**Work Paper WPSDGENRLG0028**

**Revision 0**

**San Diego Gas & Electric**

**LED Pool and Spa Lighting**

### Core Measure Summary Table

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| General Measure Information | | | | | | | | PT | | 1st Baseline Period | | | | 2nd Baseline Period | | | | TOU |
| Measure Name | Measure RunID | Solution Code | CZ | Building Type | Load Shape | EUL | Unit Definition | Program Type (NEW, ROB, RET) | Applicable Code | Gross Unit Annual Electricity Savings (kWh/unit) | User Entered kW Savings per unit (kW/unit) | Gas Savings (Therms) | 1st Baseline Useful Life | kWh Saving per unit (kWh/unit) | kW Savings per unit (kW/unit) | Gas Savings (Therms) | 2nd Baseline Useful Life | % TOU |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | WPSC-Htl-w06-vNA-Ret-EM-LT-LED-45p8W-PoolLtDC-OHiEff-OutL-300WInc | LT-19365 | 06 | Lodging - Hotel | Outdoor Lt | 12.0 | Fixture | RET | No | 371.13 | 0.00 | 0.00 | 12.00 | N/A | N/A | N/A | N/A | 0.00 |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | WPSC-Htl-w08-vNA-Ret-EM-LT-LED-45p8W-PoolLtDC-OHiEff-OutL-300WInc | LT-19365 | 08 | Lodging - Hotel | Outdoor Lt | 12.0 | Fixture | RET | No | 371.13 | 0.00 | 0.00 | 12.00 | N/A | N/A | N/A | N/A | 0.00 |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | WPSC-Htl-w09-vNA-Ret-EM-LT-LED-45p8W-PoolLtDC-OHiEff-OutL-300WInc | LT-19365 | 09 | Lodging - Hotel | Outdoor Lt | 12.0 | Fixture | RET | No | 371.13 | 0.00 | 0.00 | 12.00 | N/A | N/A | N/A | N/A | 0.00 |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | WPSC-Htl-w10-vNA-Ret-EM-LT-LED-45p8W-PoolLtDC-OHiEff-OutL-300WInc | LT-19365 | 10 | Lodging - Hotel | Outdoor Lt | 12.0 | Fixture | RET | No | 371.13 | 0.00 | 0.00 | 12.00 | N/A | N/A | N/A | N/A | 0.00 |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | WPSC-Htl-w13-vNA-Ret-EM-LT-LED-45p8W-PoolLtDC-OHiEff-OutL-300WInc | LT-19365 | 07 | Lodging - Hotel | Outdoor Lt | 12.0 | Fixture | RET | No | 371.13 | 0.00 | 0.00 | 12.00 | N/A | N/A | N/A | N/A | 0.00 |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | WPSC-Htl-w14-vNA-Ret-EM-LT-LED-45p8W-PoolLtDC-OHiEff-OutL-300WInc | LT-19365 | 14 | Lodging - Hotel | Outdoor Lt | 12.0 | Fixture | RET | No | 371.13 | 0.00 | 0.00 | 12.00 | N/A | N/A | N/A | N/A | 0.00 |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | WPSC-Htl-w15-vNA-Ret-EM-LT-LED-45p8W-PoolLtDC-OHiEff-OutL-300WInc | LT-19365 | 15 | Lodging - Hotel | Outdoor Lt | 12.0 | Fixture | RET | No | 371.13 | 0.00 | 0.00 | 12.00 | N/A | N/A | N/A | N/A | 0.00 |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | WPSC-Htl-w16-vNA-Ret-EM-LT-LED-45p8W-PoolLtDC-OHiEff-OutL-300WInc | LT-19365 | 16 | Lodging - Hotel | Outdoor Lt | 12.0 | Fixture | RET | No | 371.13 | 0.00 | 0.00 | 12.00 | N/A | N/A | N/A | N/A | 0.00 |

Note: **For the complete list of Measures, refer to the attached calculation spreadsheet**

