

Work Paper PGE3PLTG173
Compact Fluorescent Direct Install
Revision 6

Pacific Gas & Electric Company
Customer Energy Solutions

Compact Fluorescent Direct Install

Measure Codes 0L00-0L02, 0L05-0L15, 0L22-0L30, 0L34, 0L38-0L39, 0L41, 0L44-0L45, 0L47, 0L50-0L53,
0N01-0N03, 0N06-0N11, 0N13,
LC77-LC81, LC83-LC85, LC87, LC89-LC90, LC92, LC96 – LC98, LC100-LC101, LC105-LC107

8/10/2017

At-a-Glance Summary

Applicable Measure Codes:	0L00-0L02, 0L05-0L15, 0L22-0L30, 0L34, 0L38-0L39, 0L41 0L44-0L45, 0L47, 0L50-0L53, 0N01-0N03, 0N06-0N11, 0N1 LC77-LC81, LC83-LC85, LC87, LC89-LC90, LC92, LC96 – LC98, LC100-LC101, LC105-LC107								
Measure Description:	The compact fluorescent lamps programs pay contractors (in Direct install programs) to replace customers' existing incandescent lamps with more efficient compact fluorescent lighting.								
Energy Impact Common Units:	Per lamp								
Base Case Description:	Various. Source: PG&E Calculations								
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 (\$/unit):	Various.								
Measure Equipment Cost (\$/unit):	Various.								
Measure Incremental Cost (\$/unit):	Various.								
Effective Useful Life (years):	Various Refer to .xls attached Source: 2016 DEER.								
Program Type:	Replace on Burnout (ROB)								
Net-to-Gross Ratios:	<table border="1"> <thead> <tr> <th>NTGR ID</th> <th>NTGR</th> </tr> </thead> <tbody> <tr> <td>NonRes-sAll-mCFL</td> <td>0.85</td> </tr> <tr> <td>Res-sAll-mCFL</td> <td>0.85</td> </tr> <tr> <td>Res-Default>2</td> <td>0.55</td> </tr> </tbody> </table> <p>Source: 2017 Disposition for Screw-In Lamps, and PGEScrewInLampResubmittalReview-31Jul2017</p>	NTGR ID	NTGR	NonRes-sAll-mCFL	0.85	Res-sAll-mCFL	0.85	Res-Default>2	0.55
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NonRes-sAll-mCFL	0.85								
Res-sAll-mCFL	0.85								
Res-Default>2	0.55								
Important Comments:	Removed references to PGECOLTG107, PGECOLTG110 & PGECOLTG111. PGECOLTG110 was retired effective 1/1/2016. PGECOLTG107 and PGECOLTG111 will be retired beginning 7/1/2017.								

Document Revision History

Revision #	Date	Description	Author (Company)
Revision 0	06/8/12	Created Direct Install & Downstream Version of PGECOLTG111 R5 & PGECOLTG107 R5 Modifications from the original include: 1. New DI & downstream NTG & ISR values 2. Adjustments to Cost Data to better align with ER transaction type	Breesa Collyer, PG&E
Revision 0	08/22/2012	Updated nomenclature per ED direction for the following: Building types-BCR to Any Building vintage-AV to Any Climate Zone-All to Any Application Type-ER to ROB	Breesa Collyer, PG&E
Revision 0	1/7/2013	Add Measures 0L23, 0L03, 0L14, 0L30, 0L34, 0L46, 0L49, L856 for Residential Building Types.	Sherry Hu, PG&E
Revision 1	10/18/2013	Added Middle Income Direct Install (MIDI) codes	Mark Tiemens, PG&E
Revision 2	5/30/2014	Revised savings values per ED workpaper Disposition for Lighting Retrofits. Updated DI measures to vary by building type instead of Res/Com	Mark Tiemens, PG&E
Revision 3	10/27/2014	Updated mis-categorization of measures LC101-LC103, LC73-LC74 and clarified measure descriptions for 0L15, 0L21, and 0L22. Fixed EUL ID use sub categories in Excel	Mark Tiemens, PG&E
Revision 4	1/1/2016	Updated NTG, Annual Hours of Operation, GSIA, EUL, CDF, IE, and base case and measure costs per DEER 2016. Removed all downstream measures.	Linda Wan, PG&E / Alina Zohrabian, PG&E / Tai Voong, PG&E
Revision 5	11/16/2016	Retired measure codes L450, L0234 and L0235; Updated Residential Interactive Effect(IE) per DEER 2017	Mini Damodaran (PG&E)/Alina Zohrabian (PG&E)
Revision 6	6/7/2017	Removed references to PGECOLTG110 retired effective 1/1/2016, PGECOLTG107 & PGECOLTG111 which are retired effective 7/1/2017. Updated WRR, base case percentages and NTG as per 2017 Disposition for Screw-In Lamps; Base costs changed based on base case %; NTG changed from 0.6 to 0.85 for Res, and 0.9 to 0.85 for Res; Retired measure codes LC82, LC86, LC88, LC91, L856, 0L04, 0L03, 0L16, 0L17, 0L18, 0L19, 0L20, 0L21, 0N04, 0L40, 0L42, 0L43, 0N05, 0N12, LC99.	Alina Zohrabian (PG&E)/Mini Damodaran (PG&E)
	8/10/2017	NTG used for CFL fixture implementations for the residential sector were changed from Res-sAll-mCFL" =0.85 to "Res-Default>2" = 0.55 based on "PGEScrewInLampResubmittalReview-31Jul2017" from CPUC.	Mini Damodaran (PG&E)

