**Work Paper PGECOLTG165**

**LED A-Lamps**

**Revision 2**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**LED A-Lamps**

**Measure Codes LL01 to LL19**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Applicable Measure Codes:** | LL01-LL19 |
| **Measure Description:** | LED A-Lamps, Energy Star |
| **Energy Impact Common Units:** | Lamp. |
| **Base Case Description:** | Incandescent or CFL A-lamp  Source: DEER 2016 |
| **Base Case Energy Consumption:** | Various. Based on Energy Division disposition of WRR=2.96 |
| **Measure Energy Consumption:** | Various. Refer to .xlsx file attached  Source: Energy Star and Energy Division recommendation |
| **Energy Savings (Base Case – Measure)** | Various. Refer to .xlsx file attached |
| **Costs Common Units:** | $ per lamp. |
| **Base Case Equipment Cost ($/lamp):** | Various.  Refer to .xlsx file attached |
| **Measure Equipment Cost ($/lamp):** | Various.  Refer to .xlsx file attached |
| **Gross Measure Cost ($/lamp)** | Various.  Refer to .xlsx file attached |
| **Measure Incremental Cost ($/lamp):** | Various.  Refer to .xlsx file attached |
| **Effective Useful Life (years):** | Various. Refer to .xlsx file attached  Source: DEER 2016 |
| **Program Type:** | ROB |
| **Net-to-Gross Ratios:** | |  |  |  | | --- | --- | --- | | **NTGR ID** | **Sector** | **NTGR** | | NonRes-sAll-MLtgLED-Deemed | NonRes | 0.6 | | Com-Default>2yrs | Com | 0.6 | | Res-sAll-MLtgLED-Deemed | Res | 0.6 | | Res-Default>2 | Res | 0.55 |   Source: DEER 2016 |
| **Important Comments:** |  |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision #** | **Date** | **Section by Section Description of Revisions** | **Author (Company)** |
| Revision 0 | 8/20/13 | PGECOLTG165 R0 LED A-Lamps.doc  Original Workpaper | Alina Zohrabian (PG&E) |
| Revision 1 | 5/2/14 | PGECOLTG165 R1 LED A-Lamps.doc  Added DI values from (PGE3PLTG191-R0). For updated values, see file PGECOLTG165 R1.xlsx | Alina Zohrabian (PG&E) |
| Revision 2 | 1/1/2016 | Updated NTG, annual hours of operation, IE, CDF, EUL, per DEER 2016. Costs have also been updated. | Linda Wan (PG&E)/Alina Zohrabian (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 existing incandescent A-lamps with Light Emitting Diode (LED) A-lamps.

**Requirements:**

* Must replace an incandescent or CFL A-lamp
* Must be on the ENERGY STAR qualified product list and be listed with the Department of Energy Lighting Facts Program

Table 1 Measure Codes and Description

|  |  |
| --- | --- |
| **Product Code** | **Description** |
| LL01 | LED A-Lamp < 8 watts |
| LL02 | LED A-Lamp 8 to < 9 watts |
| LL03 | LED A-Lamp 9 to < 10 watts |
| LL04 | LED A-Lamp 10 to < 11 watts |
| LL05 | LED A-Lamp 11 to < 12 watts |
| LL06 | LED A-Lamp 12 to < 13 watts |
| LL07 | LED A-Lamp 13 to < 14 watts |
| LL08 | LED A-Lamp 14 to < 15 watts |
| LL09 | LED A-Lamp 15 to < 16 watts |
| LL10 | LED A-Lamp 16 to < 17 watts |
| LL11 | LED A-Lamp 17 to < 18 watts |
| LL12 | LED A-Lamp 18 to < 19 watts |
| LL13 | LED A-Lamp 19 to < 20 watts |
| LL14 | LED A-Lamp 20 to < 21 watts |
| LL15 | LED A-Lamp 21 to < 22 watts |
| LL16 | LED A-Lamp 22 to < 23 watts |
| LL17 | LED A-Lamp 23 to < 24 watts |
| LL18 | LED A-Lamp 24 to < 25 watts |
| LL19 | LED A-Lamp ≥ 25 watts |

