**Work Paper PGECOLTG114**

**Linear Fluorescent Interior Fixture**

**Revision 7**

**Pacific Gas & Electric Company**

**Customer Energy Efficiency Department**

**Non Residential Interior High Performance Linear Fluorescent Fixtures with NEMA Premium HE Ballast**

**Measure Codes LT001, LT002, LT003, LT004, LT005, LT006**

# At-a-Glance Summary

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Applicable Measure Codes:** | **LT001** | **LT002** | **LT003** | **LT004** | **L1T005** | **LT006** |
| **Measure**  **Description:** | Replace, one-for-one, existing incandescent, mercury vapor, standard metal halide or high pressure sodium fixtures in interior applications with complete high performance, HP T8 lamp/fixture and NEMA premium Hi-Efficiency Ballast (identified as low ballast factor <= 0.80), lower wattage than the fixture being replaced. | | | | | |
| >585 Watt Lamp Base case, 352 to 585 Watt Replacement Fixture | >351 Watt Lamp Base case, 235 to 351 Watt Replacement Fixture | >234 Watt Lamp Base case, 145 to 234 Watt Replacement Fixture | >144 Watt Lamp Base case, 119 to 144 Watt Replacement Fixture | >118 Watt Lamp Base case, 65 to 118 Watt Replacement Fixture | >64 Watt Lamp Base case, 0 to 64 Watt Replacement Fixture |
| **Energy Impact Common Units:** | Fixture | | | | | |
| **Base Case Description:** | Various Pulse Start Metal Halide Fixtures : Refer to .xlsx file attached.  Source: DEER2016 | | | | | |
| **Base Case Energy Consumption:** | Various: Refer to .xlsx file attached.  Source: DEER2016 | | | | | |
| **Measure Energy Consumption:** | Various: Refer to .xlsx file attached.  Source: DEER2016 | | | | | |
| **Energy Savings (Base Case – Measure)** | Various: Refer to .xlsx file attached.  Source: DEER2016 | | | | | |
| **Costs Common Units:** | $ per fixture | | | | | |
| **Base Case Equipment Cost ($/unit):** | Various: Refer to .xlsx file attached.  Source: WO017 | | | | | |
| **Measure Equipment Cost ($/unit):** | Various: Refer to .xlsx file attached.  Source: WO017 | | | | | |
| **Measure Incremental Cost ($/unit):** | Various: Refer to .xlsx file attached.  Source: PG&E Calculations | | | | | |
| **Effective Useful Life (years):** | Varies (Max of 15 years), ILtg-T5  Source: DEER2016 | | | | | |
| **Program Type:** | ROB, NC | | | | | |
| **Net-to-Gross Ratios:** | NonRes-sAll-mLFHB-Deemed 0.65  Source: DEER2016 | | | | | |
| **Comments** |  | | | | | |

# Document Revision History

**Revision # Date Description Author (Company)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Superseded** | 06/04/07 | Int Linear Fluor Fixt 060407.doc | (PG&E) |
| **Superseded** | 01/15/07 | Linear Fluor Fixtures 01-15-07 – HO.doc | (PG&E) |
| **Superseded** | 01/15/07 | Linear Fluor Fixtures 01-15-07 .doc | (PG&E) |
| **Revision 0** | 03/07/08 | Linear Fluorescent Interior Fixture PGECOLTG114 R0.doc | Emily Leslie (HDR/BVA) |
| **Revision 1** | 10/05/09 | Linear Fluorescent Interior Fixture PGECOLTG114 R1.doc  MODIFICATIONS:   1. Modified Gas Energy Savings formula 2. Revised Therms saving values 3. Changed values for measure code id as “other” & “WRF” 4. Modified NTG ratio | Richmond Apande (PG&E) |
| **Revision 2** | 02/25/10 | Linear Fluorescent Interior Fixture PGECOLTG114 R2.doc  MODIFICATIONS:  1. Changed Measure Codes & added HP T8 Lamp/NEMA ballasts in the text.  2. Updated NTGR values for 2009-11  3. Modified kW, kWh & Therms savings values  4. Modified Costs | Richmond Apande (PG&E) |
| **Revision 3** | 02/25/10 | Linear Fluorescent Interior Fixture PGECOLTG114 R3.doc  MODIFICATIONS:  Include Attachment A recommendation | Alina Zohrabian (PG&E) |
| **Revision 4** | 06/15/12 | Linear Fluorescent Interior Fixture PGECOLTG114 R4.doc  MODIFICATIONS:   1. Removed T12 baseline from text. 2. Modified kW, kWh & Therm savings. 3. Modified costs. | David Gilliland (kW Engineering),  Alina Zohrabian (PG&E) |
| **Revision 4** | 8/28/12 | OTR explanation is added in the workpaper, For Vintage AV is changed to EX and For Climate Zone All is changed to IOU | Alina Zohrabian (PG&E) |
| **Revision 5** | 7/14/13 | Revised Savings values per ED Workpaper Disposition for Lighting Retrofit, issue March, 2013. For updated savings values, see file PGECOLTG114 R5-Calcs.xlsx  Measure wattage adjustments. Measure L1036 changed from 480 to 600 watts. Measure L1035 changed from 96 to 94 watts. Measure L1033 changed from 73 to 78 watts.  ISR changed from 1 to 0.92. | Alina Zohrabian (PG&E) |
| **Revision 6** | 5/16/2014 | Added DI values from (PGE3PLTG172) and revised savings values per ED Workpaper Disposition for Lighting Retrofits, December 14, 2013. | Mark Tiemens (PG&E) |
| **Revision 7** | 1/1/2016 | Updated base case and measure costs per Work Order 17. Updated NTG, annual hours of operation, EUL, CDF, IE per DEER 2016. | Linda Wan (PG&E)/Alina Zohrabian (PG&E)/Tai Voong (PG&E) |