### Costing and NTG Summary Table

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| General Measure Information | | | | PT | | NTG | | | IR | 1st Baseline Period | 2nd Baseline Period | IMC | DIM |
| Measure Name | Solution Code | CZ | Unit Definition | Program Type (NEW, ROB, RET) | Applicable Code | NTG Non-Res. | NTG Res. | NTG Multi Family | NTG Non-Res. | Gross Measure Cost per unit | Gross Measure Cost per unit | Incremental Measure Cost per unit | Delivery & Incentive Method |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | LT-19365 | 6 | Fixture | RET | No | 0.85 | 0.85 | 0.85 | 1.00 | From Program | $0.00 | $309.50 | Financial Support / Direct Install |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | LT-19365 | 8 | Fixture | RET | No | 0.85 | 0.85 | 0.85 | 1.00 | From Program | $0.00 | $332.98 | Financial Support / Direct Install |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | LT-19365 | 9 | Fixture | RET | No | 0.85 | 0.85 | 0.85 | 1.00 | From Program | $0.00 | $342.59 | Financial Support / Direct Install |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | LT-19365 | 10 | Fixture | RET | No | 0.85 | 0.85 | 0.85 | 1.00 | From Program | $0.00 | $321.60 | Financial Support / Direct Install |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | LT-19365 | 7 | Fixture | RET | No | 0.85 | 0.85 | 0.85 | 1.00 | From Program | $0.00 | $318.04 | Financial Support / Direct Install |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | LT-19365 | 14 | Fixture | RET | No | 0.85 | 0.85 | 0.85 | 1.00 | From Program | $0.00 | $312.70 | Financial Support / Direct Install |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | LT-19365 | 15 | Fixture | RET | No | 0.85 | 0.85 | 0.85 | 1.00 | From Program | $0.00 | $332.98 | Financial Support / Direct Install |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | LT-19365 | 16 | Fixture | RET | No | 0.85 | 0.85 | 0.85 | 1.00 | From Program | $0.00 | $351.13 | Financial Support / Direct Install |

Note: **For the complete list of Measures, refer to the attached calculation spreadsheet**

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision # | MM/DD/YY | Author/Affiliation | Summary of Changes |
| 0 | 04/05/12 | Yun Han/SCE | * Original WP from WPSCRELG0071.1 * Updated to new WP template v0.1 w/v2.2 worksheet * Added Article 680 reference * Updated Residential operating hours to 48 and Dusk to Dawn to 4100 * Changed Mobile Home savings to Single Family savings * Updated with 2011 NTG values |
| 1 | 3/29/13 | Charles Harmstead /SDGE | * Adopted SCE workpaper SCE13LG071, Revision 0 with no changes |

# Section 1. General Measure & Baseline Data

## 1.1 Measure & Delivery Description

### 1.1a Measure Description

This work paper details the replacement of incandescent pool lamps with LED pool lighting in commercial and residential swimming pools and spas. The pool and spa lighting fixtures addressed in this work paper refers to the underwater pool lighting used to provide safety and aesthetics to the area.

The data used in this work paper are from SCE’s Emerging Technology study conducted in 2010 (ET10SCE1130) [[[1]](#endnote-1)]. The energy savings in this work paper include baseline incandescent wattages ranging from 300 to 500 Watts.

Table 1 lists the measures included in this work paper.

Table 1 Measure Names

|  |  |
| --- | --- |
| Product Code | Measure name |
|  | 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent |
|  | 45.8 Watt Pool Light (Dusk to Dawn) LED replacing 300 Watt Incandescent |
|  | 45.8 Watt Pool Light (Res) LED replacing 300 Watt Incandescent |
|  | 52.4 Watt Pool Light (Dusk to Close) LED replacing 400 Watt Incandescent |
|  | 52.4 Watt Pool Light (Dusk to Dawn) LED replacing 400 Watt Incandescent |
|  | 52.4 Watt Pool Light (Res) LED replacing 400 Watt Incandescent |
|  | 67.4 Watt Pool Light (Dusk to Close) LED replacing 500 Watt Incandescent |
|  | 67.4 Watt Pool Light (Dusk to Dawn) LED replacing 500 Watt Incandescent |
|  | 67.4 Watt Pool Light (Res) LED replacing 500 Watt Incandescent |

### 1.1b Delivery and Incentive Mechanism

The delivery methods are Financial Support – Down-Stream Incentive – Deemed and Financial Support – Direct Install. The install type is Replace on Burnout (ROB) and Retrofit (RET).

ROB measures replace existing equipment with more energy efficient equipment on failure of the existing equipment. ROB is also a blanket install type applied to certain types of technologies that are typically held long past their effective useful lives such as appliances and large process equipment.

RET programs replace existing equipment that is working and has remaining useful life (RUL) with new, energy efficient equipment. RET can also apply to situations where the customer would have not taken action to replace their current inefficient equipment without program involvement such as direct install program measures.

