**Work Paper PGECOLTG177**

**LED BR-R Lamps**

**Revision 6**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**LED BR/R Lamps**

**Measure Codes L1071-L1073, LT432 – LT439**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Applicable Measure Codes:** | L1071 – L1073, LT432- LT439 |
| **Measure Description:** | LED R-BR Lamps |
| **Energy Impact Common Units:** | Lamp. |
| **Base Case Description:** | 40% LED, 10% CFL, and 50% Incandescent/Halogen.  Source: Disposition “2018ScrewInLampSavingsMethods-1March2018” |
| **Base Case Energy Consumption:** | Various.  Source: PG&E Calculations |
| **Measure Energy Consumption:** | Various.  Source: PG&E Calculations. |
| **Energy Savings (Base Case – Measure)** | Various.  Source: PG&E Calculations. |
| **Costs Common Units:** | $ per lamp. |
| **Base Case Equipment Cost ($/lamp):** | Various. |
| **Measure Equipment Cost ($/lamp):** | Various. |
| **Gross Measure Cost ($/lamp)** | Various. |
| **Measure Incremental Cost ($/lamp):** | Various. |
| **Effective Useful Life (years):** | Various.  Source: 2016 DEER |
| **Program Type:** | ROB, ER |
| **Net-to-Gross Ratios:** | |  |  | | --- | --- | | **NTGR ID** | **NTGR** | | All-Ltg-ScrwInLED | 0.91 |   Source: Disposition “2018ScrewInLampSavingsMethods-1March2018” |
| **Important Comments:** |  |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision #** | **Date** | **Section by Section Description of Revisions** | **Author (Company)** |
| Revision 0 | 2/26/13 | PGECOLTG177 R0 LED BR/R-Lamps.doc  Original Workpaper | Alina Zohrabian (PG&E) |
| Revision 1 | 9/16/13 | PGECOLTG177 R1 LED BR/R-Lamps.doc  Created WRR from the original workpaper calculation and applied it to the lowest wattage in the range (based on a direction from a phone conversation with Kevin Madison on 9/12/13. | Alina Zohrabian (PG&E) |
| Revision 1 | 10/8/13 | PGECOLTG177 R1 LED BR/R-Lamps.doc  Revised program description | Alina Zohrabian (PG&E) |
| Revision 2 | 5/7/14 | PGECOLTG177 R2 LED BR/R-Lamps.doc  Added DI values (No original DI workpaper existed) and Revised savings values per ED workpaper Disposition for lighting Retrofit, December 14, 2013. For updated savings values, see file PGECOLTG177 R2.xlsx | Alina Zohrabian (PG&E) |
| Revision 3 | 1/1/2016 | Updated NTG, GSIA, EUL, annual hours of operation, CDF, and IE per DEER 2016. Base case costs and measure costs have also been updated. | Linda Wan (PG&E)/ Alina Zohrabian (PG&E) |
| Revision 4 | 11/28/2016 | Updated Residential Interactive Effect(IE) per DEER 2017 | Mini Damodaran (PG&E)/ Alina Zohrabian (PG&E) |
| Revision 5 | 6/7/2017 | Updated WRR, base case percentages and NTG as per 2017 Disposition for Screw-In Lamps; Base costs changed based on base case %; NTG changed to 0.91; Updated Program Restrictions and Guidelines | Alina Zohrabian (PG&E)/ Mini Damodaran (PG&E) |
| Revision 6 | 4/30/2018 | Updated baseline technology mix to 40% LED, 10% CFL, and 50% Incan/Halogen;  New WRR = 4.17 for <11w, 3.28 for >=11W to <14W, and 2.97 for >14W per “2018ScrewInLampSavingsMethods-1March2018” disposition. Base case costs and measure costs have also been updated. Added measure type ER for Res DI channel and updated Program Requirements accordingly.  Updated NTG to 0.91 with the new NTG ID “All-Ltg-ScrwInLED”. Effective 7/1/2018. | Randy Kwok (PG&E) |

