Work Paper SCE13LG097

**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 |
| **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: 12 years |
| **Measure Installation Type** | Replace on Burnout (ROB) |
| **Net-to-Gross Ratio** | Com-Default>2yrs: 0.60 |
| **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 | 4/13/12 | John Rossi/EMCOR | * Updated to the 2013-2014 template. |
| 1 | 7/8/14 | Jack Melnyk/SCE | * Added new solution (Measure) Codes to expand LED wattage choices * The existing base HID and new measure LED fixtures are not limited by style but the costing (and, therefore incentive development) is based on HID and LED cobra styles * Adjusted annual operating hours from 4140 to 4100 per DEER * Trued baseline connected wattages to 2013 SPC Standard Fixture Watts values * Moved Application Requirements and Recommendations from References to paper body * Added NTG & IR values and codes to calc sheet * Added backup attachment as basis for LED measure ranges * Work paper updated for reporting period, effective 7/1/2014-12/31/2014 |
| 2 | 9/23/15 | Yun Han/SCE | * New WP template for 2016 program year * Misc. Commercial BT converted to Office – Small * Added Partnership – Downstream Deemed delivery method |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
| 2 | CS |  |  |  |  |

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 | N/A |

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 all SCE climate zones in all exterior applications. The calculation template [Attachment 1] only contains Office – Small building type which is the closest match to the previous building type Misc. Commercial, but the 4,380 dusk-to-dawn operating hours is applicable to any exterior lighting application in any building type.

**Application Requirements**

1. SCE tariff LS-1 is not covered by this workpaper. LS-1 includes company (SCE)-owned and maintained street lighting. Customers on LS-1 specify type of service, lamp size, and location of street lights.
2. Customer incentives may be developed for cobra style fixtures on SCE tariffs LS-2 and LS-3, which are addressed by this workpaper. On LS-2 and LS-3, the customer owns the street lighting equipment including, but not limited to the pole, mast arm, fixture and lamp, and all connecting cable in a street light system. Like LS-1, the customer specifies the type of service, lamp size (here LED fixture wattage), and location of street lights.
3. Customers on SCE Tariffs LS-2 and LS-3 should select *complete LED fixtures* from the Design Lights Consortium (DLC) Qualified List. LED retrofit kits *do not qualify for LS-2 or LS-3 service.*
4. To initiate an incentive application for LS-3 fixtures the customer must submit existing fixture and meter location maps showing , for each affected circuit, voltage, and fixture quantities, wattages, and sources.
5. Dimmable (or field tunable) LED fixtures cannot installed on the unmetered LS-2 tariff. Customers desiring dimmable (or field tunable) LED fixtures shall install them only on LS-3. On a per circuit basis, customers on the unmetered LS-2 do have the option to convert to the metered LS-3 after paying SCE meter installation costs (obtain from SOLO). “Dimmable” means step dimmable, continuously dimmable, or field tunable.
6. 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-2 and LS-3 have no color temperature requirements. An LED color temperature range of 4000K+/-350K 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.

## 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 |
| Replace on Burnout (ROB) | Above Code or Standard | N/A | EUL | N/A |

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.* |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| 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. |

The delivery methods available for these measures are:

* Financial Support / Down-Stream Incentive – Deemed
* Midstream Programs/Mid-Stream Incentive

The Midstream Lighting Program provides incentives on certain pre-approved energy-efficient products at the point of sale in order to decrease electricity consumption in SCE’s service territory.  SCE reimburses the distributor a pre-authorized incentive amount for each qualifying product sold to a qualifying purchaser for which the distributor has provided a point of sale discount in the amount of such incentive, subject to program requirements described in the midstream program agreement.  The distributor provides sales data including make & model to verify the wattage of the measures. An inspector will also visit the site where these measures were installed to verify the installation.

## 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. 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 |

**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.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| OLtg-Com-LED-50000hr | LED Fixture - Outdoor- Commercial | Com | Lighting | 12 | 4 |

### 1.4.2 Codes and Standards Analysis

**Title 24:** The 2013 Title 24 [355] Outdoor Lighting Requirements are specified in Section 147. However, as specified in Section 147 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 (2013) | Section 140.7 – Requirements for Outdoor Lighting | July 1, 2014 |

## 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
* 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]

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.

The following example shows the annual electric kWh savings for the measure “LED Street Lighting up to 28 Watts replacing 50W HPS”.





