Work Paper SCE17LG117

**Revision 1**

**Southern California Edison**

**LED T8 Replacement Lamps UL Type A**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | LT-11950 , LT-11966, LT-19146, and LT-20467 |
| **Measure Description** | 4-foot LED T8 Replacement Lamp UL Type A |
| **Base Case Description** | 4-foot Linear Fluorescent T8 Lamps |
| **Units** | Per lamp |
| **Energy Savings** | Refer to Excel Calculation Attachment |
| **Full Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Incremental Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Effective Useful Life** | ILtg-Lfluor-Elec – varies by building type |
| **Measure Installation Type** | RET/ER |
| **Net-to-Gross Ratio** | Com-Default>2yrs: 0.60  Ag-Default>2yrs: 0.60  Ind-Default>2yrs: 0.60  Res-Default>2yrs: 0.55 |
| **Important Comments** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 5/25/17 | Ajay Wadhera/SCE | * Workpaper revised based on SCE13LG117.0 * Used new 2017 template * Updated savings and cost analysis based on additional deemed program participation data * Updated ET program influence documentation * Added new delivery methods for RET, OBF, and Partnerships * Made this workpaper statewide * Revert back to RET Install Type per conversation with CPUC ExAnte Staff on 5/25/2017 |
| 1 | 7/11/2018 | Ajay Wadhera/SCE | * Workpaper revised for 2019 program cycle * Updated to new version of calculation template * Updated cost data * Updated NTG from 0.7 to 0.6 * Added parking garage solution code based on “PGECOLTG151 R8 Outdoor InterimSolution” parking garage HOU assumptions. |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
| 0 | CS | 5/23/16 | 6/6/16 |  |  |
|  |  |  |  |  | * [Attachment 5] |
| 0 | Cal TF | 3/6/15 | 3/6/15 |  | * Result is an ET study mentioned in Section 1.5.2 |
| 0 | CS | 6/23/2016 | 6/23/2016 |  | * Implemented delta watts and NTG values as suggested. |

Cal TF website: <http://www.caltf.org/>

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This work paper details the replacement of 4-foot Linear Fluorescent T8 lamps with LED T8 Lamp UL Type A.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | LED T8 Lamp UL Type A 4 foot |
| Existing Condition | Linear Fluorescent T8 Lamp 4 foot |
| Code/Standard | F32T8 Linear Fluorescent Lamp |
| Industry Standard Practice | N/A |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
|  |  | LT-11950 |  | 4 foot LED T8 Lamp UL Type A Replacing Linear Fluorescent T8 Lamp (Non-Res) |
|  |  | LT-11966 |  | 4 foot LED T8 Lamp UL Type A Replacing Linear Fluorescent T8 Lamp (Common Area) |
|  |  | LT-19146 |  | 4 foot LED T8 Lamp UL Type A Replacing Linear Fluorescent T8 Lamp (Dwelling Area) |
|  |  | LT-20467 |  | 4 foot LED T8 Lamp UL Type A Replacing Linear Fluorescent T8 Lamp (Parking Garages) |

**Eligibility Requirements**

The measures in this work paper are eligible in all Commercial building types and Residential Multifamily and Double-Wide Mobile Home building types (Common and Dwelling Areas) in all Climate Zones. Parking garages are also eligible.

To qualify for incentives, the LED tube must be 4-foot and designated as UL Type A. The lamp must be listed under the Primary Use Category “Replacement Lamps (plug and play) (UL Type A)” on the DLC’s Qualified Products List (QPL) and meet additional criteria outlined below. The LED T8 Lamp specification sheet must also list all of the compatible ballast model numbers to ensure proper operation of the measure.

The products on the QPL will be filtered and must meet the specs as listed below.

