Short Form Work Paper WPSDGENRLG0028

**Revision 1**

**San Diego Gas & Electric**

**Energy Efficiency Engineering**

**LED Pool and Spa Lighting**

**October 12, 2017**

# SDG&E LED Pool and Spa Lighting

## Introduction

This short form workpaper (WP) documents the values adopted from SCE’s WP entitled “LED Pool and Spa Lighting” (SCE17LG071.0 - LED Pool and Spa Lighting\_Final\_Revised\_2\_3\_17.docx). SDG&E adopts all the values in SCE17LG071.0 - LED Pool and Spa Lighting\_Final\_Revised\_2\_3\_17, with the following exception:

1. SDG&E will only reference Replace on Burn-out(ROB) installation type
2. SCE have implementations for lamp and fixture replacements. Fixtures are referred to “light” in their documentation. To provide better clarity, SDG&E will change “light” to “fixture” in their implementation descriptions.

## Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **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 |
| 2 | 10/12/17 | Kelvin Valenzuela/SDGE | Adopted SCE workpaper SCE17LG071, Revision 0, only referencing Replace On-Burnout (ROB) impacts. Changed “light” to “fixture” to help distinguish from “lamp” implementation IDs. |

## Measure Summary

Table : Measure Summary Table

| **Section** | **Value** |
| --- | --- |
| **Summary & Purpose** | This short form workpaper documents ex-ante load impacts and cost-effectiveness values for LED Pool and Spa Lighting. The base energy consumption and measure energy consumption values are from SCE’s workpaper, SCE17LG071, Revision 0.  SCE’s workpaper details the replacement of incandescent pool lamps or luminaires with LED pool lighting in commercial and residential swimming pools and spas. Individual measure codes refer to either full luminaire replacements, or just lamp replacements. 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 workpaper are from SCE’s Emerging Technology study conducted in 2010, ET10SCE1130 [A] unless noted otherwise. The energy savings in this workpaper included baseline incandescent wattages ranging from 100 to 500 Watts. |
| **1.1 Measure & Baseline Data** | Measure:  464011 – 15.5 Watt Pool Fixture (Dusk to Close) LED replacing 100 Watt Incandescent  464012 - 15.5 Watt Pool Fixture (Dusk to Dawn) LED replacing 100 Watt Incandescent  464001 - 15.5 Watt Pool Fixture (Res) LED replacing 100 Watt Incandescent  464002 - 15.5 Watt Spa Fixture (Res) LED replacing 100 Watt Incandescent  464013 - 45.8 Watt Pool Fixture (Dusk to Close) LED replacing 300 Watt Incandescent  464014 - 45.8 Watt Pool Fixture (Dusk to Dawn) LED replacing 300 Watt Incandescent  464003 - 45.8 Watt Pool Fixture (Res) LED replacing 300 Watt Incandescent  464004 - 45.8 Watt Spa Fixture (Res) LED replacing 300 Watt Incandescent  464015 - 52.4 Watt Pool Fixture (Dusk to Close) LED replacing 400 Watt Incandescent  464016 - 52.4 Watt Pool Fixture (Dusk to Dawn) LED replacing 400 Watt Incandescent  464005 - 52.4 Watt Pool Fixture (Res) LED replacing 400 Watt Incandescent  464006 - 52.4 Watt Spa Fixture (Res) LED replacing 400 Watt Incandescent  464017 - 67.4 Watt Pool Fixture (Dusk to Close) LED replacing 500 Watt Incandescent  464018 - 67.4 Watt Pool Fixture (Dusk to Dawn) LED replacing 500 Watt Incandescent  464007 - 67.4 Watt Pool Fixture (Res) LED replacing 500 Watt Incandescent  464008 - 67.4 Watt Spa Fixture (Res) LED replacing 500 Watt Incandescent  463999 - 15.5 Watt Pool Lamp (Res) LED replacing 100 Watt Incandescent  464020 - 15.5 Watt Pool Lamp (Dusk to Dawn) LED replacing 100 Watt Incandescent  464000 - 15.5 Watt Spa Lamp (Res) LED replacing 100 Watt Incandescent  464019 - 15.5 Watt Pool Lamp (Dusk to Close) LED replacing 100 Watt Incandescent  464021 - 45.8 Watt Pool Lamp (Dusk to Close) LED replacing 300 Watt Incandescent  464022 - 45.8 Watt Pool Lamp (Dusk to Dawn) LED