# Table of Contents

[At-a-Glance Summary ii](#_Toc512857022)

[Document Revision History iii](#_Toc512857023)

[Table of Contents iv](#_Toc512857024)

[List of Tables iv](#_Toc512857025)

[Section 1. General Measure & Baseline Data 1](#_Toc512857026)

[1.1 Product Measure Description & Background 1](#_Toc512857027)

[1.3 Measure Application Type 4](#_Toc512857028)

[1.4 Product Base Case and Measure Case Data 4](#_Toc512857029)

[1.4.1 DEER Base Case and Measure Case Information 4](#_Toc512857030)

[1.4.2 Codes & Standards Requirements Base Case and Measure Information 5](#_Toc512857031)

[1.4.3 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information 6](#_Toc512857032)

[1.4.4 Assumptions and Calculations from other sources—Base and Measure Cases 7](#_Toc512857033)

[Section 2. Calculation Methods 8](#_Toc512857034)

[2.1 Electric Energy Savings Estimation Methodologies 8](#_Toc512857035)

[2.2. Demand Reduction Estimation Methodologies 8](#_Toc512857036)

[2.3. Gas Energy Savings Estimation Methodologies 9](#_Toc512857037)

[Section 3. Load Shapes 10](#_Toc512857038)

[3.1 Base Case Load Shapes 10](#_Toc512857039)

[3.2 Measure Load Shapes 10](#_Toc512857040)

[Section 4. Base Case & Measure Costs 11](#_Toc512857041)

[4.1 Base Case(s) Costs 11](#_Toc512857042)

[4.2 Measure Case Costs 11](#_Toc512857043)

[4.3 Incremental & Full Measure Costs 11](#_Toc512857044)

[4.3.1 Full Measure Cost 11](#_Toc512857045)

[4.3.2 Incremental Measure Costs 11](#_Toc512857046)

[References 12](#_Toc512857047)

# List of Tables

[Table 1 Measure Codes and Descriptions 1](#_Toc512857048)

[Table 2 CEC Voluntary California Quality LED Lamp Specification 2](#_Toc512857049)

[Table 3 Delivery Method and Applicable Building Types 2](#_Toc512857050)

[Table 4 Measure Application Type 4](#_Toc512857051)

[Table 5 Wattage Reduction Ratio 4](#_Toc512857052)

[Table 6 Net-to-Gross Ratios 5](#_Toc512857053)

[Table 7 Installation Rate 5](#_Toc512857054)

[Table 8 Effective and Remaining Useful Life 5](#_Toc512857055)

[Table 9 Previous CALiPER Testing of BR30 and R30 LED Lamps 6](#_Toc512857056)

[Table 10 CALiPER Testing of Conventional BR30 and R30 Lamps 6](#_Toc512857057)

[Table 11 Results of the CALiPER Testing of BR30/R30 for the series 16 LED Lamps 7](#_Toc512857058)

[Table 12 Building Types and Load Shapes 10](#_Toc512857059)

[Table 13 Full and Incremental Measure Cost Equations 11](#_Toc512857060)

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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 R/BR lamps with LED R/BR lamps.

This work paper update complies with the new baseline technology mix and wattage reduction ratio (WRR) given in the CPUC’s March1, 2018 disposition for all ROB measures.

PG&E also included in this work paper update the early retirement (ER) measure type only applicable to residential direct install (DI) programs targeting hard to reach (HTR) customers.

Measure codes are separated between incandescent to LED and CFL to LED early retirements to reflect the customer’s pre-existing equipment in place. Lamp specifications for ER measures are the same as ROB measures. If Program Restrictions and Guidelines for Early Retirement (ER) Measures cannot be met by programs, ROB residential DI measures will be used instead.