**SCE Program Requirement**

|  |  |  |  |
| --- | --- | --- | --- |
| **Performance Metric** | **DLC Requirement** | **DLC Tolerance** | **SCE Program Requirement (no tolerance)** |
| Luminaire Efficacy | ≥110 LPW | -3% | ≥110 LPW |
| CRI | ≥80 | -2 points | ≥80 |
| CCT | ≤ 5,000K | N/A | ≤ 5,000K |
| Power Factor | ≥0.9 | -3% | ≥0.9 |
| Total Harmonic Distortion | ≤20% | +5% | ≤20% |
| Lumen Maintenance | L70≥50,000 | N/A | L70≥50,000 |
| Minimum Warranty | 5 years | N/A | 5 years |

**Commercial Direct Install Program** contractors have extensive knowledge of the lighting products they use for the DI Program.  Direct Install contractors will confirm LED T8 lamps installed are compatible, per manufacturer’s specifications, with the existing ballasts.  Documentation can be provided regarding the lamp/ballast compatibility for the various components used and encountered in their Direct Install. The sampling rate for pre-inspection is 6% and post-inspection between 10-20%.

**Commercial Downstream Deemed Program** would require applicants to submit manufacturer’s specification sheets detailing compatible ballasts and circling the one in their location. LED T8 tubes without this information available will not be eligible for the program. Ballasts will then be checked during inspections aligned with current inspection policy.

**Midstream Program** will verify the LED T8 Lamp specification sheet by working with lighting distributors who provide incentives on qualified lighting products.  Distributors have extensive knowledge of their lighting inventory and will provide incentives on products that meet SCE’s requirements.  LED T8 Lamps will be pre-approved for use in the Midstream program to ensure that only LED T8 lamps with specification sheets that list the ballast model tested are eligible for incentives.  Distributors will provide the necessary documentation to SCE requirements to verify the product is eligible for incentives.  Distributors will also let their customers know that they carry products that list compatible ballasts and should be verified before making the purchase.

The **SCE Multifamily Energy Efficiency Rebate (MFEER) Program** offers rebates on a wide variety of energy-saving products and services to motivate the multifamily property owners/managers to install energy efficient products in both common and dwelling areas of multifamily complexes. The MFEER program addresses the ongoing concern with “split incentives”, where the residents are not the owners of the property, so they lack incentive to improve their energy usage. Similarly, the property owners do not live on-site and pay higher utility expenses due to inefficient appliances, thus lack any incentive to upgrade. The MFEER is designed to drive this customer segment toward participation by offering property owners a variety of energy efficiency measures and services.

The MFEER program also offers select energy-efficient products and services at “no-cost” to customers implemented via direct install. Direct install measures are implemented by authorized-program contractors who perform program outreach and provide project management which includes energy audits, customer enrollment, product procurement, installation and quality assurance.

The MFEER program quality control ensures product eligibility by verifying qualified products lists and product specifications of the energy efficient product installed. Pre-inspection isn’t performed, but data is collected. All projects that receive over $20,000 in incentives require a 100% post-inspection while all others will require 10% post-inspection. SCE requires a detailed Product Location Form (PLF) for each project submitted for rebate or incentive. The PLF is an Excel spreadsheet with a tab for measures installed. Consistent with program policies and procedures, field inspections are also conducted to verify installations and accuracy of the information provided in submitted incentive applications.

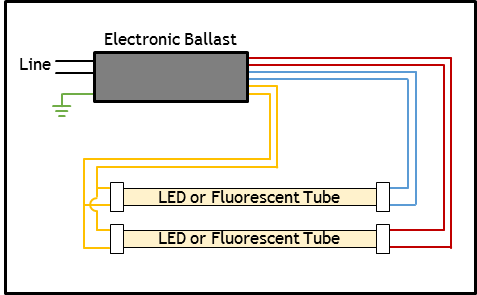
To ensure proper operation of the measure technology, customers will be required to submit the product specification sheet listing the entire compatible ballast model numbers indicating which ballast model is currently installed at their location.

## 1.2 Technical Description

LED T8 lamp Design Lights Consortium (DLC) defines the UL Type A as:

Four-foot or two-foot LED "tubes" designed to replace four-foot or two-foot fluorescent lamps, respectively. Products in this category employ lamp holders to connect to the fixture being retrofitted and are designed to be "plug and play" replacements for fluorescent lamps. That is, products in this category can operate off existing fluorescent ballast, and do not require mechanical or electrical changes to the fixture. Note that due to testing considerations, at this time only products that can operate off electronic instant start ballasts are eligible. Replacement lamps designed to operate off existing magnetic ballasts, or off other types of electronic ballasts, are not eligible.