replacing 300 Watt Incandescent  463805 - 45.8 Watt Pool Lamp (Res) LED replacing 300 Watt Incandescent  463806 - 45.8 Watt Spa Lamp (Res) LED replacing 300 Watt Incandescent  464023 - 52.4 Watt Pool Lamp (Dusk to Close) LED replacing 400 Watt Incandescent  463807 - 52.4 Watt Spa Lamp (Res) LED replacing 400 Watt Incandescent  463808 - 52.4 Watt Pool Lamp (Res) LED replacing 400 Watt Incandescent  464024 - 52.4 Watt Pool Lamp (Dusk to Dawn) LED replacing 400 Watt Incandescent  464025 - 67.4 Watt Pool Lamp (Dusk to Close) LED replacing 500 Watt Incandescent  464010 - 67.4 Watt Spa Lamp (Res) LED replacing 500 Watt Incandescent  464026 - 67.4 Watt Pool Lamp (Dusk to Dawn) LED replacing 500 Watt Incandescent  464009 - 67.4 Watt Pool Lamp (Res) LED replacing 500 Watt Incandescent |
| **1.2 Technical Description** | Per ET10SCE1130 study [A], “A Light Emitting Diode (LED) pool lamp is an underwater lighting luminaire used to illuminate swimming pools for safety, security, and aesthetics. The LED replaces the incandescent pool lamp traditionally screwed into an airtight fixture that submerges under water. It comes in two different variations: as a fixture replacement and as a screw-in replacement. The fixture replacement requires an entire fixture replacement along with the wiring that runs through an underground conduit, while the screw-in replacement only replaces the incandescent lamp with an LED lamp within the same/existing fixture.”  “Whether LED or incandescent, the LED pool lamp works by cooling itself with water. The fixture fits inside a niche that is typically three feet below the water level. Although screwed into the niche with one screw, the fixture has holes around the face to let water pass through.”  “A LED is a semiconductor completely covered in epoxy. It emits light when there is a proper amount of current in the LED. Often used as indicator lights, the small, low-output LED is a mature technology. However, advances in LED technology have made them brighter and more efficient, thereby expanding the application of LEDs to other markets. The operation of the LED pool lamp is the same as that of the incandescent pool lamp from the perspective of the end-user”. |
| Measures | See Requirements |
| Code for All Measures | There are no applicable codes in Title 24 Building Energy Efficiency Standards [496]. Title 20 [422] contains an applicable code that requires a minimum average lamp efficacy of incandescent reflector lamps. California Electrical Code [461] Article 680 contains restrictive installation and equipment requirements necessary to prevent severe shock to human bodies around swimming pools, spas, hot tubs, and fountains.   |  |  |  | | --- | --- | --- | | **Code** | **Reference** | **Effective Dates** | | Title 20 (2015) | Section 1605.3(k)1 Table K-9 | July 1, 2015 | | T24 California Electrical Code | Article 680 | January 1, 2014 | |
| 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 the table below. This information can also be found in Table 5 of the ET report [A].  **LED Minimum Lumens at 3000K Color Temperature**   |  |  | | --- | --- | | **Incandescent Lamp Replaced** | **LED Minimum Lumens** | | 100W\* | 475 | | 300W | 2,092 | | 400W | 3,201 | | 500W | 4,573 |   **\*100W lumens was calculated based on 300-500W lamps [Attachment 2]**  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”. The table below shows the minimum lumen output for LED pool lights above 6000K. This information can also be found in Table 5 of the ET report.  **LED Minimum Lumens at >6000K Color Temperature**   |  |  | | --- | --- | | Watts | Lumens | | 100W Replacement\* | 475 | | 300W Replacement | 2,000 | | 400W Replacement | 2,732 | | 500W Replacement | 3,039 |   **\*100W replacement lumens was calculated**  **based on screw-in 300W replacement [Attachment 2]**  A separate document was created to address the minimum qualifying criteria for LED pool/spa lights which is a recommended minimal requirement, but not currently required. Therefore, data from ET10SCE1130 study [A] is used for this work paper. |