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Section 1. General Measure & Baseline Data

1.1 Measure Description & Background

The compact fluorescent lamps (CFL) programs pay contractors in Direct install (DI) programs to replace customers' existing incandescent lamps with more efficient compact fluorescent lighting. The measures in this workpaper use the same DEER 2016 calculation methodology.

Program Restrictions and Guidelines

The delivery method is Direct Install for commercial and residential customers.

Terms and Conditions:

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

Market Applicability:

Single and Multi-Family Installations are eligible. These measures include direct install rebates.

Table 1 Delivery Method and Applicable Building Types

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

Delivery Type	Applicable Building Types	Application Type
Direct Install	DEER Building Types	ROB

1.2 Product Technical Description

The CFL DI program encourages commercial and residential customers to replace existing incandescent lamps with more efficient compact fluorescent lighting. These measures are consistent with DEER methodology.

1.3 Installation Type Descriptions

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) website¹.

Table 2 Measure Application Type

Installation Type	Savings		Life	
	1 st Baseline (BL)	2 nd BL	1 st BL	2 nd BL
Replace on Burnout (ROB)	Above Code or Standard	N/A	EUL	N/A
New Construction (NEW/NC)	Above Code or Standard	N/A	EUL	N/A
Retrofit or Early Replacement (RET/ER)	Above Customer Existing	Above Code or Standard	RUL	EUL-RUL
Retrofit Add-on (REA)	Above Customer Existing	N/A	EUL	N/A

All the measures within this workpaper are ROB.

A delivery mechanism is a delivery method paired with an incentive method. Delivery mechanisms are used by programs to obtain program participation and energy savings.

Delivery Method Descriptions

Delivery Method	Description
New Construction	The program offers financial incentives and/or design assistance to customers involved with new building construction. This is intended is to motivate customer to exceed Title 24 building energy efficiency requirements (residential or nonresidential).
Partnership	The program implements projects through a partnership between the utility and an institutional, government, or community-based organization.
Up/mid-Stream Programs	See Up/mid-Stream Incentive in the Incentive Method table.

Incentive Method Descriptions

Incentive Method	Description
Direct Install	The program implements energy efficiency measures for qualifying customers, at no cost to the customer.

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 measure wattage. Table below shows the approved CFL WRR from July 1st, 2017 based on 2017 “Comprehensive Workpaper Disposition for: Screw-In Lamps” Disposition from the California Public Utilities Commission; Energy Division, dated May 26, 2017².

Table 3 CFL Wattage Reduction Ratio

CFL Type Description	WRR
Interior reflector lamps	1.74
Interior non-reflector lamps	1.56
Exterior lamps	1.74
All nonresidential	1.59

Hours of Operation

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

Net to Gross (NTG) Assumption

NTG values from the July 1st, 2017 are based on “2017 Disposition for Screw-In Lamps”. NTG used for CFL fixture implementations for the residential sector were changed from Res-sAll-mCFL to Res-Default>2 based on “PGEScrewInLampResubmittalReview-31Jul2017”. 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	Delivery Method	NTGR
NonRes-sAll-mCFL	Nonresidential LED A-lamp and screw-in reflector, all delivery mechanisms	NonRes	Any	Any	0.85
Res-sAll-mCFL	Residential LED A-lamp and screw-in reflector, all delivery mechanisms	Res	Any	Any	0.85
Res-Default>2	All other EEM with no evaluated NTGR; existing EEM with same delivery mechanism for more than 2 years mechanisms	Res	Any	Any	0.55