**UL Type A Configuration**



## 1.3 Installation Types and Delivery Mechanisms

The Installation Types are:

* Retrofit or Early Replacement (RET/ER)

As this is a retrofit measure, the POE requirements do not apply to this measure.

The delivery methods are:

* Financial Support / Direct Install
* Financial Support / Down-Stream Incentive – Deemed
* Midstream Programs / Mid-Stream Incentive
* Partnership /Direct install and Down-Stream Incentive – Deemed
* Financial Support / Down-Stream Incentive – Deemed - OBF

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Retrofit or Early Replacement (RET/ER) | Above Customer Existing | Above Code or Standard | RUL | EUL-RUL |

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** |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |
| Mid-Stream Programs | *See Mid-Stream Incentive in the Incentive Method Descriptions table.* |
| Partnership | The program implements projects through a partnership between the utility and an institutional, government, or community-based organization. |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Direct Install | The program implements energy efficiency measures for qualifying customers, at no cost to the customer. |
| Down-Stream Incentive | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized. |
| Mid-Stream Incentive  Mid-Stream Buy Down | The program gives a financial incentive to a midstream market actor (distributor, vendor, or retailer) to encourage the promotion of efficient measures. Buy Down means that the incentive is required to be passed down to the end-use customer. |
| On-bill Finance – Loan (OBF) | The program offers financing for the cost of an efficient measure as part of the utility bill. This can be an add-on option to an existing program or can serve as an organizing principle for its own program. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | Yes |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | No |
| DEER Version | Non-DEER |
| Reason for Deviation from DEER | DEER does not contain this type of measure. |
| DEER Measure IDs Used | N/A |

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI tool. The relevant NTG values for the measures are in the table below. To address potential concerns related to both quality and persistence, two Emerging Technology studies were explicitly conducted for the measures in this work paper. These two studies provided the basis/assurance upon which this wider offer was developed.

The timeline below illustrates the work that SCE’s ET program has taken on developing the background for this measure and how it has supported bringing this technology into the mass market EE portfolio.

The Emerging Technologies program has been evaluating LED technology for use in many applications including recessed troffers and cans, parking structures, high/low bay, street and outdoor lighting for some time. Products tested include new fixtures, flat panel fixtures, retrofit kits and replacement tubular lamps (Types A, B and C).