| **1.3 Installation Type and Delivery Mechanisms** |  |
| Installation Type | Replace on Burn-out (ROB) |
| Delivery Mechanisms | Downstream Rebate – Deemed  Direct Install |
| **1.4.1 DEER Data** |  |
| Net-to-Gross Ratio | Res-Default-HTR-di Com-Default-HTR-di  Res-Default>2yrs  Com-Default>2yrs |
| Effective and Remaining Useful Life | OLtg-Res-LED-20000hr  OLtg-Com-LED-50000hr |
| **Section 2. Calculation Methodology** | DEER Operating hours were referenced for Commercial Applications. Hours in the residential space referenced SCE’s ET study.  Measure Description - LED Pool Luminaire, LED Spa Luminaire, LED Pool Lamp, or LED Spa Lamp  Base Case Description - Incandescent Pool Luminaire, Incandescent Pool Lamp, Incandescent Spa Luminaire, or Incandescent Spa Lamp |
| Energy Savings/Peak Demand Reduction – All Measures | The LED pool lamps or luminaires replace incandescent lamps or luminaires ranging from 100-500 Watts for pools and spas. The wattages, listed in the table below, were determined by tests conducted in the field with various wattages for the ET10SCE1130 study [A, Table 5]. The wattage of the 300W equivalent LED was determined from an average of 2 different LED pool lights. Spa lights use the same wattages as the pool lights. Base case and measures wattages are the same for both lamps and luminaires.  **Base and Measure Wattages**   |  |  |  | | --- | --- | --- | | **Measures** | **Basecase – Incandescent Watts (W)** | **Measure - LED Watts (W)** | | LED Pool Lights Replacing 100W\* | 100 | 15.5 | | LED Pool Lights Replacing 300W | 300 | 45.8 | | LED Pool Lights Replacing 400W | 400 | 52.4 | | LED Pool Lights Replacing 500W | 500 | 67.4 |   \*Information from pool light manufacturers  For non-residential applications, the pool lights either operate 4 hours/day for dusk to close operation (1460 hrs/year) or 4380 hours/year for dusk to dawn operation. The dusk to close and dusk to dawn operation data was logged from the ET10SCE1130 study [A]. Although dusk to dawn was logged at 13 hours, DEER-defined 4380 hours was used for energy savings calculations.  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 and spa lights are used 66 hours/year based on the Emerging Technology - Market Behavior Study (ET11SCE4050) that surveyed 189 customers on how long they operate their pools/spas at home [B]. Therefore, pool and spa savings for residential applications will have different operating hours. 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.  The table below lists the energy savings and demand reduction for LED Pool lights.  **Table 10 Energy Savings and Demand Reduction**   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Measures** | **Base Case (kW)** | **Measure (kW)** | **Delta Watts (kW)** | **Energy Savings (kWh)** | **Peak Demand Reduction (kW)** | | 45.8 Watt Pool Fixture (Dusk to Close) LED replacing 300 Watt Incandescent | 0.300 | 0.046 | 0.254 | 371.13 | 0 | | 52.4 Watt Pool Fixture (Dusk to Close) LED replacing 400 Watt Incandescent | 0.400 | 0.052 | 0.348 | 507.50 | 0 | | 67.4 Watt Pool Fixture (Dusk to Close) LED replacing 500 Watt Incandescent | 0.500 | 0.067 | 0.433 | 631.60 | 0 | | 15.5 Watt Pool Fixture (Dusk to Close) LED replacing 100 Watt Incandescent | 0.100 | 0.0155 | 0.085 | 123.37 | 0 | |
| **Section 3. Load Shapes** | SDGE:03-BCR-BothResidentialandCommercial-LIT\_EXT WinterOnly |
| **Section 4. Costs** |  |
| **Section 4.1 Base and Measure Costs** |  |
| Base Cost | See ex ante tables |
| Measure Cost | See ex ante tables |