***Program Restrictions and Guidelines***

The delivery method is Upstream/Midstream Programs for commercial customers and the Upstream Lighting Program for residential customers. For Multifamily customer 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 CEC Voluntary California Quality LED Lamp Specification

|  |  |
| --- | --- |
| **Upstream** | **Midstream / Downstream** |
| Close to or meets full CEC Spec by having at least:   * CA beam shape requirements * CCT of 2700K or 3000K * CRI>=90 * R9>0 (“best in lamp class and channel”)\* * Dimmable * Must either be on THE ENERGY STAR Qualified Products List (QPL), or have begun ENERGY STAR Rated Life testing, and continue in testing until the product is accepted for the QPL. * Must be listed on the QPL within 9 months of the applicable IOU's allocation begin/confirmation date. * Must be listed on the Department of Energy LED Lighting Facts Product List within 9 months of the applicable IOU's allocation begin/confirmation date. | * Must be on THE ENERGY STAR Qualified Products List. |
| Meets ENERGY STAR Plus lamp specifications, plus at least:   * CA beam shape requirements * CCT of 2700K or 3000K * CRI>=80 (“best in lamp class and channel”) * R9>0 (“best in lamp class and channel”) * Dimmable * Must either be on THE ENERGY STAR Qualified Products List (QPL), or have begun ENERGY STAR Rated Life testing, and continue in testing until the product is accepted for the QPL. * Must be listed on the QPL within 9 months of the applicable IOU's allocation begin/confirmation date. * Must be listed on the Department of Energy LED Lighting Facts Product List within 9 months of the applicable IOU's allocation begin/confirmation date. |  |

\*Best in lamp class and channel - Utility managers will choose the products that are “best in class”. What represents “best in class” will change depending on the specific product and channel. Thus, categories with a greater number of high-CRI products available (i.e. PARs and retrofit kits) will be held to a higher standard than other categories with fewer options (i.e. A-Lamps and BRs). Furthermore, channels with more choices of energy efficient lighting (i.e. large home improvement stores) will be held to a higher standard than other categories with fewer options (i.e. mom and pop hardware stores).

**Terms and Conditions:**

The customer must be a residential or non-residential PG&E electric customer.

**Market Applicability:**

Single and Multi-Family Installations and Double-Wide Mobile Homes are eligible. These measures include mid and upstream rebates and Direct Install and Hard to Reach components where noted in the data.

The table below shows 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***

The A-lamps are the general purpose lamps that are used vastly in residential applications. 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 by continuing to improve to be able to compete in any application.

## 1.3 Transaction Types

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

|  |  |  |
| --- | --- | --- |
| **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 for A-Lamps are 40, 60, 75 and 100 watt lamps. There are also some CFL base cases. The base case wattages follow the DEER Wattage Reduction Ratio (WRR) methodology.

## 1.4.1 DEER Base Case and Measure Case Information

The Database for Energy Efficient Resources (DEER) 2016 contains measures for LED A-Lamps using the WRR method. The base case wattages use the WRR of 2.96 for A-Lamps. The 2.96 WRR assumes a 50% CFL saturation for A-lamps in residential and non- residential applications. The measure case wattages are selected based on Energy Division’s recommendation of wattages with very small increments regardless of the existence of such product in the Energy Star list.

**Hours of Operation**

The DEER 2016 hours of operation and interactive effects are used for the savings calculations. DEER hours of operation vary for each building type.

**Net-to-Gross Assumption**

The NTG values are from DEER 2016. The table 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** |
| Com-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Com | Any | Any | 0.6 |
| Res-Default>2 | All other EEM with no evaluated NTGR; existing EEM with same delivery mechanism for more than 2 years | Res | Any | Any | 0.55 |
| NonRes-sAll-MLtgLED-Deemed | Nonresidential LED: replacing CFL or incandescent lamps; deemed; all delivery mechanisms except upstream | NonRes | Any | NonUpStrm | 0.6 |
| Res-sAll-MLtgLED-Deemed | Residential LED: replacing CFL or incandescent lamps; deemed; all delivery mechanisms except upstream | Res | Any | NonUpStrm | 0.6 |

**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 20,000 hours. Since the effective useful life (EUL) is dependent on the hours of operation, the EUL varies by building type.

The EUL is calculated using the following equation:

EUL = (Rated Life of Lamp (20,000 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-20000hr | LED lamp - Indoor - Residential | Res | Lighting | 16 | 5.33 |
| ILtg-Com-LED-20000hr | LED Lamp - Indoor- Commercial | Com | Lighting | Varies (max 12 years) | Varies |

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

***Title 20:*** These measures do fall under Title 20 [2015] of the California Energy Regulations. The regulation follows the Federally-Regulated general Service Incandescent Lamps and Shown in Table k-4 and k-6 in Title 20.