**Requirements:**

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

Table Measure Codes and Descriptions

|  |  |  |
| --- | --- | --- |
| **Measure Code** | **Description** | **MAT** |
| L1071 | LED R-BR: <11 Watts | ROB |
| L1072 | LED R-BR: 11 to <14 Watts | ROB |
| L1073 | LED R-BR: 14 to ≤22 Watts | ROB |
| LT432 | LED R-BR: 5.5 WATTS REPLACING 50W R-BR | ER |
| LT433 | LED R-BR: 9 WATTS REPLACING 65W R-BR | ER |
| LT434 | LED R-BR: 11 WATTS REPLACING 75W R-BR | ER |
| LT435 | LED R-BR: 15 WATTS REPLACING 85W R-BR | ER |
| LT436 | LED R-BR: 5.5 WATTS REPLACING CFL 15W R-BR | ER |
| LT437 | LED R-BR: 9 WATTS REPLACING CFL 18W R-BR | ER |
| LT438 | LED R-BR: 11 WATTS REPLACING CFL 23W R-BR | ER |
| LT439 | LED R-BR: 15 WATTS REPLACING CFL 26W R-BR | ER |

For ER measures actual lamp rated wattage of incandescent and CFL are used for the base case to reflect the customer’s pre-existing equipment in place.

***Program Restrictions and Guidelines for ROB Measures***

This workpaper is configured to accommodate any additional program changes to address higher efficacy lamps, if necessary. Currently the lamps rebated through the residential upstream program must meet both Energy Star and the CEC Voluntary California Quality Light-Emitting Diode (LED) Lamp Specification (CEC Spec) requirements. These lamps meet higher quality product performance criteria as defined by CEC. The CEC Spec has added new efficacy requirements.

For lamps rebated through the commercial programs the minimum efficacy requirements have increased due to stricter Energy Star requirements. IOU’s program staff will work with CPUC program staff to make sure all the rebated lamps meet the appropriate program rules and to reach towards the same common goals.

This workpaper covers R/BR products that are offered through multiple channels as follows:

* Upstream/Midstream Programs for commercial customers
* Upstream Lighting Program for residential customers
* Direct Install (DI) delivery channels
* 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 CEC Voluntary California Quality LED Lamp Specification

|  |  |
| --- | --- |
| **Residential: Upstream & Downstream Lighting Program** | **Commercial Midstream / Upstream;**  **Direct Install, Residential Direct Install ER** |
| Must meet CEC specification 3.1[[1]](#endnote-1) and Energy Star 2.0[[2]](#endnote-2) 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-3) as “Voluntarily Certified”. | Must be on THE ENERGY STAR Qualified Products List. |

**Terms and Conditions:**

The customer must be a PG&E electric customer.

**Market Applicability:**

Single and Multi-Family Installations are eligible. These measures include mid and upstream rebates and direct install where noted in the data.

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

Table Delivery Method and Applicable Building Types

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

***Program Restrictions and Guidelines for Early Retirement (ER) Measures***

For Residential Direct Install Programs targeting Hard to Reach (HTR) customers following program requirements apply:

#### Option 1

1. Eligible for Hard to Reach (HTR) customers only. If customer doesn’t qualify for HTR then ROB measures should be utilized. HTR definition pursuant to Resolution G-3497 as referenced in A.17-01-013 et al Proposed Decision (04/04/2018):

*Specific criteria were developed by staff to be used in classifying a customer as hard-to-reach. Two criteria are considered sufficient if one of the criteria met is the geographic criteria defined below. There are common as well as separate criteria when defining hard-to-reach for residential versus small business customers. The barriers common to both include:*

* *Those customers who do not have easy access to program information or generally do not participate in energy efficiency programs due to a combination of language, business size, geographic, and lease (split incentive) barriers. These barriers to consider include:*
* *Language – Primary language spoken is other than English, and/or*
* *Geographic – Businesses or homes in areas other than the United States Office of Management and Budget Combined Statistical Areas of the San Francisco Bay Area, the Greater Los Angeles Area and the Greater Sacramento Area or the Office of Management and Budget metropolitan statistical areas of San Diego County.*
* *For residential added criteria to the above to consider:*
* *Income – Those customers who qualify for the California Alternative Rates for Energy (CARE) or the Family Electric Rate Assistance Program (FERA), and/or*
* *Housing Type – Multi-family and Mobile Home Tenants (rent and lease).*

