life in Energy Star is 25,000 hours and most products show a lamp life of 25,000 or 35,000 hours, the Energy Division recommended a lamp life of 15,000 hours. Since the effective useful life (EUL) is depended on hours of operation, the EUL varies by building type. The EUL is calculated using the following equation:

EUL = (Rated Life of Lamp (15,000 hours)) / (Average Operating Hours for Building Type)

Table 6 Effective and Remaining Useful Life

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| ILtg-Res-LED-15000hr | LED lamp - Indoor - Residential - small wattage Globe, Any Candle shape | Res | Lighting | 16 | 5.33 |
| ILtg-Com-LED-15000hr | LED Lamp - Indoor- Commercial - Small wattage Globe, Any Candle shape | Com | Lighting | Varies (max 12 years) | Varies |

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

***Title 20:*** These measures do not fall under Title 20 [2015] of the California Energy Efficiency Regulations.

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

***Federal Standards:*** These measures do not fall under Federal DOE Energy Regulations.

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

There are relevant CALiPER studies which were stated in the previous version of this workpaper. However this workpaper is following the disposition for integral LED lamp replacement guidelines from Energy Division to calculate the savings. As the LEDs improve and the efficacy increases the wattage reduction ratio methodology should be revisited since it will not be an appropriate method to calculate savings going forward.

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

This workpaper complies with the “2018ScrewInLampSavingsMethods-1March2018” Disposition from the California Public Utilities Commission; Energy Division dated March 1, 2018.

# Section 2. Calculation Methods

## 2.1 Electric Energy Savings Estimation Methodologies

Energy savings vary by market sector and building type because of differences in operating hours and interactive effect multipliers. The operating hours and interactive effects for Commercial were taken from DEER 2016 data. The operating hours and interactive effects for Residential were taken from DEER 2017. Refer to the equation below for the energy savings calculation:



The following example calculation demonstrates the annual energy savings, kWh per year, for the “Res” building type, for a 2W LED candelabra:

## 2.2. Demand Reduction Estimation Methodologies

Demand reduction varies by market sector and building type due to different HVAC interactive effects and coincident peak demand multipliers for each type of building type. The operating hours, interactive effects, and coincident diversity factors (CDF) for each segment were taken from DEER 2017 data. Below is the equation to calculate demand savings:



The following example calculation demonstrates the annual energy demand savings, kW per year, for the “Res” building type, for a 2W LED candelabra:

## 2.3. Gas Energy Savings Estimation Methodologies

Gas estimates are entirely based on the estimated increased gas use through calculated interactive effects. This measure includes HVAC interactive effects savings. The equation below calculates the gas savings:



The following example calculation demonstrates the annual gas savings, therms per year, for the “Res” building type, for a 2W LED candelabra:

# Section 3. Load Shapes

Load shapes are an important part of the lifecycle 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 lifecycle cost analysis that determines a measure’s Total Resource Cost (TRC) benefit.

## 3.1 Base Case Load Shapes

The closest load shape chosen for this measure is the DEER interior CFL lighting load shape.

## 3.2 Measure Load Shapes

The measure load shape for this measure is determined based on the applicable residential and commercial market sector and the Lighting end-use. This load shape is different from the base case due to the savings impact of the measures and is shown by the load shapes listed below.

The closest load shape chosen for this measure is the DEER interior CFL lighting load shape.

Table 7 Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| All Commercial, “Com,” “OTR” | PGE:DEER:Com:Indoor\_CFL\_Ltg | NON\_RES |
| All Residential, “Res” | PGE:DEER:Indoor\_CFL\_Ltg | RES |

# Section 4. Base Case & Measure Costs

To comply with the December 11, 2017 disposition PG&E obtained cost data through web scraping and also changed the percentages of the technology mix in the base cost as per the disposition. PG&E will share the cost data with other IOUs to collaborate and be consistent statewide.

## 4.1 Base Case Costs

The base case costs are web scraped. See “PGECOLTG163 R7 – CandelabraCostSummary.xlsx” for more details on the cost data and analysis.

The base case costs are split into 35% LED, 5% CFL and 60% incandescent/halogen based on the Disposition “2018ScrewInLampSavingsMethods-1March2018” from the California Public Utilities Commission; Energy Division, dated March 1, 2018.

## 

## 4.2 Measure Case Costs

#### The measure case costs are web scraped. See “PGECOLTG163 R7 – CandelabraCostSummary.xlsx” for more details on the cost data and analysis.

## 4.3 Incremental & Full Measure Costs

Table 8 Full and Incremental Measure Cost Equations

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| ROB | (MEC + MLC) – (BEC + BLC) | (MEC + MLC) – (BEC + BLC) | N/A |
| NEW/NC |
| RET/ER | (MEC + MLC) – (BEC + BLC) | MEC + MLC | (MEC + MLC) – (BEC + BLC) |
| REF | (MEC + MLC) – (BEC + BLC) | MEC + MLC | N/A |
| REA | MEC + MLC | MEC + MLC | N/A |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

BEC = Base Case Equipment Cost; BLC = Base Case Labor 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.

The Full measure cost is used for Direct Install Measures. A labor cost of $5.75 is used from WO017. For full measure costs please refer to the LED lamp cost spreadsheet.

### 4.3.2 Incremental Measure Costs

The labor required installing base case or measure case is equivalent. Therefore, labor cost is not considered in incremental measure costs. For incremental measure costs please refer to the LED lamp cost spreadsheet.

# References

1. CEC Spec v3.1: <http://www.energy.ca.gov/business_meetings/2017_packets/2017-12-13/Item_01e_VoluntaryLEDSpec/Voluntary%20CA%20Quality%20Spec%20v.3.1.pdf> [↑](#endnote-ref-2)
2. EnergyStar v2.0: [https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Lamps%20V2%20Revised%20Spec.pdf](https://urldefense.proofpoint.com/v2/url?u=https-3A__www.energystar.gov_sites_default_files_asset_document_ENERGY-2520STAR-2520Lamps-2520V2-2520Revised-2520Spec.pdf&d=DwMFAg&c=Oo_p3A70ldcR7Q3zeyon7Q&r=M7ZuqrjnCKKdd6iZuPafHA&m=psO7v846uQkM-QeHy1Xlz-JUn0JETLA2stvrtYiw4Gg&s=PUnkpZ2kuGRgddGRQtwlMgF0gTNkA-ouIUUmzW55Ys8&e=) [↑](#endnote-ref-3)
3. MAEDBS, State-regulated Light Emitting Diode Lamp list, <https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx> [↑](#endnote-ref-4)
4. 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-5)