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 and the 2006-2008 Lighting Evaluation. The relevant IR values for the measures in this work paper are in the table below:

Table 5 Installation Rates

GSIA ID	Description	Sector	BldgType	ProgDelivID	GSIAValue
MFm-IntCFL-PGE	Interior CFL; Annual Installation Rate; Multi-family	Res	MFm	NonUpStrm	0.89
MFm-IntCF-PGE	Interior Compact Fluorescent fixture; Annual Installation Rate; Multi-family	Res	MFm	NonUpStrm	0.87
Mfm-ExtCF-PGE	Exterior Compact Fluorescent fixture; Annual Installation Rate; Multi-family	Res	MFm	NonUpStrm	0.89
PGE_Prop_CFL_0.89	2006-2008 lighting evaluation - DI RES	Res	Any	Direct Install	0.89
Com-CFL-PGE	Non-Res CFL; Non-Upstream Program; Annual Installation Rate	Com	Any	NonUpStrm	0.77

Effective Useful Life

The effective useful life values were taken from 2016 DEER. The EUL varies according to lamp annual hours for CFL lamps.

Table 6 Effective Useful Life

EUL ID	Description	Sector	EUL (Years)	Version VersionSource
ILtg-CFL-Com	CFL Lamps - Indoor- Commercial - 10,000 Rated Hours	Com	Varies	DEER2016 2015 Uncertain Measures Update
ILtg-CFL-Res	CFL Lamps - Indoor- Residential - 10,000 Rated Hours	Res	3.5	DEER2016 2015 Uncertain Measures Update
ILtg-CFLfix-Res	CFL Fixtures - Indoor - Residential	Res	16	DEER2014 D08 v2.05
ILtg-CFL-ResCmn	CFL Lamps - Indoor- Residential Common Area- 10,000 Rated Hours	Res	Varies	DEER2014 Lighting Disposition
ILtg-CFLfix-ResCmnArea	CFL Fixtures - Indoor - Residential Common Area	Res	15	DEER2014 Lighting Disposition
OLtg-CFL	CFL Lamps - Outdoor- Residential - 10,000 Rated Hours	Res	3.5	DEER2016 2015 Uncertain Measures Update
OLtg-CFL-Com	Outdoor CFL Lamps - 10,000 Hour	Com	2.44	DEER2014 D08 v2.05
OLtg-CFLfix	CFL Fixtures - Outdoor - Residential	Res	16	DEER2014 D08 v2.05

1.4.2 Codes & Standards Requirements Base Case and Measure Information

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

Title 20: California Title 20 [2015] lists the federal standards for incandescent reflector lamps.

Federal Standards: Federally-regulated incandescent reflector lamps must meet a minimum average lamp efficacy level as shown in the table below. Because the measures in this workpaper and the corresponding base case incandescent reflector wattages are governed by DEER methodology, the Title 20 efficacy requirements were not used to dictate the base and measure cases for this workpaper.

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

These measures are in DEER and the methodology and results from DEER are used for this work paper.

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

This workpaper follows the 2017 “Comprehensive Workpaper Disposition for: Screw-In Lamps” Disposition from the California Public Utilities Commission; Energy Division, dated May 26, 2017.

Section 2. Calculation Methodology

Wattage Reduction Ratio (WRR) savings estimation methodology is used per 2017 “Comprehensive Workpaper Disposition for: Screw-In Lamps” Disposition from the California Public Utilities Commission; Energy Division, dated May 26, 2017, based on values in Table 5 to calculate the energy savings. 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.

$$\Delta \text{Watts/lamp} \left[\frac{\text{Watts}}{\text{lamp}} \right] = (\text{Base case Watts/lamp}) - (\text{Measure Case Watts/lamp})$$

Where $\text{Base Case Watts/lamp} = \text{Measure Case Watts/lamp} \times \text{WRR}$

2.1 Electric Energy Savings Estimation Methodologies

The energy savings calculation 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:

$$\text{Energy Savings} \left[\frac{\text{kWh}}{\text{lamp}} \right] = (\text{kW/lamp}) \times (\text{Annual hours of operation}) \times (\text{Energy Interactive Effects})$$