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# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This work paper documents the rationale for the “Interior High-Bay Linear Fluorescent Fixtures” measure as listed in the PG&E Lighting Catalog, as part of Pacific Gas and Electric Company’s Customer Energy Efficiency Program.

**Requirements:**

* Only complete, new High Performance (HP) T8/T5, Super T8, T8 VHO, or T5 HO interior linear fluorescent fixtures qualify.
* New fixtures must not exceed the maximum “New Fixture Wattage” listed in Table 1 for each range of lamp wattage being replaced. New fixture wattage is the total system wattage (Lamp and Ballast).
* Rebates are based on a one-for-one replacement of incandescent or high intensity discharge (HID) fixtures including, mercury vapor, high pressure sodium, and standard metal halide or pulse start metal halide. Existing lamp wattage is used rather than total fixture wattage (i.e. a 250 Watt high pressure sodium fixture is a 250 Watt base case and qualifies under the L1033 rebate code).
* Any wattage incandescent lamp may be replaced by complete new linear fluorescent fixtures.
  + To calculate the base case wattage for incandescent fixtures with more than one lamp, multiply the number of lamps by nominal lamp wattage as listed on lamp label.
* In all cases, the wattage of the replacement fixture must be less than the wattage of the existing lamp.
* All 32 Watt T8 lamps must be HP T8 or Super T8 lamps and listed on the qualified HP T8 lamp list at **www.cee1.org**.
* All lamps must be rated ≥ 20,000 hours average rated lamp life based on 3 hours per start when operated on Program Rapid-Start Ballasts.
* T5 HO and T8 VHO lamps must have Color Rendering Index (CRI) that is equal to or greater than 82.
* All T8 ballasts must be NEMA premium or designated HP electronic ballast listed on **www.cee1.org**, T5 HO and T8 VHO must be Program Rapid Start ballasts.

**Exclusions:**

* Exterior installations do not qualify.
* Not eligible for additional rebates under the "Compact Fluorescent Fixtures" category.
* Other fixture configurations may be considered under our Customized Retrofit Incentive Program.
* Replacement fixtures for T12 Linear Fixtures are not eligible for this rebate.

**Additional Details:**

– T8 and T5: Program Rapid-Start ballasts are designed to provide maximum lamp life in frequent lamp starting applications such as in areas where occupancy sensor controls are used.

– T8 Only: Instant Start electronic ballasts are the most popular type of electronic ballast today because they provide maximum energy savings and start lamps without delay.

