**Work Paper PGECOLTG158**

**Exterior Induction Fixtures**

**Revision 5**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Exterior Induction Fixtures**

**Measure Codes L0262, L0263, L0264, L0265, L0267**

# At-a-Glance Summary

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Applicable Measure Codes:** | **L0262** | | **L0263** | | **L0264** | **L0265** | **L0267** |
| **Measure Description:** | Exterior Induction Fixtures. | | | | | | |
| **Energy Impact Common Units:** | Per Fixture | | | | | | |
| **Base Case Description:** | Incandescent or HID fixtures including mercury vapor, high pressure sodium, and standard metal halide or pulse start metal halide | | | | | | |
| **Base Case Energy Consumption:** | Source: PG&E Calculations. | | | | | | |
| **Measure Energy Consumption:** | Source: PG&E Calculations. | | | | | | |
| **Energy Savings**  **(Base Case – Measure):** | Source: PG&E Calculations. | | | | | | |
| **Costs Common Units:** | $ per fixture | | | | | | |
| **Base Case Equipment Cost ($/unit):** | Varies | Varies | | Varies | | Varies | Varies |
| **Measure Equipment Cost ($/unit):** | Varies | Varies | | Varies | | Varies | Varies |
| **Full Measure Cost ($/unit)** | Varies | Varies | | Varies | | Varies | Varies |
| **Measure Incremental Cost ($/unit):** | Varies | Varies | | Varies | | Varies | Varies |
| **Effective Useful Life (years):** | 15 years, OLtg-HID  Source: DEER 2016 | | | | | | |
| **Measure Application Type:** | ROB | | | | | | |
| **Net-to-Gross Ratios:** | NTG = 0.60 Com-Default>2yrs  Source: DEER 2016 | | | | | | |
| **Important Comments:** |  | | | | | | |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision #** | **Revision Date** | **Section-by-Section Description of Revisions** | **Author (Company)** |
| Revision 2 | 1/21/2010 | Exterior Induction Fixtures PGECOLTG158 R2.doc (R2 is the original work paper) | Judith Jennings, PG&E |
| Revision 3 | 5/29/12 | PGECOLTG158 R3 Exterior Induction Fixtures.doc Updated to DEER 2011 values and NTG. | Tim Conroy, PG&E |
| Revision 3 | 8/29/12 | For Building type changed OTR to ANY, For Vintage AV is changed to ANY and For Climate Zone All is changed to ANY (Since this measure is for Exterior Lighting) | Alina Zohrabian (PG&E) |
| Revision 4 | 5/13/14 | Updated base case wattages per November 2013 ED Disposition. Added DI values from (PGE3PLTG190) and applied the 2014 IE and Hours from DEER (posted 2/20/14). For updated savings values, see file PGECOLTG158 R4.xlsx.  Updated labor costs with 2014 RS Means Building Construction Cost Data. | Jia Huang (PG&E)  Tai Voong (PG&E) |
| Revision 5 | 1/1/2016 | Updated Title 24 and Title 20 information. Updated base case costs and measure costs from SCE Exterior Induction Work Paper. | Linda Wan (PG&E)/Alina Zohrabian (PG&E)/Tai Voong (PG&E) |

# Table of Contents

[At-a-Glance Summary ii](#_Toc438561225)

[Document Revision History iii](#_Toc438561226)

[Table of Contents iv](#_Toc438561227)

[List of Tables iv](#_Toc438561228)

[Section 1. General Measure & Baseline Data 1](#_Toc438561229)

[1.1 Product Measure Description & Background 1](#_Toc438561230)

[1.3 Measure Application Type 3](#_Toc438561231)

[1.4 Product Base Case and Measure Case Data 4](#_Toc438561232)

[1.4.1 DEER Base Case and Measure Case Information 4](#_Toc438561233)

[1.4.2 Codes & Standards Requirements Base Case and Measure Information 5](#_Toc438561234)

[1.4.3 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information 6](#_Toc438561235)

[1.4.4 Assumptions and Calculations from other sources—Base and Measure Cases 6](#_Toc438561236)

[Section 2. Calculation Methods 7](#_Toc438561237)

[2.1 Electric Energy Savings Estimation Methodologies 7](#_Toc438561238)

[2.2. Demand Reduction Estimation Methodologies 7](#_Toc438561239)

[2.3. Gas Energy Savings Estimation Methodologies 7](#_Toc438561240)

[*Section 3. Load Shapes* 8](#_Toc438561241)

[3.1 Base Case Load Shapes 8](#_Toc438561242)

[3.2 Measure Load Shapes 8](#_Toc438561243)

[Section 4. Base Case & Measure Costs 9](#_Toc438561244)

[4.1 Base Case(s) Costs 9](#_Toc438561245)

[4.2 Measure Case Costs 9](#_Toc438561246)

[4.3 Incremental & Full Measure Costs 9](#_Toc438561247)

[References 10](#_Toc438561248)