|  |  |
| --- | --- |
| Date | Action |
| 2010 | ET10SCE1180 - LED T8 Project Initiated (Cancelled): Due to lack of standards and documentation of new LED T8 products, the project was cancelled. |
| 6/30/2011 | ET10SCE1190 - LED Recessed Luminaire Project Initiated: This project was focused on evaluating LED options for replacing Linear Fluorescent technology in Recessed Troffer Applications. Due to a high volume of inquiries into LED T-8 tube replacements, two LED T-8 tubes were also tested. |
| 10/1/2012 | LED Luminaire Study Completed (ET10SCE1190 - LED Recessed Luminaires): Results indicated that the LED tubes tested in a lenses 2x4 troffer fixture showed similar results to LED 2x4 fixtures though their distribution pattern was narrower. Efficacy of the DLC listed LED Tube was similar to the low end of the LED fixtures tested, however there are only a limited amount of tubes specified on the DLC QPL. Cost of the LED Tubes was $50 per lamp. |
| 5/30/2103 | SCE Moratorium on LED Tubes: Due to the cost, compatibility and performance concerns with the products available at the time, LED Tube Replacement Lamps were prohibited as a program offering. A memo was sent to all Account Reps to be used as talking points for customer inquiries. |
| 5/1/2014 | LED Tubes ET Study Initiated (ET14SCE1040 – LED Tube Retrofit): ET had been following the progression of the technology as well as standardization in classifying the types of replacement lamps. The DOE had conducted a comprehensive study on the technology and several new products became available that claimed to address some of the concerns. A new ET project was initiated to evaluate the improvements in the technology by testing the different type of LED Tubes (now defined as UL Types A, B and C) in the laboratory setting. The lamps were tested for their performance as claimed by manufacturer specs on photo metrics, power and power quality and efficacy. |
| 11/7/2014 | WP Guidance doc from ED Staff |
| 12/15/2014 | 1st Conference Call Meeting with ED Staff |
| 12/16/2014 | ED Staff Meeting on VA study |
| 1/14/2015 | 2nd Conference Call Meeting with ED Staff |
| 2/25/2015 | ED-IOU Tech Collab Meeting |
| 3/3/2015 | CALTF Presentation |
| 5/4/2015 | Custom scaled field placement Started (ET15SCE8040 – LED Tube Retrofit SFP): This study was to gather additional data as required to document early ballast failure concerns as well as sampling of existing installed ballast stock. Data collected from the Customized Project installations included a sampling of existing ballast and lamp make and model numbers, ballast and fluorescent lamp age, light levels pre/post as well as 6 week and 1 year (or 4380 hours, whichever comes first), and tracking of installed lamps and existing ballasts. |
| 10/1/2015 | Tubes Report Complete (ET14SCE1040 – LED Tube Retrofit): |
|  | The ballast-compatible (UL Type A) LED tubes performed within manufacturer specs and with efficacy better than linear fluorescent lamps and was able to dim considerably better than fluorescent lamps. The testing also included integrated driver direct line voltage (UL Type B) and remote driver (UL Type C). |
|  | During the laboratory testing a few representative samples of the many available LED tube products were being evaluated primarily on a per lamp basis. For additional pricing and compatibility data a Scaled Field Placement was recommended. As such the Custom SFP mentioned above was initiated. |
| 5/16/2015 | WP Submittal |
| 6/24/2016 | WP Resubmittal and approval for Aliso Canyon effort with 4-month data collection requirement. WP to be re-submitted by Jan. 31, 2017 for implementation March 1, 2017. |
| 12/31/16 | Data collection concluded |

Based on preliminary review [Attachment 9], the ET NTG will not be used. Also since this measure has been implemented by utility programs for more than 2 years, a DEER default NTG value is being used this time.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| Com-Default>2yrs | All other EEM with no evaluated NTGR; new technology in program for more than 2 years | Com | Any | Any | 0.60 |
| Ag-Default>2yrs | All other EEM with no evaluated NTGR; new technology in program for more than 2 years | Ag | Any | Any | 0.60 |
| Ind-Default>2yrs | All other EEM with no evaluated NTGR; new technology in program for more than 2 years | Ind | Any | Any | 0.60 |
| Res-Default>2yrs | All other EEM with no evaluated NTGR; new technology in program for more than 2 years | 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. The relevant IR values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1 |

**Effective and Remaining Useful Life**

The EUL and RUL values were obtained using the DEER READI tool. DEER defines the RUL as 1/3 of the EUL value. The RUL value is only applicable to the first baseline period for an RET measure with an applicable code baseline. The relevant EUL and RUL values for the measures in this work paper are in the table below.

This work paper replaces the linear fluorescent lamp with an LED lamp while using the existing linear fluorescent ballast. Based on guidance from the Commission Staff, the EUL is the RUL of the host equipment. Although field data gathered in Attachment 3 suggests 7 years ballast RUL, this work paper will use (70,000/HOU/3) to calculate the EUL and if the EUL is larger than the RUL value of the EUL ID indicated below, the RUL value will be used as the EUL value.