1. Document inventory of removed equipment by one of the following options:
   1. Record of wattage and type (CFL or Incandescent) of replaced equipment.
      1. In instances where exact lamp type is not available, replacement lamps from adjacent measure wattage are permissible within the same technology type. For example, a 50W incandescent can be replaced by a 5.5W or 9W LED measure.
      2. It is not permissible to use a measure code for a different technology type. A 23 W CFL cannot be replaced by a 11 WATTS REPLACING 75W R-BR measure.
   2. Pictures of replaced equipment - end of day pile per household.
   3. Recycling receipts which bulb quantities are included.
2. Provide field team training documentation that only existing functioning incandescent or CFL lamps, within reach of safe installation are to be replaced with corresponding allowed LED lamps per Option 1, 2a.

#### Option 2

#### If programs fail to provide any of the above evidence for ER, then ROB measures must be used following all applicable Program Restrictions and Guidelines for ROB Measures.

***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 by continuing to improve to be able to compete in any application.

The R symbol (short for Reflector) is to indicate that a bulb includes a parabolic or elliptical section below the major diameter designed to have a reflector coating to direct the light beam. The B symbol on the BR (Bulged Reflector) lamp is to indicate a bulb in which the curve making up the major portion of the side of the bulb has a radius greater than one-half the bulb diameter and a center in the plane of maximum diameter. The first number symbol indicates the diameter of the bulb in eights of an inch. For example, a BR30 lamp has a nominal diameter of 30 eights of an inch, or 3.75 inches[[4]](#endnote-4).

R/BR lamps are directional lamps but have a softer distribution and wider beam angles than PAR lamps and are used mostly in residential applications. These lamps come in different sizes and diameters such as R20, BR20, R30, BR30, and BR40. LEDs are inherently directional which makes them well suited for use in lamps intended to replace conventional reflector lamps. Additionally, the optics can be arranged at the LED package level, eliminating the need for reflectors and lenses that shape the beam.

## 1.3 Measure Application Type

The Database for Energy Efficiency Resources (DEER) developed by the California Public Utilities Commission defines the measure application type. The Support table “Measure Application Type” in the “Measure Catalog” can be found using the latest version of the Remote Ex-Ante Database Interface (READI) on the Database for Energy-Efficient Resources (DEER) website**[[5]](#endnote-5)**.

Table  Measure Application Type

|  |  |  |
| --- | --- | --- |
| **Code** | **Description** | **Comment** |
| ROB | Replace on Burnout | *Measure technology applied instead of Code/Standard technology at the time of replacement, Single baseline (above code), incremental or full costs* |
| ER | Early Retirement | *Measure applied while existing equipment still viable, or retrofit of existing equipment* |

PG&E has added the Early Retirement (Accelerated Replacement) measure type for this workpaper update. Measures within this workpaper are either ROB or ER.

## 1.4 Product Base Case and Measure Case Data

### 1.4.1 DEER Base Case and Measure Case Information

The base case wattage is calculated using the wattage reduction ratio (WRR). WRR is the ratio of the deemed baseline wattage to the deemed LED wattage. Table 5 below shows the approved WRR from “2018ScrewInLampSavingsMethods-1March2018” Disposition from the California Public Utilities Commission; Energy Division, dated March 1, 2018.

Table Wattage Reduction Ratio

|  |  |
| --- | --- |
| **Description** | **WRR** |
| LED lamps less than 11 watts | 4.17 |
| LED lamps equal to or greater than 11 watts to less than 14 watts | 3.28 |
| LED lamps equal to or greater than 14 watts | 2.97 |

**Hours of Operation**

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

**Net to Gross Assumption**

Table below shows the approved NTG values from the 2018 Phase 1 Screw-in Lamp Disposition, Section 5. The table below summarizes all applicable Net-to-Gross ratios for programs that may be used by this measure.