Table 1 Product Codes and Descriptions

|  |  |
| --- | --- |
| **Product Code** | **Description of New Linear Fluorescent HP T8/T5 Fixture** |
| LT001 | HP T8/T5, >585 WATT LAMP BASE CASE, 352 TO 585 WATT REPLACEMENT FIXTURE |
| LT002 | HP T8/T5, >351 WATT LAMP BASE CASE, 235 TO 351 WATT REPLACEMENT FIXTURE |
| LT003 | HP T8/T5, >234 WATT LAMP BASE CASE, 145 TO 234 WATT REPLACEMENT FIXTURE |
| LT004 | HP T8/T5, >144 WATT LAMP BASE CASE, 119 TO 144WATT REPLACEMENT FIXTURE |
| LT005 | HP T8/T5, >118 WATT LAMP BASE CASE, 65 TO 118 WATT REPLACEMENT FIXTURE |
| LT006 | HP T8/T5, >64 WATT LAMP BASE CASE, 0 TO 64 WATT REPLACEMENT FIXTURE |

***Program Restrictions and Guidelines***

***Terms and Conditions:***

These measures are for interior fixtures only. All fixtures must be hardwired. Fixtures are not eligible for additional rebates under the Compact Fluorescent Fixtures and HP T8 or T8/T5 Linear Fluorescent Lamps with NEMA/Electronic Ballasts categories, but may qualify for an occupancy sensor rebate under the Occupancy Sensor category, provided all requirements are met.

***Market Applicability:***

This measure is available to all non-residential customers.

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

Table 2 Delivery Method and Applicable Building Types

|  |  |  |
| --- | --- | --- |
| **Delivery Type** | **Applicable Building Types** | **Application Type** |
| Downstream | All Commercial Building Types | ROB, NC |
| Direct Install | All Commercial Building Types | ROB, NC |

## 1.2 Product Technical Description

The measure case high performance fluorescent lamps are more efficient than the baseline lamps and provide similar illumination levels at lower wattage. The NEMA High Efficiency Electronic ballasts provide the same light output as standard electronic ballast but do so more efficiently, reducing lighting power.

## 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 3 Measure Application Type[[1]](#endnote-1)

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

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

All the measures within this workpaper are ROB and NC.

## 1.4 Product Base Case and Measure Case Data

The base case wattages of the Pulse Start Metal Halide Fixtures are based on methodology outlined in ED Workpaper Disposition for Lighting Retrofits, December 14, 2013 and in 2015 Uncertain Measures Update.

## 1.4.1 DEER Base Case and Measure Case Information

The Database for Energy Efficient Resources (DEER) 2016 contains the measures for HP high bay linear fluorescent fixtures using the Delta Wattage Assumption. The base case technology is HID and the standard case is metal halide for LT006 and Pulse start metal halide for the rest of the measures.

**Hours of Operation**

The DEER 2016 hours of operation and interactive effects are used for savings calculations.

**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 4 Net-to-Gross Ratios

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| NonRes-sAll-mLFHB-Deemed | Nonresidential Linear Fluorescent: high bay applications; deemed; all delivery mechanisms | NonRes | Any | Any | 0.65 |

**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 value was obtained using the DEER READI tool. The relevant IR value for these measures is in the table below:

Table 5 Installation Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| Com-HiBay-PGE | Non-Res High-Bay; Annual Installation Rate | Com | Any | NonUpStrm | 0.92 |

**Effective Useful Life (EUL)**

EUL varies based on the Building Type. The EUL for Linear Fluorescent fixtures is calculated either using the Rated Life of the Ballast and the hours of operation for the building type installed or 15 years, whichever is less. DEER 2016 specifies 70,000 hours for non-Residential linear fluorescent ballast hours[[2]](#endnote-2). The formula for calculating the EUL is shown below:

EUL (Years) = 70,000 hrs / Building type operational hours or 15 years (whichever is less)

Table 6 Effective Useful Life

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| ILtg-T5 | HID Lighting (T-5) | Com | Lighting | Varies (Max 15 yrs) | Varies |

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

***Title 20 [2015]:*** The fluorescent lighting standards listed in the California Code of Regulations, Title 20 Public Utilities and Energy, Article 4 Appliance Efficiency Regulations, matches an outdated version of the US Department of Energy’s (DOE) energy conservation standards for general service fluorescent lamps[[3]](#endnote-3). The updated DOE rules take precedent as of July 14th, 2012, and are summarized in the *Federal Standards* section below.

***Title 24 [2013]:*** These measures are not specifically regulated by California Code of Regulations, Title 24 Part 6 Building Energy Efficiency Standards for Residential and Nonresidential Buildings.