The following example shows the demand reduction estimates for the measure “LED Street Lighting up to 28 Watts replacing 50W HPS”.



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 |

# Section 4. Costs

Base and measure costs come from multiple sources all compiled in the attachment [Attachment 4].

## 4.1 Base Case Cost

Three lighting distributors provided base and measure reference costs for the measures defined in this work paper. Table below shows base case material 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 | ROB | $ 174.25 | $ 68.00 | $ 242.25 |
| LT-73136 | ROB | $ 174.25 | $ 68.00 | $ 242.25 |
| LT-80500 | ROB | $ 174.25 | $ 68.00 | $ 242.25 |
| LT-24820 | ROB | $ 174.25 | $ 68.00 | $ 242.25 |
| LT-78130 | ROB | $ 214.74 | $ 68.00 | $ 282.74 |
| LT-35164 | ROB | $ 225.67 | $ 68.00 | $ 293.67 |
| LT-61338 | ROB | $ 268.18 | $ 68.00 | $ 336.18 |
| LT-81983 | ROB | $ 343.04 | $ 68.00 | $ 411.04 |
| LT-94198 | ROB | $ 213.11 | $ 68.00 | $ 281.11 |
| LT-18053 | ROB | $ 213.11 | $ 68.00 | $ 281.11 |
| LT-39353 | ROB | $ 240.89 | $ 68.00 | $ 308.89 |
| LT-59292 | ROB | $ 233.77 | $ 68.00 | $ 301.77 |
| LT-35035 | ROB | $ 249.54 | $ 68.00 | $ 317.54 |
| LT-46736 | ROB | $ 342.44 | $ 68.00 | $ 410.44 |

## 4.2 Measure Case Cost

**Measure Case Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure** | **Installation Type** | **Measure Equipment Cost** | **Measure Labor Cost** | **Total Measure Cost** |
| LT-27419 | ROB | $361.53 | $68.00 | $429.53 |
| LT-73136 | ROB | $378.06 | $68.00 | $446.06 |
| LT-80500 | ROB | $411.44 | $68.00 | $479.44 |
| LT-24820 | ROB | $448.51 | $68.00 | $516.51 |
| LT-78130 | ROB | $505.93 | $68.00 | $573.93 |
| LT-35164 | ROB | $667.97 | $68.00 | $735.97 |
| LT-61338 | ROB | $814.73 | $68.00 | $882.73 |
| LT-81983 | ROB | $777.60 | $68.00 | $845.60 |
| LT-94198 | ROB | $324.72 | $68.00 | $392.72 |
| LT-18053 | ROB | $331.50 | $68.00 | $399.50 |
| LT-39353 | ROB | $332.53 | $68.00 | $400.53 |
| LT-59292 | ROB | $339.99 | $68.00 | $407.99 |
| LT-35035 | ROB | $496.70 | $68.00 | $564.70 |
| LT-46736 | ROB | $755.74 | $68.00 | $823.74 |

## 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** |
| ROB | (MEC + MLC) – (BEC + BLC) | (MEC + MLC) – (BEC + BLC) | N/A |

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** | |
| **1st Baseline** | **2nd Baseline** |
| LT-27419 | ROB | $ 187.28 | $ 187.28 | N/A |
| LT-73136 | ROB | $ 203.81 | $ 203.81 | N/A |
| LT-80500 | ROB | $ 237.19 | $ 237.19 | N/A |
| LT-24820 | ROB | $ 274.26 | $ 274.26 | N/A |
| LT-78130 | ROB | $ 291.19 | $ 291.19 | N/A |
| LT-35164 | ROB | $ 442.30 | $ 442.30 | N/A |
| LT-61338 | ROB | $ 546.55 | $ 546.55 | N/A |
| LT-81983 | ROB | $ 434.56 | $ 434.56 | N/A |
| LT-94198 | ROB | $ 111.61 | $ 111.61 | N/A |
| LT-18053 | ROB | $ 118.39 | $ 118.39 | N/A |
| LT-39353 | ROB | $ 91.64 | $ 91.64 | N/A |
| LT-59292 | ROB | $ 106.22 | $ 106.22 | N/A |
| LT-35035 | ROB | $ 247.16 | $ 247.16 | N/A |
| LT-46736 | ROB | $ 413.30 | $ 413.30 | N/A |

# Attachments

1.2.3.4.

# References



[355]