Table 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.

Table Installation Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **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 EULs for both products are listed as min 25,000 and max 50,000 hours, Energy Division recommended a lamp life of 20,000 hours for LED BR/R Lamps. Since the EUL is dependent on the hours of operation, the EUL varies by building type. The Energy Division also recommended using a maximum value of 12 years for EUL, which is the life of a pin-based CFL fixture in commercial application. For residential application the life of a pin-based CFL fixture is 16 years.

The EUL is based on 20,000 hours approved Lamp life divided by average annual hours of operation for each building type:

EUL = (Lamp Life (20,000 hours)) / (Average Operating Hours Per Year)

Table 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) | Varies |

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

***Title 20:*** Under Title 20 [2015] incandescent reflector lamps manufactured before July 15, 2012 must meet Table K-3 minimum average lamp efficacy (LPW). For incandescent reflector lamps manufactured on or after July 15, 2012, Table K-4 must be satisfied. Additional minimum average lamp efficacy requirements of Table K-9 are in effect for state-regulated incandescent reflector lamps manufactured on or after January 1, 2008.

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

***Federal Standards:*** These measures do 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

#### 1.4.3.1 CALiPER Application Summary Report 161:

The most recent CALiPER report stated that as of January of 2012, DOE estimated that BR30 lamps made up approximately 38% of the installed base case of PAR, BR, and R lamps, which corresponds to approximately 2.02 million units in the US. Approximately 89% of the products were estimated to be installed in residential applications.

Based on the CALiPER report product selection the BR30/R30 with 65 watts is the most common of all the BR/R lamps especially in residential applications. CALiPER tested a few BR/R lamps in the earlier rounds (4 products in round 2, one product in round 3, and one product in round 9). The test ID RT42 was reported in “retail replacement lamps in April, 2012. CALiPER tested not only for lumen output, input wattage and efficacy, but for CCT (Correlated Color Temperature),CRI (Color Rendering Index), power factor, R9 (Special color rendering index, mostly for red colors), Duv (the distance from Planckian locus on the CIE 1960 chromaticity diagram). Some of the results of the tests are shown in table below.

Table Previous CALiPER Testing of BR30 and R30 LED Lamps

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **DOE CALiPER Test ID** | **Initial Output (lm)** | **Total Input Power**  **(w)** | **Efficacy**  **(lm/W)** | **Power Factor** | **CRI** | **CCT** |
| 07-08 | 229 | 8.8 | 27 | 0.58 | 72 | 2945 |
| 07-09 | 310 | 9.1 | 34 | 0.59 | 82 | 5973 |
| 07-13 | 406 | 15.6 | 26 | 0.47 | 14 | 2689 |
| 07-14 | 352 | 13.8 | 25 | 0.46 | 13 | 4006 |
| 07-18 | 180 | 8.6 | 21 | 0.60 | 77 | 7878 |
| 09-64 | 186 | 3.5 | 53 | 0.50 | 71 | 5554 |
| RT42 | 365 | 8.0 | 46 | 0.49 | 67 | 3225 |
| **Minimum** | **180** | **3.5** | **21** | **0.46** | **13** | **2689** |
| **Mean** | **291** | **9.6** | **33** | **0.53** | **57** | **4610** |
| **Maximum** | **406** | **15.6** | **53** | **0.60** | **82** | **7878** |

As we can see from the earlier results of the testing of the lamp efficacy, of the LED lamps were between 21 to 53 (lm/W) with a mean of 33 lm/W. The minimum lumen output and the minimum efficacy of these LED lamps don’t come close to the conventional lamps tested by CALiPER and shown in Table 9. Although the mean efficacy of the LED and conventional lamps are close, the mean lumen outputs do not come close.