CS also recommended that LtgFixture-Default is used for Res building types since ILtg-Lfluor-Elec is limited to commercial installations.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| ILtg-Lfluor-Elec | Linear Fluorescent with Electronic Ballast | Any | Lighting | (70,000/HOU)/3 or the max of RUL value. | N/A |
| LtgFixture-Default | CS recommended for Res | Res | Lighting | (70,000/HOU)/3 or the max of RUL value. | N/A |

### 1.4.2 Codes and Standards Analysis

Title 24 2016 [496], Section 141.0(b)2I states:

**Lighting System Alterations** shall meet the applicable requirements in TABLE 141.0-E and the following:

1. Lighting System Alterations include alterations where an existing lighting system is modified, luminaires are replaced, or luminaires are disconnected from the circuit, removed and reinstalled, whether in the same location or installed elsewhere.

**EXCEPTION 1 to Section 141.0(b)2Iii:** Alterations that qualify as a Luminaire Modification-in-

Place.

**EXCEPTION 2 to Section 141.0(b)2Iii:** Portable luminaires, luminaires affixed to moveable partitions, and lighting excluded in accordance to Section 140.6(a)3.

**Luminaire Modifications-in-Place** shall meet the applicable requirements in TABLE 141.0-F and the following:

1. To qualify as a Luminaire Modification-in-Place, luminaires shall only be modified by one or more of the following methods:
   1. Replacing lamps and ballasts with like type or quantity in a manner that preserves the original luminaire listing.
   2. Changing the number or type of light source in a luminaire including: socket renewal, removal or relocation of sockets or lamp holders, and/or related wiring internal to the luminaire including the addition of safety disconnecting devices.
   3. Changing the optical system of a luminaire in part or in whole.
   4. Replacement of whole luminaires one for one in which the only electrical modification involves disconnecting the existing luminaire and reconnecting the replacement luminaire.
2. Luminaire Modifications-In-Place shall include only alterations to lighting system meeting the following conditions:
   1. Luminaire Modifications-in-Place shall not be part of or the result of any general remodeling or renovation of the enclosed space in which they are located.
   2. Luminaire Modifications-in-Place shall not cause, be the result of, or involve any changes to the panelboard or branch circuit wiring, including line voltage switches, relays, contactors, dimmers and other control devices, providing power to the lighting system.

**EXCEPTION to Section 141.0(b)2Iiii2.** Circuit modifications strictly limited to the addition of occupancy or vacancy sensors and class two lighting controls are permitted for Luminaire

Modifications-in-Place

Title 20 2018 [515] includes regulations to fluorescent lamp ballasts, replacement fluorescent lamp ballasts, and lamps.

2012 Federal Standards for General Service Fluorescent Lamps issued by Department of Energy effective July 14, 2012 contains Energy Conservation Standards that apply to various linear fluorescent lamp types [[[1]](#endnote-1)].

2012 Federal Standards for General Service Fluorescent Lamps issued by Department of Energy effective July 14, 2012 contains Energy Conservation Standards that apply to various linear fluorescent lamp types [[[2]](#endnote-2)].

This measure is a lamp-only replacement and does not trigger any of the above code references.

Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 24 (2016) | Section 141.0(b)2Iii Lighting System Alterations, 141.0(b)2Iii Luminaire Modifications-in-Place | July 1, 2016 |
| Title 20 (2018) | 2018 Appliance Efficiency Regulations | May 1, 2018 |
| NEMA (2012) | Federal standards for general service fluorescent lamps issued by DOE | July 14, 2012 |

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

Two Department of Energy CALiPER studies related to LED tubes application and cost effectiveness are attached [6, 7]. These studies provide context related to the quickly evolving improvement in LED lamps as well as the analysis related to applications where they are most cost effective.

The following two Emerging Technology studies outline the basis for savings and quality of installation considered for this measure.

### 1.5.1 ET14SCE1040 - LED Tube Retrofit Lab Assessment [497, Attachment 3]

* Emerging Technologies Assessment, Alvaro Mendoza, October 2015 (Note: Ongoing long term lumen depreciation testing with cycling)
* Late 2014 through 2015, Linear LED Tube replacement lamps (Ballast Compatible, Internal Driver, External Driver)
* Photometric and Electrical Measurements
* Photometric and Electrical performance
* Multiple lamp manufacturers tested

Based on the long term testing, no major lumen degradation has been observed and no negative effects were observed for the fluorescent ballasts after about 3,500 hours of cycled testing. Measured temperatures of the lamps and ballast have been stable since the beginning of the test.