# List of Tables

[Table 1 Product Codes and Measure Descriptions 1](#_Toc438561249)

[Table 2 Delivery Method and Applicable Building Types 1](#_Toc438561250)

[Table 3 Measure Application Type 4](#_Toc438561251)

[Table 4 DEER Net-to-Gross Ratios 4](#_Toc438561252)

[Table 5 Installation Rate 5](#_Toc438561253)

[Table 6 Effective Useful Life 5](#_Toc438561254)

[Table 7 Building Types and Load Shapes 8](#_Toc438561255)

[Table 8 Full and Incremental Measure Cost Equations 9](#_Toc438561256)

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# Section 1. General Measure & Baseline Data

## 1.1 Product Measure Description & Background

***Catalog Description –***

Table Product Codes and Measure Descriptions

|  |  |
| --- | --- |
| **Product Code** | **Measure Description** |
| L0265 | FIXTURE EXT INDUCTION > 180-250 WATTS |
| L0267 | FIXTURE EXT INDUCTION > 120-180 WATTS |
| L0264 | FIXTURE EXT INDUCTION > 100 -120 WATTS |
| L0263 | FIXTURE EXT INDUCTION > 70 -100 WATTS |
| L0262 | FIXTURE EXT INDUCTION ≤ 70 WATTS |

***Program Restrictions and Guidelines***

**Requirements**:

• Only complete, new induction fixtures or retrofit kits.

• New fixtures must not exceed the maximum “New Lamp Wattage” listed in the table above for each lamp being replaced. New lamp wattage is the total lamp only wattage.

• Rebates are based on a one-for-one replacement of incandescent or high intensity discharge (HID) fixtures including, mercury vapor, high pressure sodium, and standard metal halide or pulse start metal halide.

• Any wattage incandescent lamp ≥ 60 Watts may be replaced by complete new exterior induction fixtures.

• In all cases, the wattage of the replacement fixture must be less than the wattage of the existing lamp.

• May qualify for an additional control(s) rebate through the “Exterior Photocells” category, provided all requirements are met and Title 24 does not already mandate a required photocell/occupancy sensor.

Any wattage incandescent lamp; Slimline T12, T12 HO and T12 VHO fluorescent lamps 60 Watts or greater may be replaced by complete new exterior Induction fixtures.

**Exclusions**:

• Street and roadway installations do not qualify; please refer to PG&E’s Street Light Program for details refer to [**www.pge.com/led**](http://www.pge.com/led).

• Pulse start metal halide does not qualify. Please refer to “Exterior HID Fixtures w/Electronic Ballasts” category.

***Terms and Conditions:*** The customer must be a commercial PG&E electric customer.

***Market Applicability:*** The measures discussed in this work paper are applicable to nonresidential market sectors. These are both downstream and direct install measures.

Table Delivery Method and Applicable Building Types

|  |  |  |
| --- | --- | --- |
| **Delivery Type** | **Applicable Building Types** | **Application Type** |
| Direct Install | Any | ROB |
| Downstream | Any | ROB |

***1.2 Product Technical Description***

Induction lamps are a large lumen package fluorescent technology that does not require an electrode, but relies on radio frequency or magnetic induction to energize the lamp. Induction lighting is a high-efficacy alternative to HID lighting that provides color rendering that is superior to standard metal halide lighting, and boasts a very long lifetime. The CRI (Color Rendering Index) of induction lamps1 is 80, in comparison to a CRI from 65 to 75 for standard metal halide lamps. Manufacturers claim a lifetime for the lamp itself of 100,0001 hours, or 60,000 hours if the lamp is replaced at the end of the generator/ballast lifetime[[1]](#endnote-1).

Induction lamps are similar to ordinary fluorescent lamps, in that the inside of the lamp is coated with phosphors, and the lamp is filled with a vapor containing a small amount of mercury. In ordinary fluorescent lamps, the mercury vapor is excited by electrodes within the lamp, while the current is regulated by ballast. The excited mercury atoms give off ultraviolet light when they drop back to an unexcited state, which in turn excites the phosphor coating, causing it to fluoresce. The fluorescing phosphors produce visible light.

In the case of induction lamps, the energy within the gas is excited by electromagnetic induction, without the need for electrodes. One typical shape is that of an incandescent A-lamp, but with a glass tube inserted in the base that contains a radio antenna (a coil wound around a ferrite core), as illustrated by the early patent drawing reproduced in Figure 1. Another form of induction lamp is more of a donut shape, with two glass tubes joined together by short tubes containing electromagnetic coils that induce the current in the mercury gas, as shown on page 156 of the Sylvania lamp catalog.1 Power is supplied to the coils by a high-frequency electronic generator/ballast.

In ordinary fluorescent lamps, the electrodes are the components that give out most quickly. Because induction lamps are electrodeless, manufacturers claim a lifetime of 60,000 to 100,000 hours. In addition to energy savings, this longer lifetime can greatly reduce maintenance costs. Moreover, the spectrum and quality of light from induction sources provide excellent color rendering at CRI=80 or higher, compared to a CRI in the range of 65 to 75 for standard metal halide lamps as stated in the previous section.