Table CALiPER Testing of Conventional BR30 and R30 Lamps

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **DOE CALiPER Test ID** | **Source Type** | **Initial Output (lm)** | **Total Input Power**  **(w)** | **Efficacy**  **(lm/W)** | **Power Factor** | **CRI** | **CCT** |
| 12-54 | Incandescent | 650 | 65.7 | 10 | 1.00 | 100 | 2698 |
| 08-13 | Incandescent | 732 | 65.0 | 11 | 1.00 | 99 | 2681 |
| 12-21 | CFL | 776 | 14.9 | 52 | 0.60 | 83 | 2684 |
| 12-58 | CFL | 732 | 16.1 | 46 | 0.57 | 83 | 2883 |
| 08-06 | CFL | 841 | 15.8 | 53 | 0.55 | 82 | 2740 |
| **Minimum** |  | **650** | **14.9** | **10** | **0.55** | **82** | **2681** |
| **Mean** |  | **746** | **35.5** | **34** | **0.74** | **89** | **2737** |
| **Maximum** |  | **841** | **65.7** | **53** | **1.00** | **100** | **2883** |

In the most recent CALiPER study, 13 LED lamps were tested and the results are considerably different than previous LED test data. The efficacy of these newer products are in the range of 51 to 91 (lm/W) with a mean of 59 lm/W, which is very comparable and in many cases much better than the conventional lamps. The lumen output of these LED’s is from 463 to 860 lumens with a mean of 662 lumens. The light output of these products in also well comparable to the conventional lamps. CALiPER tested for color consistency and color temperature and for other characteristics and the results are shown in the Table 10.

Table Results of the CALiPER Testing of BR30/R30 for the series 16 LED Lamps

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **DOE CALiPER Test ID** | **Initial Output (lm)** | **Total Input Power**  **(w)** | **Efficacy**  **(lm/W)** | **Power Factor** | **CRI** | **CCT** |
| 12-15 | 544 | 6.0 | 91 | 0.53 | 81 | 5389 |
| 12-16 | 564 | 11.1 | 51 | 0.97 | 83 | 3520 |
| 12-17 | 745 | 12.1 | 62 | 0.74 | 84 | 2675 |
| 12-18 | 859 | 14.0 | 61 | 0.78 | 81 | 2704 |
| 12-19 | 740 | 11.3 | 65 | 0.98 | 77 | 6586 |
| 12-20 | 550 | 9.5 | 58 | 0.93 | 83 | 2769 |
| 12-51 | 595 | 11.7 | 51 | 0.88 | 92 | 2663 |
| 12-52 | 463 | 8.1 | 57 | 0.93 | 85 | 2966 |
| 12-53 | 616 | 12.1 | 51 | 0.94 | 93 | 2729 |
| 12-55 | 699 | 13.5 | 52 | 0.76 | 83 | 2734 |
| 12-56 | 667 | 11.6 | 58 | 0.87 | 82 | 2709 |
| 12-57 | 705 | 12.6 | 56 | 0.80 | 82 | 3112 |
| 12-59 | 860 | 14.3 | 60 | 0.77 | 81 | 3000 |
| **Minimum** | **463** | **6.0** | **51** | **0.53** | **77** | **2663** |
| **Mean** | **662** | **11.4** | **59** | **0.84** | **84** | **3350** |
| **Maximum** | **860** | **14.3** | **91** | **0.98** | **93** | **6586** |

A few of the conclusions that CALiPER reported for the LED testes were:

* The lumen output of many of the products was equivalent to 65 Watt or 75 Watt incandescent BR30/R30 lamps.
* Most of the “series 16” LED’s had color quality attributes similar to incandescent lamps.
* The power factor of the “series 16” LED’s was considerably better than previously tested LED BR30/R30 lamps, with all but one of the products exceeding the ENERGY STAR minimum requirements.
* Many of the manufacturer claims were accurate; however, there was a tendency for the lamps to exhibit higher efficacies than reported in the manufacturer’s literature.