Temperature measurements taken inside four different open fixtures in various lamp configurations showed that LEDs have considerably lower temperature than the linear fluorescent lamps. LED lamps were below 100°F while linear fluorescent lamps were greater than 125°F. LED T8 lamps also showed better performance across the entire dimming range than linear fluorescent lamps in terms of efficacy and visible flicker. The figure below shows the internal fixture ambient temperature of the LED and Linear Fluorescent lamps.

**Internal Fixture Ambient Temperature**



The Figure below shows the current Total Harmonic Distortion (THDi) caused by each of the lamps on a 2-lamp setup. Ballast compatible lamps performed similar to linear fluorescent lamps and showed no negative signs.

**THDi of 2-Lamp Tests**



The Figure below shows the Ballast Luminous Efficacy (BLE) of the LED T8 lamps tested. After eight months of continuous on-off fixture cycling with 3500 hours of on-time operation, the Ballast Luminous Efficiency (BLE) measurements, which measure the ratio of electrical output to electrical input as defined by DOE test procedures, indicate that the fluorescent ballast have not been affected by the operation of replacement LED tubes. The BLE values obtained from lab testing with LED T8 lamps are consistent with typical BLE values observed on the fluorescent ballasts when operating with T8 fluorescent lamps (above 80%). This chart demonstrates that there is no indication that replacement LED tubes degrade the performance of compatible fluorescent ballasts.

**Ballast Luminous Efficacy**



### 1.5.2 ET15SCE8040 – LED Tube Retrofit Scaled Field Placement (SFP)

* Emerging Technologies Assessment, completed Q4 2016
* See filtered DLC List, Linear LED Tube replacement lamps (Ballast Compatible Only)
* Sampling of installations, tracking, surveys, light measurements (pre and post)
* Average RUL, Average Lamp Wattage, Equivalency
* Number of customer satisfaction surveys received

During the LED Tube Retrofit SFP, account managers were provided with a check-list of items the projects must meet before moving forward as shown below. More details can be found in the attachment [Attachment 4]. This form was intended only for the SFP and will not be used during the launch of this deemed measure.

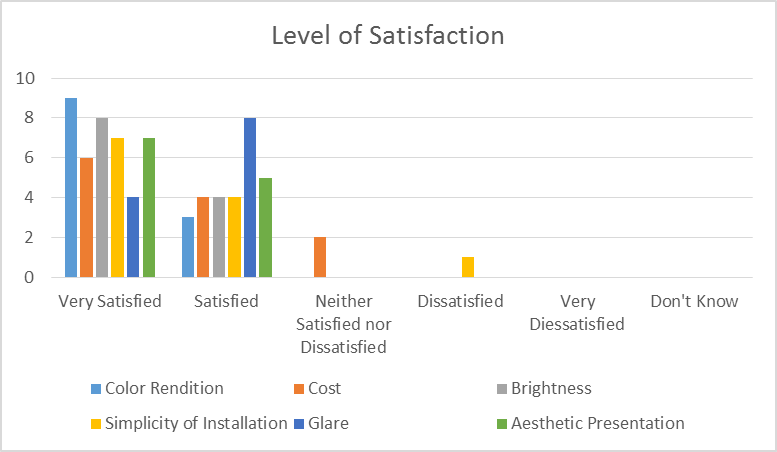
* LED T8 lamp must be a Type A
* Must use existing linear fluorescent ballast
* 4-foot long
* Required check for ballast compatibility
* Dimmable ballast if existing system was dimmable
* Warranty on QPL must match the specification sheet
* Lamps were to only be installed in pre-qualified fixture types such as strip, cove, wrap, and prismatic troffers

Data such as baseline/measure information, type of fixture, pre/post light measurement, and ballast life were gathered. Raw data can be found in the attachments [Attachment 5].

Ballast life was either taken from the date stamp on the ballast or verbally from the customer. Some customers did not know how long the existing ballasts have been in operation. Averaging all the remaining useful life of the ballasts resulted in a RUL of 6.9 years, which is higher than the typical DEER lamp life of 20,000 hours.