RET measures have two savings periods, one for the RUL period of the existing equipment noted as the first baseline period and one for the EUL-RUL of the new equipment noted as the second baseline period.

### 1.1c Measure Requirements

Use of LED pool lighting does not preclude user’s responsibility for compliance with all code requirements and lighting performance recommendations where applicable to pool lighting applications. Illuminating Engineering Society Handbook 9th edition recommends luminance of the pool surface from underwater lights differentiated by 4 different classes of pools. The IES Handbook also states “As a general rule, unit power density (UPD) required for underwater lights varies between 5 to 30 watts per square meter (0.5 to 3 watts per square foot) of water surface depending on the class of facility and efficacy of light sources.” IES recommendations refer to incandescent lighting.

For LED pool lights that match the color temperature of the incandescent, it must meet the minimum light levels of the incandescent lamps as shown in Table 2.

Table 2 LED Minimum Lumens at 3000K Color Temperature

|  |  |
| --- | --- |
| **Incandescent Lamp Replaced** | **LED Minimum Lumens** |
| 300W | 2,092 |
| 400W | 3,201 |
| 500W | 4,573 |

Study from ET10SCE1130 [A] has shown that LEDs with cooler color temperatures exhibit higher illumination levels from fewer lumens. This is due to the blue light traveling farther in water as it acts as a “blue filter”. Table 3 shows the minimum lumen output for LED pool lights above 6000K.

Table 3 LED Minimum Lumens at ~6000K Color Temperature

|  |  |
| --- | --- |
| **Watts** | **Lumens** |
| 300W Replacement | 2,000 |
| 400W Replacement | 2,732 |
| 500W Replacement | 3,039 |

## 1.2 DEER Differences Analysis

This specific measure is not included in DEER 2011, DEER 2008 V2.05 [49], DEER 2005 [26], and does not contain any similar measures or base cases.

Table 4 DEER Difference Summary

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Modified DEER Methodology | No |
| Scaled DEER Measure | No |
| DEER Building Prototypes Used | No |
| Deviation from DEER | DEER does not contain this measure |
| DEER Version | N/A |
| DEER Run ID and Measure Name (Sample) | N/A |

## 1.3 Code Analysis

There are no applicable codes in Title 20 [277] and Title 24 [208]. California Electrical Code Article 680 contains restrictive installation and equipment requirements necessary to prevent severe shock to human bodies around swimming pools, spas, hot tubs, and fountains.

Table 5 Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 24 (2008) | N/A | N/A |
| Title 20 (2010) | N/A | N/A |
| T24 California Electrical Code | Article 680 | August 18, 2005 |

## 1.4 Measure Effective Useful Life

DEER11 documentation provides EUL and RUL information to be used for the 13-14 program cycle on [www.deeresources.com](http://www.deeresources.com). The DEER documentation “Summary of EUL-RUL Analysis for the April 2008 Update to DEER” provides the RUL value as a flat 1/3 of the EUL value. The RUL value will only be applied to the first baseline period for retrofit measures that have applicable code that will affect the energy savings. In all other installation types and retrofit with no applicable code that affects the energy savings, the RUL is not applicable to either the first or second baseline period.

To obtain the EUL value the DEER08 documentation, EUL\_Summary\_10-1-08.xls [213], was consulted. Table 6 below identifies the value/methodology used for the measures in this work paper. Per The maximum EUL that can be claimed is 16 years for Residential and 12 years for Non-Residential, based on a 20,000 hour LED lamp life.

This work paper uses DEER EUL\_ID Oltg-LED.

Table 6 DEER08 EUL Value/Methodology

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Market | Enduse | Measure | EUL (Years) | RUL (Years) |
| Non-Residential | Lighting | LED Pool Lighting (Dusk to Dawn) | 4.89 | N/A |
| Non-Residential | Lighting | LED Pool Lighting (Dusk to Close) | 12 | N/A |
| Residential | Lighting | LED Pool Lighting (Residential) | 16 | N/A |

## 1.5 Net-to-Gross Ratios for Different Program Strategies

The NTG value was obtained from the “DEER2011\_NTGR\_2012-05-16.xls” on the DEER website as required by Version 4 of the California Public Utilities Commission (CPUC) Energy Efficiency Policy Manual [132]. The relevant NTGR for this measure is shown in

Table 7 below.

Table 7 Net-to-Gross Ratio

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NTGR\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID | NTG\* |
| ET-Default | Emerging Technologies approved by ED through work paper review | All | Any | All | 0.85 |

\*Denotes that the column is taken from the DEER NTG Table.