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

The base case is split into 40% LED, 10% CFL and 50% incandescent/halogen based on the disposition “2018ScrewInLampSavingsMethods-1March2018” from the California Public Utilities Commission; Energy Division, dated March 1, 2018.

# Section 2. Calculation Methods

ROB Measures

Wattage Reduction Ratio (WRR) savings calculation methodology is used per Screw-In Lamps” disposition from the California Public Utilities Commission’s Energy Division, dated March 1, 2018 with values given as follows: WRR = 4.17 for <11w, 3.28 for >=11W to <14W, and 2.97 for >14W.

ER Measures

* 1st Baseline: Actual lamp rated wattage of incandescent and compact fluorescent (CFL) are used for the base case to reflect what the customer has in place. The corresponding measure case LED wattages to incandescent are obtained from the “Product Analysis” tab in the “2018ScrewInLampDispositionBackup-21Dec2017-1.xlsm” file provided by the CPUC’s commission staff. The base case CFL wattages are determined based on the lumen output equivalency of the corresponding incandescent lamps.
* 2nd Baseline: Due to limited savings associated with the 2nd baseline, the calculations show no savings for the second baseline.

The demand difference (Δ Watts/lamp) is simply the difference between the electric demand of the base case lamp and the electric demand of the measure case lamp. The base case wattage of the lamp is calculated by applying the WRR multiplier to the lowest measure case wattage within the measure case range.





## 2.1 Electric Energy Savings Estimation Methodologies

The energy savings calculation for ROB measure type uses the wattage reduction ratio (WRR) methodology. 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:

#### 

#### Where

The following example calculation demonstrates the annual energy savings, kWh per year, for the ASM building type, for a 6W LED R/BR lamp:

**Example:**

## 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 ASM building type, for a 6W LED R/BR lamp:

## 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 energy demand savings, kW per year, for the

ASM building type, for a 6W LED R/BR lamp:

# 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 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 March 1, 2018 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.

For Direct Install programs actual costs are reported based on post-install project invoices. Placeholder material and labor costs are assigned to DI measures in the work paper.

Direct Install ER measures are exempted from the early retirement cost calculation.

## 4.1 Base Case(s) Costs

#### ROB base case costs are web scraped. See “PGECOLTG177 R6 - R-BRCostSummary.xlsx” for more details on the cost data and analysis.

The base case costs for ROB measures are split into 40% LED, 10% CFL and 50% incandescent/halogen based on the Disposition “2018ScrewInLampSavingsMethods-1March2018” from the California Public Utilities Commission’s Energy Division, dated March 1, 2018.

Direct Install measures are allowed to report full measure cost; therefore, the base case cost is set to zero.

## 4.2 Measure Case Costs

#### ROB measure case costs are web scraped. See “PGECOLTG177 R6 - R-BRCostSummary.xlsx” for more details on the cost data and analysis.

ER measure case costs are placeholder material and labor costs assigned to each measure code in the work paper.

## 4.3 Incremental & Full Measure Costs

Table 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 |
| 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. Actual costs are reported based on post-installation project invoices; however, placeholder material and labor costs are being assigned to each measure code in the work paper. For full measure costs please refer to the LED lamp cost spreadsheet. DI ER projects are not subject to the requirement of ER cost calculation.

### 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 RBR-Cost-2018.xls 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-1)
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-2)
3. MAEDBS, State-regulated Light Emitting Diode Lamp list, <https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx> [↑](#endnote-ref-3)
4. CALiPER, Application Summary Report 16: LED BR30 and R30 Lamps, July 2012 [↑](#endnote-ref-4)
5. The Support table “Measure Application Type” in the Measure Catalog can be found using the latest version of the Remote Ex-Ante Database Interface (READI) on the Database for Energy-Efficient Resources (DEER) website, <http://www.deeresources.com/> [↑](#endnote-ref-5)