Based on customer satisfaction surveys, customers who installed LED T8 lamps were mostly satisfied and would recommend the same technology to others. Although this is not a complete list of surveys received, customers who did take the survey were very satisfied with color, installation, and aesthetics. Survey chart is shown below. A total of 12 surveys out of 35 projects were provided.

**Customer Satisfaction Survey**



**Ballast Replacements**

A follow-up review occurred 6 weeks after installation to monitor ballast replacements. Although 95% were unchanged, fewer than 2% were replaced within the 6-week period and fewer than 1% were replaced within the 1-year or 4,380 hours follow up. Note that 4% were initially replaced due to compatibility issues as shown in figure below. Program Requirements for this measure now address this potential compatibility problem by requiring that the LED T8 lamp documentation to provide a list of compatible ballast model numbers. Note that the compatible ballast testing will also address the potential issue of mis-matching differing ballast factors and lamps.



## 1.6 Data Quality and Future Data Needs

N/A

# Section 2. Calculation Methodology

The updated savings values were obtained using a weighted average of the baseline type lamps (25, 28, 30 & 32W) identified in the deemed trial from multiple SCE utility programs in Q3-4 2016. Baseline wattages were normalized to account for a Normal Ballast factor of 0.88. The measure wattages were obtained from the DLC QPL. The resultant savings are calculated from subtracting the Measure Weighted Average Watts from the Normalized Baseline Weighted Average Watts. A total of 175,712 lamp data were analyzed and the wattage breakdown is as follows:

|  |  |
| --- | --- |
| Base Case Wattage | % Saturation (From Program Install Results) |
| 25W | 0.35% |
| 28W | 39.64% |
| 30W | 0.17% |
| 32W | 59.84% |

For further reference to analysis, please refer to Attachment 8.

The tables below indicate the weighted baseline wattages used to generate the savings:

**Baseline Average**

|  |  |  |
| --- | --- | --- |
| **Nominal LF Watts** | **# of Lamps** | **Normalized Base Watts** |
| 32 | 105,153 | 28.16 |
| 28 | 69,651 | 24.64 |
| 25 | 608 | 22.00 |
| 30 | 300 | 26.40 |
| **Total Weighted Average** | | **26.67** |

**Measure Average**

|  |  |  |
| --- | --- | --- |
| **Nominal LF Watts** | **# of Lamps** | **Normalized Measure Watts** |
| 32 | 105,153 | 15.61 |
| 28 | 69,651 | 17.40 |
| 25 | 608 | 17.03 |
| 30 | 300 | 14.50 |
| **Total Weighted Average** | | **16.32** |

The equation below shows the delta watt calculation derived using the above stated methodology:

**Sample Delta Watts Calculation:**

Baseline Average Watts – Measure Average Watts = Delta Watt Savings

26.67W – 16.32W = 10.36W

The energy savings estimates are calculated as follows:



The following is sample energy savings calculations for a 4-foot LED T8 Lamp UL Type A replacing Linear Fluorescent T8 Lamp in an Assembly building type, Climate Zone 6, and RET install type.

The demand reduction estimates are calculated as follows:



The following is sample demand reduction calculations for a 4-foot LED T8 Lamp UL Type A replacing Linear Fluorescent T8 Lamp in an Assembly building type, Climate Zone 6, and RET install type.

**Parking garages:** Parking garages are assumed to be **2613.75** hours of use. This Equivalent Full-Load Hours (EFLH) is the average of the allowed low power usage per DISPOSITION FOR WORKPAPER SCE13LG123 revision 0, issued September 30, 2016 at 35% power and lower-power usage per Title 24, section 130.2(c)3 at 20% power. The calculated mid-point or average of 20% and 35% is 27.5%, which is within the range allowed for the dimmed-power state by Title24. Calculations follow DISPOSITION FOR WORKPAPERS COVERING EXTERIOR LED LIGHTING FIXTURES, issued March 1, 2017. The HOU is approved in the “PGECOLTG151 R8 Outdoor InterimSolution” workpaper. The Interactive effects were considered to be 1 and the kW savings are zero.

