Work Paper SCE17LG097

**Revision 2**

**Southern California Edison**

**LED Street Lighting**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | Refer to Excel Calculation Attachment |
| **Measure Description** | LED Street Lighting |
| **Base Case Description** | HPS/PSMH Street Lighting (Pre-Existing Condition)  LED Street Lighting (Standard Practice Baseline) |
| **Units** | Per fixture |
| **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** | OLtg-Com-LED-50000hr  (RUL: 4 Years) |
| **Measure Installation Type** | Early Retirement (RET) |
| **Net-to-Gross Ratio** | Com-Default>2yrs: 0.60  Res-Default>2: 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 | 6/23/2017 | Lake Casco (TRC) | * This work paper is an update of SCE113LG097.2 * New template update for 2017 program year * All (16) California Climate Zones included in calculation template * Costs updated based on online resources, construction cost catalogue and distributor quotes * Added Residential Multi-family building type to calculations * Added Direct Install |
| 1 | 06/30/17 | Lake Casco (TRC) | * Adjusted HOU from 4,380 to 4,100 per the Exterior Lighting Disposition |
| 2 | 02/27/18 | Ajay Wadhera (SCE) | SCE17LG097 Revision 2 is intended solely for grandfathered AB-719 projects pursuant to the CPUC memo received by SCE on October 10, 2017.   * Converted Install type from ROB to RET. * Added Partnerships/ Direct Install Delivery Method. * Assumed second baseline savings to be zero since LED is considered as baseline. * Instead of LS-1, 2, and 3 tariffs, all SCE tariffs are allowed to receive incentives. |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
|  |  |  |  |  |  |

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

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This work paper details the calculation methodology used in determining annual energy savings by replacing a cobra style high intensity discharge (HID) luminaire (fixture) in street lighting applications with a light emitting diode (LED) fixture. Two HID sources are addressed: high pressure sodium (HPS) and pulse start metal halide (PSMH). The measure savings for this work paper are based on the replacement of HID lighting sources, specifically HPS and PSMH, with LED fixtures. The following Table lists all of the measures applicable to this work paper.

Note: Street lighting is defined for this document as service for the lighting of automobile-carrying streets, highways, and other public thoroughfares, and publicly-owned and publicly–operated automobile parking lots.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | LED Street Lighting |
| Existing Condition | \*HPS/PSMH Street Lighting |
| Code/Standard | N/A |
| Industry Standard Practice | \* LED Street Lighting |

\*Baselines assumed per direction stated in CPUC Memorandum Dated 10/10/2017 [Attachment 6]

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
|  |  | LT-27419 |  | Up to 28 Watt Street Light LED replacing 50 Watt High Pressure Sodium |
|  |  | LT-73136 |  | 29 to 43 Watt Street Light LED replacing 70 Watt High Pressure Sodium |
|  |  | LT-80500 |  | 44 to 54 Watt Street Light LED replacing 100 Watt High Pressure Sodium |
|  |  | LT-24820 |  | 55 to 90 Watt Street Light LED replacing 150 Watt High Pressure Sodium |
|  |  | LT-78130 |  | 91 to 130 Watt Street Light LED replacing 200 Watt High Pressure Sodium |
|  |  | LT-35164 |  | 131 to 190 Watt Street Light LED replacing 250 Watt High Pressure Sodium |
|  |  | LT-61338 |  | 191 to 222 Watt Street Light LED replacing 310 Watt High Pressure Sodium |
|  |  | LT-81983 |  | 223 to 260 Watt Street Light LED replacing 400 Watt High Pressure Sodium |
|  |  | LT-94198 |  | 29 to 43 Watt Street Light LED replacing 70 Watt Pulse Start Metal Halide |
|  |  | LT-18053 |  | 44 to 54 Watt Street Light LED replacing 100 Watt Pulse Start Metal Halide |
|  |  | LT-39353 |  | 55 to 90 Watt Street Light LED replacing 150 Watt Pulse Start Metal Halide |
|  |  | LT-59292 |  | 55 to 90 Watt Street Light LED replacing 175 Watt Pulse Start Metal Halide |
|  |  | LT-35035 |  | 91 to 130 Watt Street Light LED replacing 250 Watt Pulse Start Metal Halide |
|  |  | LT-46736 |  | 131 to 190 Watt Street Light LED replacing 400 Watt Pulse Start Metal Halide |

Note: All MH lamp wattages <150W have always been PSMH since the arc tube legs are too small to accommodate a probe starter electrode. The wattage range of 175W through 400W has been available in PSMH for over a decade and most of those earlier probe start systems have been replaced. 150W is the lowest probe start MH wattage but the ballast is a 175W one (probe: M57).The lamp is made low in voltage (110V vs 132V for 175W) which causes the lamp to operate at 150W. (Source is Tom Harding Senior Lighting Engineer and a primary designer of PSMH, Venture Lighting (a Division of Advanced Lighting Technologies)).