**Standards for Federally-Regulated General Service Incandescent Lamps**

**Table K-6**

|  |  |  |  |
| --- | --- | --- | --- |
| **Rated Lumen Ranges** | ***Maximum Rate*** | ***Maximum Rate*** | ***Maximum Rate*** |
| 1490-2600 | 72 | 1,000 hours | January 1, 2012 |
| 1050 – 1489 | 53 | 1,000 hours | January 1, 2013 |
| 750 – 1049 | 43 | 1,000 hours | January 1, 2014 |
| 310 – 749 | 29 | 1,000 hours | January 1, 2014 |

**Standards for Federally-Regulated Modified Spectrum General Service Incandescent Lamps-**

**Table K-7**

|  |  |  |  |
| --- | --- | --- | --- |
| **Rated Lumen Ranges** | ***Maximum Rate*** | ***Maximum Rate*** | ***Maximum Rate*** |
| 1118-1950 | 72 | 1,000 hours | January 1, 2012 |
| 788-1117 | 53 | 1,000 hours | January 1, 2013 |
| 563-787 | 43 | 1,000 hours | January 1, 2014 |
| 232-562 | 29 | 1,000 hours | January 1, 2014 |

***Title 24:*** These measures do not fall under Title 24 [2013] of the California Energy Regulations.

***Federal Standards:*** These measures do fall under Federal DOE or EPA Energy Regulations. The standards are the same as Title 20 regulations.

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

***1.4.3.1 CALiPER Application Summary Report 16:***

CALiPER reports were used in Integral LED lamp workpapers submitted for 2013-2014, however CPUC Energy Division denied their use in favor of the Watt Reduction Ratios used in this workpaper. This work paper uses the approved 2.96 WRR for savings calculations.

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

This workpaper follows the Workpaper Disposition for Integral LED Lamp Replacements from the California Public Utilities Commission, Energy Division dated May 14, 2012.

# Section 2. Calculation Methods

The lighting wattage difference (Watts per unit) is the difference between the electric demand of the base case unit and the electric demand of the measure case unit. The hours of operation and interactive effects are from DEER 2016.

**∆Watts/lamp:** The demand difference (watts per lamp) is simply the difference between the electric demand of the base case lamp and the electric demand of the measure case lamp.

∆Watts/lamp = Base Case Watts/lamp - Measure Case Watts/lamp

**Example:**

∆Watts/lamp = (8\*2.96) W – 8 W = 15.68 ∆Watts/lamp

## 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 each segment were taken from DEER 2016 data. Refer to the equation below for the energy savings calculation:

**Annual Electric Savings:**

Annual Energy Savings [kWh/lamp] = (∆Watts/lamp) x (Annual Hours of Operation) x (Energy Interactive Effects) / (1,000 Watts / kW)

**Example: Res building type**

Annual Energy Savings for A-Lamps 8 to <9 W = 15.68 ∆Watts/lamp x 541 hours x 1.02 kWh/kWh / 1,000 Watts/kW   
= 8.65 kWh (these calcs are rounded and maybe slightly different than the excel calcs)

## 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 2016 data. Below is the equation to calculate demand savings:

**Demand Reduction:**

Demand Reduction [kW/lamp] = (∆Watts/lamp) x (Lighting Coincident Demand) x (Demand Interactive Effects) / (1,000 Watts/kW)

**Example: Res building type**

Demand Reduction for A-Lamps 8 to <9 W = 15.68 ∆Watts/lamp x 0.044 x 1.35 kW/kW / 1,000 Watts/kW   
= 0.000931 kW (these calcs are rounded and maybe slightly different than the excel calcs)

## 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 impacts. The equation below calculates gas savings:

**Annual Gas Savings:**

Annual Gas Savings [∆Therms/lamp] = (∆Watts/lamp) x (Annual Hours of Operation) x (Gas Interactive Effects) / 1,000 Watts/kW

**Example: Res building type**

Annual Gas Savings for 8 to <9 Watts = 15.68 ∆Watts/lamp x 541 hours x -0.0240 Therms/kWh / 1,000 Watts/kW   
= -0.204 Therms (these calculationss are rounded and maybe slightly different than the excel calculations)

# 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 and commercial 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 residentialand commercialmarket sector and the lighting end-use.

Table 7 Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| All Commercial | PGE:DEER:Com:Indoor\_CFL\_Ltg | NON\_RES |
| All Residential | 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. Please refer to the LED lamp cost workbook for detailed information.

## 4.1 Base Case(s) Costs

The base case costs are split into 50% CFL and 50% incandescent. CFL costs are taken from the READI Tool v 2.3.0. Costs not available from READI have been interpolated. Incandescent costs are calculated from WO017[[1]](#endnote-1) workbook. The base case wattages are mapped to individual LED wattages using a table from the Energy Star Calculator.

## 4.2 Measure Case Costs

Most costs for LED lamps were provided by Navigant as part of a study on LEDs. Several were interpolated or extrapolated from the Navigant data. The California LED Workpaper Update Study[[2]](#endnote-2) recommends using 25 percentile utilizing CA specific data.

## 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. 2010-2012 WO017 Ex Ante Measure Cost Study Final Report. Submitted by: Itron, Inc. May 27, 2014. [↑](#endnote-ref-1)
2. California LED Workpaper Update Study. Navigant Consulting. August 28, 2015. [↑](#endnote-ref-2)