Operating hours with controls:

Please refer to [Attachment 1] for savings on all other building types.

# Section 3. Load Shapes

The ideal load shape for net benefits estimates would represent the difference between the base case and measure case. The closest load shapes that are applicable to the measures in this work paper are listed in the table below.

Building Types and Load Shapes

|  |  |  |  |
| --- | --- | --- | --- |
| **Solution Codes** | **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| LT-11950  LT-20467 | Assembly | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Education - Community College | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Education - Primary School | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Education - Relocatable Classroom | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Education - Secondary School | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Education - University | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Grocery | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Health/Medical - Hospital | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Health/Medical - Nursing Home | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Lodging - Guest Rooms | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Lodging – Hotel | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Lodging – Motel | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Manufacturing - Bio/Tech | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Manufacturing - Light Industrial | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Office – Large | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Office – Small | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Restaurant - Fast-Food | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Restaurant - Sit-Down | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Retail - Multistory Large | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Retail - Single-Story Large | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Retail – Small | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Storage - Conditioned | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Storage - Unconditioned | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Warehouse - Refrigerated | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| LT-11966, LT-19146 | Residential Mobile Home - Double-Wide | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |
| Residential Multi-family | DEER:Indoor\_Non-CFL\_Ltg | NON\_RES |

# Section 4. Costs

## 4.1 Base Case Cost

Base material cost was taken from the Work Order 17 calculator [Attachment 2]. Labor cost is based upon the measure labor cost taken from the ET15SCE8040 SFP ET study as the required installation effort is the same.

**Base Cost**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Solution Codes** | **Material** | **Labor** | **Total** | **Units** |
| All Solution Codes | $3.61 | $8.47 | $12.08 | Lamp |

## 4.2 Measure Case Cost

Measure cost was taken from the program participation data conducted in Q1 2018 [Attachment 10]. The total cost of the material and the total number of lamps were used to come up with an average cost. Labor cost is based upon the measure labor cost taken from the SFP ET study as the required installation effort is the same.

**Measure Cost**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure Code** | **Measure Name** | **Material** | **Labor** | **Total** | **Units** |
| All Solution Codes | 4 foot LED T8 Lamp UL Type A Replacing Linear Fluorescent T8 Lamp | $8.27 | $8.47 | $16.74 | Lamp |

## 4.3 Full and Incremental Measure Cost

**Full and Incremental Measure Cost Equations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| RET/ER | (MEC + MLC) – (BEC + BLC) | MEC + MLC | (MEC + MLC) – (BEC + BLC) |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

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

**Full and Incremental Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure** | **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost [per lamp]** | |
| **1st Baseline** | **2nd Baseline** |
| All Solution Codes | RET/ER | $4.66 | $16.74 | $4.66 |

**Attachments**

1. A1 SCE17LG117.0 Calculations\_Final.zip
2. A2 SCE17LG117.0 WO17 lighting Cost Calculator.xlsx
3. A3 SCE17LG117.0 ET14SCE1040 Final Report.pdf
4. A4 SCE17LG117.0 LED Tube Requirements.docx
5. A5 SCE17LG117.0 Caliper Led Tube Study .pdf
6. A6 SCE17LG117.0 Caliper LED Tube Study 2 .pdf
7. A7 SCE17LG117.0 ET10SCE1190 Report.pdf
8. A8 SCE17LG117.0 Cost and Data Analysis.xlsx
9. A9 SCE17LG117.0 SCE13LG117r0--PreliminaryReview.pdf
10. A10 SCE17LG117.1 - LED Tube Cost Data

# References

References\_07112018\_101102

[496]

[493]

[497]

1. <http://www.ncaee.org/modules/info/files/files_4adcd38174d01.pdf> [↑](#endnote-ref-1)
2. <http://www.ncaee.org/modules/info/files/files_4adcd38174d01.pdf> [↑](#endnote-ref-2)