Measures in this work paper are available for SCE only climate zones in all exterior applications. The calculation template [Attachment 1] only contains Residential – Multifamily and Office – Small building type which is the closest match to the previous building type Misc. Commercial. The 4,100 dusk-to-dawn operating hours is applicable to any exterior lighting application controlled by a photocell for any building type.

**Application Requirements**

1. All SCE Tariffs are allowed to receive incentives.
2. The LEDs must replace high pressure sodium (HPS) or pulse start metal halide (PSMH) high intensity discharge lighting.

**Application Recommendations**

1. For any of these LED replacements it is recommended the customer engage a qualified lighting contractor.
2. Customers installing dimmable LED on LS-3 are encouraged to voluntarily meet part load driver power factor (PF) performance and total harmonic distortion, current (THDi) performance. The voluntary performance limits are a minimum of 0.75 PF and a maximum 15% THDi over the full dimmable range of the LED fixture at its operating voltage.
3. The luminaire wattage ranges for this workpaper were developed from raw source LED’s of approximately 100 lumens per watt (85 lumens per watt average maintained).
4. LED fixtures on LS-1, LS-2, and LS-3 have no color temperature requirements. An LED color temperature range between 3000K and 5700K CCT is suggested because a national consensus and preference has developed for this range.
5. Fixture/enclosure type is recommended certified by NEMA/IEC as wet.
6. It is recommended the LED fixture including all of its electrical and mechanical components be designed for operation in an ambient temperature range of -40 deg C to +50 deg C for outdoor applications.
7. It is recommended that customers whose light fixtures may experience accelerated corrosion due to coastal salt air environments specify marine finish and stainless steel fittings and fitters.

**Program requirements and Preponderance of Evidence (POE) Documentation**

SCE17LG097 Revision 2 is intended solely for grandfathered AB-719 projects pursuant to the CPUC memo received by SCE on October 10, 2017. The CPUC memo notes that POE documentation is not required for grandfathered AB-719 projects.

## 1.2 Technical Description

The proposed measure cases, shown in table above are based on SCE Design & Engineering Services LED Assessment Studies conducted in conjunction with the SCE Street and Outdoor Lighting Organization (SOLO). Note: The measure case ranges are based on LED fixture system (light engine + driver) wattages.

## 1.3 Installation Types and Delivery Mechanisms

**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. |
| 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. |

The delivery methods available for these measures are:

* Financial Support / Down-Stream Incentive – Deemed
* Partnership/ Down-Stream Incentive – Deemed
* Partnership/ Direct Install
* Financial Support – Direct Install

## 1.4 Measure Parameters

### 1.4.1 DEER Data

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | No |
| DEER Version | N/A |
| 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 v2.4.7. The relevant NTG values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| Com-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Com | Any | Any | 0.60 |
| Res-Default>2 | All other EEM with no evaluated NTGR; existing EEM with same delivery mechanism for more than 2 years | Res | Any | Any | 0.55 |

**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 v2.4.7. 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 v2.4.7. 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. The EUL\_ID in the table below applies to both Office Small and Multi-family building types in this workpaper.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| OLtg-Com-LED-50000hr | LED Fixture - Outdoor- Commercial | Com | Lighting | N/A | 4 |

### 1.4.2 Codes and Standards Analysis

**Title 24:** The 2016 Title 24 [496] Outdoor Lighting Requirements are specified in Section 140.7. However, as specified in Section 140.7(a) Exception 3: public streets, roadways, highways and traffic signage lighting, and occurring in the public right-of-way are exempted. Thus, Title 24 does not apply to these measures.

Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 24 (2016) | Section 140.7 – Requirements for Outdoor Lighting | January 1, 2017 |

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

### 1.5.1 ET09.01 – LED Street Lighting

* Emerging Technology assessment, completed December 31, 2009
* Author - Teren Abear, Southern California Edison
* Market covered - Roadway lighting
* Techniques used - Computer modeling and field measurement
* Relevance - Qualification of LED street lights into the EE program

### 1.5.2 CSULB Parking Lot Demonstration

A six-hundred (600) fixture covered parking lot application at Long Beach State University installed in 2009 has demonstrated LED reliability and life showing only 2 fixture failures in over 45,000 continuous hours of operation. The two (2) fixtures that failed were improperly installed- a deluge of rainwater through cracks in the decking shorted them out. Regarding LED reliability Ed Ebrahimian, Director, Los Angeles Bureau of Street Lighting states (Forbes magazine 1 25 2013): “LED fixtures fail at a lesser rate than incumbent technologies. After 36 months of initial operation, for instance, high-intensity discharge (HID) fixtures in Los Angeles recorded an average annual failure rate of 10%; the average annual failure rate for LED cobra style fixtures, according to the latest figures, is 0.2% (189 of 98,000 installed)” It is further known that by mid-2014 LA had 144,000 cobra style LED installed. Of that Cree Lighting reported 187 LED failures among its 117,000 fixtures (0.16% failure rate).