The installation rate (IR) is identified in the calculation attachment. This value is obtained from a spreadsheet created by the DEER team titled ““GrossSavingsAdjustments.xlsx”. The installation rate varies by end use, sector, technology, application, and delivery method.

## Spillage rate will also be applied to measures however the values will not be tracked in the work papers. The spillage rate will be tracked in an external table to be supplied to the Energy Division.

## 1.6 Time-of-Use Adjustment Factor

As directed by the CPUC in decision 06-06-063 dated June 29, 2006, time-of-use (TOU) adjustment factors are to be applied for residential A/C and commercial A/C (packaged and split-system direct-expansion cooling) measures only. Since this is not an A/C measure, the TOU adjustment factor is 0. Additionally, if a measure is assigned a DEER08 load shape, i.e. the load shape starts with “DEER:” the TOU assigned to that measure should also be zero. Table 8 indicates that the specific measure for this work paper is not an A/C measure.

Table 8 TOU Summary Table

|  |  |
| --- | --- |
| Measure | % |
| LED Pool Lighting (Dusk to Dawn) | 0 |
| LED Pool Lighting (Dusk to Close) | 0 |
| LED Pool Lighting (Residential) | 0 |

# Section 2. Energy Savings & Demand Reduction Calculations

The LED pool lamps replace incandescent lamps ranging from 300-500 Watts for pools and spas. The measure case wattages, listed in Table 9, were determined by tests conducted in the field with various wattages for the ET10SCE1130 study. Spa lights use the same wattage as the pool lights. Therefore, energy savings from pool lights will be used for spas.

Table 9 Base and Measure Wattages

|  |  |  |
| --- | --- | --- |
|  | **Basecase – Incandescent Watts (W)** | **Measure - LED Watts (W)** |
| LED Pool Lights Replacing 300W | 300 | 45.8 |
| LED Pool Lights Replacing 400W | 400 | 52.4 |
| LED Pool Lights Replacing 500W | 500 | 67.4 |

For non-residential applications, the pool lights either operate 4 hours/day for dusk to close operation or 4100 hours/year for dusk to dawn operation.

Equation 1 illustrates the methodology used to calculate annual energy savings. Equation 2 shows a 45.8W LED pool light replacing a 300W incandescent operating 12 hours/day (dusk to dawn).

Equation 1



Equation 2



For residential applications, the pool lights are used 48 hours/year. Equation 3 shows a 45.8W LED pool light replacing a 300W incandescent in a residential pool.

Equation 3



The demand reduction for exterior installations is zero as they have a Peak Coincidence Factor of 0 [21].

Table 10 lists the energy savings and demand reduction for LED Pool lights. The calculations can be found in Attachment 2 [[[2]](#endnote-2)]. Full list of savings can be found in Attachment 1 [[[3]](#endnote-3)].

Table 10 Energy Savings and Demand Reduction

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Measure (kW)** | **Base Case (kW)** | **Delta Watts (kW)** | **Energy Savings (kWh)** | **Peak Demand Reduction (kW)** |
| 45.8 Watt Pool Light (Dusk to Close) LED replacing 300 Watt Incandescent | 0.300 | 0.046 | 0.254 | 371.13 | 0 |
| 45.8 Watt Pool Light (Dusk to Dawn) LED replacing 300 Watt Incandescent | 0.300 | 0.046 | 0.254 | 1042.22 | 0 |
| 45.8 Watt Pool Light (Res) LED replacing 300 Watt Incandescent | 0.300 | 0.046 | 0.254 | 12.20 | 0 |
| 52.4 Watt Pool Light (Dusk to Close) LED replacing 400 Watt Incandescent | 0.400 | 0.052 | 0.348 | 507.50 | 0 |
| 52.4 Watt Pool Light (Dusk to Dawn) LED replacing 400 Watt Incandescent | 0.400 | 0.052 | 0.348 | 1425.16 | 0 |
| 52.4 Watt Pool Light (Res) LED replacing 400 Watt Incandescent | 0.400 | 0.052 | 0.348 | 16.68 | 0 |
| 67.4 Watt Pool Light (Dusk to Close) LED replacing 500 Watt Incandescent | 0.500 | 0.067 | 0.433 | 631.60 | 0 |
| 67.4 Watt Pool Light (Dusk to Dawn) LED replacing 500 Watt Incandescent | 0.500 | 0.067 | 0.433 | 1773.66 | 0 |
| 67.4 Watt Pool Light (Res) LED replacing 500 Watt Incandescent | 0.500 | 0.067 | 0.433 | 20.76 | 0 |