***Federal Standards:*** On June 26th, 2009, the US Department of Energy (DOE) issued a final rule amending the energy conservation standards for general service fluorescent lamps and incandescent reflector lamps. The updated rules, which take effect on July 14th, 2012, institute the following luminous efficacy (lumens/Watt) standards for general service fluorescent lamps[[4]](#endnote-4):

Table 7 - DOE Baseline Linear Fluorescent Standards

|  |  |  |
| --- | --- | --- |
| **Lamp Type** | **Correlated Color Temperature** | **Energy Conservation Standard (Lm/W)** |
| 4-Foot Medium Bipin | ≤4,500K | 89 |
| ˃4,500K and ≤7,000K | 88 |
| 2-Foot U-Shaped | ≤4,500K | 84 |
| ˃4,500K and ≤7,000K | 81 |
| 8-Foot Slimline | ≤4,500K | 97 |
| ˃4,500K and ≤7,000K | 93 |
| 8-Foot High Output | ≤4,500K | 92 |
| ˃4,500K and ≤7,000K | 88 |
| 4-Foot Miniature Bipin Standard Output | ≤4,500K | 86 |
| ˃4,500K and ≤7,000K | 81 |
| 4-Foot Miniature Bipin High Output | ≤4,500K | 76 |
| ˃4,500K and ≤7,000K | 72 |

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

Some M&V studies were done which included Heschong Mahone’s *CEC lighting Efficiency Technology Report[[5]](#endnote-5)*, but DEER has the most relevant information as far as operating hours and interactive effects by building type. DEER2016 data is used for this measure.

# Section 2. Calculation Methods

## 2.1 Electric Energy Savings Estimation Methodologies

To calculate the electrical energy used, simply multiply the wattage difference by the hours of operation and cooling energy interactive effects, both of which are taken from DEER 2016.



Example of Energy Savings Calculation for ASM building type for measure LT001 (ROB):



## 2.2. Demand Reduction Estimation Methodologies

The lighting demand difference (Watts per unit) is simply the difference between the electric demand of the base unit and the electric demand of the energy efficient unit. The Demand savings is calculated based on the formula below:



Example of Energy Savings Calculation for ASM building type for measure LT001 (ROB):



## 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.



Example of Energy Savings Calculation for ASM building type for measure LT001 (ROB):



# 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 the 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 Non-Residential Lighting indoor lighting end use load shape.

## 3.2 Measure Load Shapes

For purposes of the net benefits estimates in the Energy Environmental Economics, Inc., 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 E3 calculator, based on the applicable non-residential market sector and the lighting end-use.

Table 8 Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| All Commercial Building Types | PGE:DEER:Com:Indoor\_Non-CFL\_Ltg | NON\_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 these affected measures. Please refer to the HiBay cost workbook for detailed information[[6]](#endnote-6).

## 4.1 Base Case(s) Costs

The base case assumes a standard or pulse start metal halide fixture with different wattages depending on the measure code. The base case cost represents the cost the customer would incur by purchasing replacement HID fixtures. The material and labor costs for the base case fixtures were calculated from Work Order 17[[7]](#endnote-7). Refer to the spreadsheet for detailed cost information.

## 4.2 Measure Costs

The measure case is linear fluorescent fixtures with different wattages depending on the measure code. The measure equipment costs are calculated using Work Order 17. The labor cost is $187.14 per the Work Order 17 report for high bay applications.

## 4.3 Incremental & Full Measure Costs

Table 9 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 $187.14 is used from WO017.

## 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.

# 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. *DEER Database for Energy-Efficient Resources, Version 2011 4.01.* EUL/RUL Values. Updated 10/10/2008. Web. Accessed 6/4/2012.

   < <http://deeresources.com/index.php?option=com_content&view=article&id=68&Itemid=60>>. [↑](#endnote-ref-2)
3. 2010 Appliance Efficiency Regulations (Title 20). California Energy Commission. Section 1605(k), page 117. December, 2010. [↑](#endnote-ref-3)
4. *Energy Conservation Standards and Test Procedures for General Service Fluorescent Lamps and Incandescent Reflector Lamps; Final Rule.* Federal Register, 74 FR 34080, July 14, 2009. Web. Accessed June 4th, 2012.

   <<http://www1.eere.energy.gov/buildings/appliance_standards/residential/incandescent_lamps_standards_final_rule.html>>. [↑](#endnote-ref-4)
5. Heschong Mahone Group, *Lighting Efficiency Technology Report.* Prepared for the California Energy Commission, Sacramento. September 1999. [↑](#endnote-ref-5)
6. PGE HiLoBay DEER2016 Cost Updates.xlsx [↑](#endnote-ref-6)
7. 2010-2012 WO017 Ex Ante Measure Cost Study Final Report. Itron, Inc. May 27, 2014. [↑](#endnote-ref-7)