## 1.6 Data Quality and Future Data Needs

N/A

# Section 2. Calculation Methodology

This measure is based on the replacement of HID lighting sourced fixtures with LED fixtures. Refer to the table below for base and measure fixture wattages.

Base & Measure Wattages

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Code** | **Measure Name** | **HID Source** | **Base (W)** | **Measure (W)** |
| LT-27419 | Up to 28 Watt Street Light LED replacing 50 Watt High Pressure Sodium | HPS | 66 | 28 |
| LT-73136 | 29 to 43 Watt Street Light LED replacing 70 Watt High Pressure Sodium | HPS | 95 | 43 |
| LT-80500 | 44 to 54 Watt Street Light LED replacing 100 Watt High Pressure Sodium | HPS | 138 | 54 |
| LT-24820 | 55 to 90 Watt Street Light LED replacing 150 Watt High Pressure Sodium | HPS | 188 | 90 |
| LT-78130 | 91 to 130 Watt Street Light LED replacing 200 Watt High Pressure Sodium | HPS | 250 | 130 |
| LT-35164 | 131 to 190 Watt Street Light LED replacing 250 Watt High Pressure Sodium | HPS | 295 | 190 |
| LT-61338 | 191 to 222 Watt Street Light LED replacing 310 Watt High Pressure Sodium | HPS | 365 | 222 |
| LT-81983 | 223 to 260 Watt Street Light LED replacing 400 Watt High Pressure Sodium | HPS | 465 | 260 |
| LT-94198 | 29 to 43 Watt Street Light LED replacing 70 Watt Pulse Start Metal Halide | PSMH | 95 | 28 |
| LT-18053 | 44 to 54 Watt Street Light LED replacing 100 Watt Pulse Start Metal Halide | PSMH | 128 | 54 |
| LT-39353 | 55 to 90 Watt Street Light LED replacing 150 Watt Pulse Start Metal Halide | PSMH | 190 | 90 |
| LT-59292 | 55 to 90 Watt Street Light LED replacing 175 Watt Pulse Start Metal Halide | PSMH | 215 | 90 |
| LT-35035 | 91 to 130 Watt Street Light LED replacing 250 Watt Pulse Start Metal Halide | PSMH | 295 | 130 |
| LT-46736 | 131 to 190 Watt Street Light LED replacing 400 Watt Pulse Start Metal Halide | PSMH | 458 | 190 |

The basis of this work paper is SCE lighting engineering experience and judgment, supported by experience, with computer modeling of LED designs, installations, operations, and controls [Attachment 2]. Since HPS and PSMH baselines are considered pre-existing baselines, the savings are only applicable for the RUL period only. The Second baseline is assumed to LED and the savings are assumed to be zero with zero life as well.

The LED wattages are developed based on lumen output of the base case technology [Attachment 3]. The LED wattage ranges are developed to approximate HID light levels +/-15% lumens. It develops an application approach based on engineering judgement and uses relative average raw source efficacies, typical and estimated fixture and light-to-target efficiencies to pick appropriate, comparable LED light, and wattages. Although photometric analysis is the more accurate methodology to determine appropriate LED replacements, this lumen matching approach conservatively calculates savings for these measures. The HOU was updated from 4,380 to 4,100 per the Exterior Lighting Disposition [Attachment 5].

The following example shows the annual electric kWh savings for the measure “LED Street Lighting up to 28 Watts replacing 50W HPS” (First Baseline only):





As this street lighting measures included in this work paper do not operate during DEER peak demand periods, the peak demand savings are assumed to be zero.

Per the October 10, 2017 memo from CPUC, only first baselines savings are allowed with 4 year first baseline life and since the second baseline is assumed to be LED the savings are calculated to be zero with zero life.

A complete list of savings for other measures in this work paper can be found in the attachment [Attachment 1].

# 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

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| Office - Small | Outdoor LT | Misc.\_Commercial |
| Residential Multi-family | Outdoor LT | Misc.\_Commercial |

# Section 4. Costs

Base and measure costs come from multiple sources all compiled in the attachment [Attachment 4]. Labor is assumed to be identical for both the base and measure costs.