# Section 3. Load Shapes

The difference between the base case load shape and the measure load shape would be the most appropriate load shape; however, only end-use profiles are available. Therefore, the closest load shape chosen for this measure is the Outdoor LT load shape. See Table 11 for a list of all Building Types and Load Shapes. See the KEMA report [31] for a more thorough discussion regarding the load shapes for this measure. The closest load shape chosen

Table 11 Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| Building Type | E3 Alt. Building Type | Load Shape |
| Lodging - Hotel | Misc.\_Commercial | Outdoor Lt |
| Lodging - Motel | Misc.\_Commercial | Outdoor Lt |
| Misc - Commercial | Misc.\_Commercial | Outdoor Lt |
| Residential Multi-family | Misc.\_Commercial | Outdoor Lt |
| Residential Mobile Home - Double-Wide | Misc.\_Commercial | Outdoor Lt |
| Residential Single Family | Misc.\_Commercial | Outdoor Lt |

# Section 4. Base Case & Measure Costs

Direct Install measures use program tracking systems for measure costs. SCE directly utilizes one or more contractors as part of the program. The actual cost can vary by contractor, the date in which the work occurred, and by the volume of business. Contractor costs are confidential information and are based upon contractually agreed upon pricing as established in their purchase order with SCE; therefore, the SCE program tracking system is the only source for this data.

All costs in this section are factored by a climate zone multiplier. All costs with climate zone multiplier applied to equipment and labor can be found in the Attachment 1 [C]. The costs of base and measure technology including labor were taken from ET10SCE1130 study and shown in Attachment 2 [B].

## 4.1 Base Case Cost

**ROB**

For this measure category, the base case cost is to be used to calculate the incremental measure cost. Base case cost shown in

Table 12 is the same for all wattages.

Table 12 Base Case Cost

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Fixture w/ Lamp** | **Labor/hr** | **Total** |
| 300, 400, 500W Incandescent | $213.51 | $65.00 | $278.51 |

## 4.2 Gross Measure Cost

**ROB**

The Gross Measure Cost is the cost to install an energy efficient measure per the E3. For ROB measures, it means the cost premium required to install the energy efficient measure over a less efficient piece of equipment.

For **ROB**, GMC is represented by the equation below:

GMC = (Measure Equipment Cost + Measure Labor Cost) –

(Base Case Equipment Cost + Base Case Labor Cost)

\*Note: Unless stated otherwise the measure case labor and base case labor are assumed to be the same value reducing the equation to the following:

*GMC = Measure Equipment Cost – Base Case Equipment Cost*

Table 13 ROB Gross Measure Cost

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Base Case Cost** | **Measure Cost** | **Gross Measure Cost** |
| LED Pool Light Replacing 300W | $278.51 | $634.26 | $355.75 |
| LED Pool Light Replacing 400W | $278.51 | $690.00 | $411.49 |
| LED Pool Light Replacing 500W | $278.51 | $690.00 | $411.49 |

## 4.3 Incremental Measure Cost

**ROB**

Incremental Measure Cost (IMC) is the premium cost to install an energy efficient measure over a standard efficiency measure or code baseline measure. The incremental cost is only used to help determine program incentives and is not affected by the first and second baseline periods and may differ from the cost used for reporting.

For Retrofit measures, IMC is represented by the equation below and shown in Table 14.

*IMC = Measure Equipment Cost – Base Case Equipment Cost*

Table 14 ROB Incremental Measure Cost

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Base Case Cost** | **Measure Cost** | **Incremental Cost** |
| LED Pool Light Replacing 300W | $278.51 | $634.26 | $355.75 |
| LED Pool Light Replacing 400W | $278.51 | $690.00 | $411.49 |
| LED Pool Light Replacing 500W | $278.51 | $690.00 | $411.49 |

# Attachments

1. 2. 

# References



[21]

[26]

[31]

[49]

[132]

[187]

[208]

[213]

[276]

1. Emerging Technology Assessment Project - ET10SCE1130 – Commercial LED Pool Lamps [↑](#endnote-ref-1)
2. Attachment 2 – LG071.0 Calcs.xlsx [↑](#endnote-ref-2)
3. Attachment 1 – Calculation Template v0.1.xlsm [↑](#endnote-ref-3)