An example calculation is presented below for measure code LC105 (4 Watt Interior Screw-in CFL) for ASM building type.

$$\text{Energy Savings} \left[\frac{\text{kWh}}{\text{unit}} \right] = \frac{(4 \times 1.59 - 4 \text{ W/unit})}{1000} \times (1160) \times (1.04) = 2.9$$

2.2. Demand Reduction Estimation Methodologies

Demand reduction varies by market sector (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 Commercial were taken from DEER 2016 data. The operating hours and interactive effects for Residential were taken from DEER 2017. The following formula was used to determine annual demand savings:

$$\text{Demand Savings} \left[\frac{\text{kW}}{\text{unit}} \right] = (\Delta \text{kW/unit}) \times (\text{lighting coincident diversity factor}) \times (\text{Demand Interactive Effects})$$

An example calculation is presented below for measure code LC105 (4 Watt Interior Screw-in CFL) for ASM building type.

$$\text{Demand Reduction} \left[\frac{\text{kW}}{\text{unit}} \right] = (0.004 \times 1.59 - 0.004 \text{ kW/unit}) \times (0.221) \times (1.18) = 0.0006$$

2.3. Gas Energy Savings Estimation Methodologies

The energy savings achieved via a reduction in lighting demand is partially offset by an increase in thermal energy needed for heating. The thermal interactive effects for Commercial were taken from DEER

2016 data. The thermal interactive effects for Residential were taken from DEER 2017. The following formula was used to determine annual gas savings:

$$\text{Annual Gas Savings} \left[\frac{\text{Therm}}{\text{unit}} \right] = (\Delta kW/\text{unit}) \times (\text{Annual hours of operation}) \times (\text{Gas Interactive Effects})$$

An example calculation is presented below for measure code LC105 (4 Watt Interior Screw-in CFL) for ASM building type.

$$\text{Gas Savings} \left[\frac{\text{therms}}{\text{unit}} \right] = (0.004 \times 1.59 - 0.004 \text{ kW/unit}) \times (1160) \times (-0.010) = -0.027$$

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 or nonresidential lighting end-use load shape.

3.2 Measure Load Shapes

For purposes of the net benefits estimates in the E3 calculator, what is required is the load shape that ideally represents the *difference* between the base equipment and the installed energy efficiency measure. This *difference* load profile is what is called the Measure Load Shape and would be the preferred load shape for use in the net benefits calculations.

The measure load shape for this measure is determined by the E3 calculator based on the applicable residential or nonresidential market sector and the lighting end-use.

Table 7 Building Types and Load Shapes

Building Type	Load Shape	E3 Alternate Building Type
Commercial	PGE:2 = Commercial Outdoor Lighting	COMMERCIAL
Commercial	PGE:DEER:Com:Indoor_CFL_Ltg	NON_RES
Residential	PGE:DEER:Indoor_CFL_Ltg	RES

Section 4. Base Case & Measure Costs

The base case cost for direct install measures is \$0.00. We assign this value because, for direct install programs, the customers would not have changed out the equipment if it were not for the program.

All CFL base case and measure case costs were taken from the DEER cost table found from the READI tool v 2.3.0. Costs for measures that are not explicitly in DEER were calculated using a variety of methods.

4.1 Base Case(s) Costs

For Direct install measures the base case assumes the customer would not have done anything without the program. Therefore base case costs are \$0 for all measure codes.

4.2 Measure Case Costs

Direct Install measure case costs vary slightly per DEER. See measure list for CFL measure case costs.

CFL Lamps

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

4.3 Incremental & Full Measure Costs

All CFL incremental & full measure costs were calculated using values from the DEER cost table. Descriptions of how incremental & full measure costs were calculated are shown below.

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

Full measure cost is used for Direct Install Measures. The labor cost was taken from the “2010-2012 Work Order 17 Ex Ante Measure Cost Study Final Report” (WO17)3.

References

¹ 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/>

² Non-DEER Work Papers and Dispositions (2013 – 2017), Screw In Lamps Disposition, <http://www.deeresources.com/index.php/non-deer-workpapers>

³ Work Oder 17, <http://www.energydataweb.com/cpucFiles/pdaDocs/1100/2010-2012%20WO017%20Ex%20Ante%20Measure%20Cost%20Study%20-%20Final%20Report.pdf>