## 4.1 Base Case Cost

Baseline material costs for pre-existing fixture technologies were acquired from various online retailers in December of 2016. Labor costs were found using the eGordian Construction Task Catalogue, which was competitively bid for use in Southern California. Also included in the labor costs are ancillary costs associated with streetlight installations, such as: traffic controls, demolition of existing fixtures and recycling of demolished materials. Since the second baseline case is considered to be LED, the costs are the same as the measure case. The table below shows base case costs. Details for the fixtures based on comparable HID to LED performance are attached [Attachment 4].

**Base Case Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure** | **Installation Type** | **Base Equipment Cost** | **Base Labor Cost** | **Total Base Cost** |
| LT-27419 | RET | $69.09 | $58.52 | $127.61 |
| LT-73136 | RET | $69.09 | $58.52 | $127.61 |
| LT-80500 | RET | $155.89 | $58.52 | $214.41 |
| LT-24820 | RET | $212.93 | $58.52 | $271.45 |
| LT-78130 | RET | $212.93 | $58.52 | $271.45 |
| LT-35164 | RET | $262.41 | $58.52 | $320.93 |
| LT-61338 | RET | $262.41 | $58.52 | $320.93 |
| LT-81983 | RET | $330.51 | $58.52 | $389.03 |
| LT-94198 | RET | $126.79 | $58.52 | $185.31 |
| LT-18053 | RET | $93.77 | $58.52 | $152.29 |
| LT-39353 | RET | $233.33 | $58.52 | $291.85 |
| LT-59292 | RET | $233.33 | $58.52 | $291.85 |
| LT-35035 | RET | $289.46 | $58.52 | $347.98 |
| LT-46736 | RET | $328.89 | $58.52 | $387.41 |

## 4.2 Measure Case Cost

Measure labor and material costs were updated based on the eGordian Construction Task Catalogue, which was competitively bid for use in Southern California. Also included in the labor costs are ancillary costs associated with streetlight installations, such as: traffic controls, demolition of existing fixtures and recycling of demolished materials. The table below shows material case costs.

**Measure Case Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure** | **Installation Type** | **Measure Equipment Cost** | **Measure Labor Cost** | **Total Measure Cost** |
| LT-27419 | RET | $257.64 | $58.52 | $316.16 |
| LT-73136 | RET | $337.01 | $58.52 | $395.53 |
| LT-80500 | RET | $349.76 | $58.52 | $408.28 |
| LT-24820 | RET | $413.54 | $58.52 | $472.06 |
| LT-78130 | RET | $521.58 | $58.52 | $580.10 |
| LT-35164 | RET | $724.19 | $58.52 | $782.71 |
| LT-61338 | RET | $1,004.61 | $58.52 | $1,063.13 |
| LT-81983 | RET | $1,115.13 | $58.52 | $1,173.65 |
| LT-94198 | RET | $337.01 | $58.52 | $395.53 |
| LT-18053 | RET | $349.76 | $58.52 | $408.28 |
| LT-39353 | RET | $413.54 | $58.52 | $472.06 |
| LT-59292 | RET | $413.54 | $58.52 | $472.06 |
| LT-35035 | RET | $521.58 | $58.52 | $580.10 |
| LT-46736 | RET | $724.19 | $58.52 | $782.71 |

## 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

The measure case and 2nd baseline are both LED fixtures; therefore, labor and material costs are the same and the incremental measure cost is $0.

**Full and Incremental Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure** | **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| LT-27419 | RET | $0 | $316.16 | $0 |
| LT-73136 | RET | $0 | $395.53 | $0 |
| LT-80500 | RET | $0 | $408.28 | $0 |
| LT-24820 | RET | $0 | $472.06 | $0 |
| LT-78130 | RET | $0 | $580.10 | $0 |
| LT-35164 | RET | $0 | $782.71 | $0 |
| LT-61338 | RET | $0 | $1,063.13 | $0 |
| LT-81983 | RET | $0 | $1,173.65 | $0 |
| LT-94198 | RET | $0 | $395.53 | $0 |
| LT-18053 | RET | $0 | $408.28 | $0 |
| LT-39353 | RET | $0 | $472.06 | $0 |
| LT-59292 | RET | $0 | $472.06 | $0 |
| LT-35035 | RET | $0 | $580.10 | $0 |
| LT-46736 | RET | $0 | $782.71 | $0 |

# Attachments

1. SCE17LG097.2 A1 Calculation Template\_Final

2. SCE17LG097.2 A2 Performance and Photometric Data.xls

3. SCE17LG097.2 A3 Estimated Fixture Wattages.xls

4. SCE17LG097.2 A4 Costs

5. SCE17LG097.2 Exterior Lighting Disposition.docx

6. SCE17LG097.2 A6 Street Lighting Memo - CPUC 101017

# References



[496]