Induction fixtures that can be used in exterior applications are manufactured by several manufacturers in the US, Europe, and Asia.

Figure 1970 Patent Drawing of Electrodeless Fluorescent Lamp

(Drawing pages of patent US3521120 A)[[2]](#endnote-2)



## 1.3 Measure Application Type

The DEER Measure Cost Data Users Guide found on [www.deeresources.com](http://www.deeresources.com) under *DEER2011 Database Format* hyperlink, DEER2011 for 13-14, spreadsheet *SPTdata\_format-V0.97.xls*, defines the terms as follows:

Table  Measure Application Type[[3]](#endnote-3)

*Identifies the measure application type in the Measure Implementation table in DEER2011.*

|  |  |  |
| --- | --- | --- |
| **Code** | **Description** | **Comment** |
| ER | Early retirement | *measure applied while existing equipment still viable, or retrofit of existing equipment* |
| ROB | Replace on Burnout | *measure applied when existing equipment fails or maintenance requires replacement* |
| NC | New Construction | *measure applied during construction design phase as an alternative to a code-compliant standard design* |

These measures are identified as ROB, or replace on burnout.

## 1.4 Product Base Case and Measure Case Data

The base case is either a metal halide or high pressure sodium fixture. The base case wattages are from DEER 2016.

|  |  |  |  |
| --- | --- | --- | --- |
| **Product Code** | **Measure Description** | **Measure Case Fixture Wattage** | **Base Case Technology and Fixture Wattage** |
| L0262 | FIXTURE EXT INDUCTION ≤ 70 WATTS | 70 W | Metal Halide 120 W |
| L0263 | FIXTURE EXT INDUCTION > 70 -100 WATTS | 100 W | High Pressure Sodium 190 W |
| L0264 | FIXTURE EXT INDUCTION > 100 -120 WATTS | 120 W | High Pressure Sodium 230 W |
| L0265 | FIXTURE EXT INDUCTION > 180-250 WATTS | 250 W | High Pressure Sodium 468 W |
| L0267 | FIXTURE EXT INDUCTION > 120-180 WATTS | 180 W | High Pressure Sodium 295 W |

## 1.4.1 DEER Base Case and Measure Case Information

The DEER READI tool was used to identify the DEER base and measure cases. Please refer to the Excel calculation workbook for DEER measure IDs.

**Hours of Operation**

DEER 2016 hours of operation per year of 4100 is used for exterior applications. This estimate was further verified against the *LS-2 Rate Schedule* as a source of current operation practices.[[4]](#endnote-4)

**Net-to-Gross Assumption**

Table 3 below summarizes all applicable DEER based Net-to-Gross ratios for programs that may be used by this measure.

Table 4 DEER Net-to-Gross Ratios

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Delivery Method** | **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 value was obtained using the DEER READI tool. The relevant IR value for the measures in this work paper is listed in the table below:

Table Installation Rate

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

**Effective Useful Life**

The EUL was obtained using the DEER READI tool. The relevant EUL value for the measures in this work paper are in the table below:

Table Effective Useful Life

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** |
| OLtg-HID | Outdoor HID Lighting | Com | Lighting | 15 |

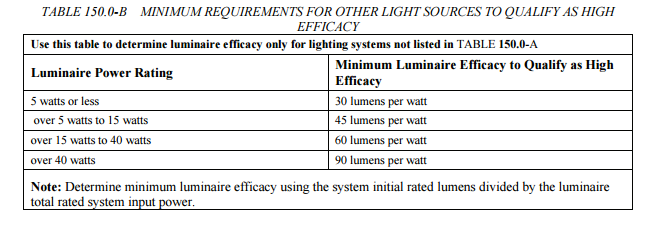
## 1.4.2 Codes & Standards Requirements Base Case and Measure Information

***Title 20 [2015]:*** As of January 1, 2009, fixtures with lamps >150W must have a pulse-start metal halide ballast with a minimum ballast efficacy of 88%, a magnetic probe-start ballast with a minimum ballast efficacy of 94%, or a non-pulse-start electronic ballast with minimum ballast efficacy of 92% for wattages greater than 250W, or 90% for wattages less than or equal to 250W.[[5]](#endnote-5)

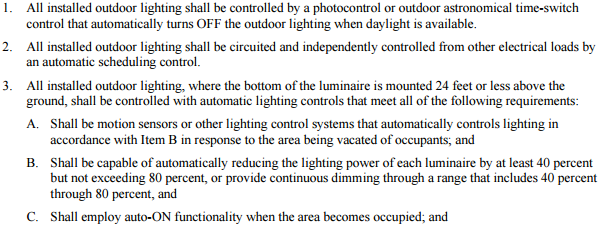
For fixtures manufactured before January 1, 2009, Title 20 contains ballast requirements, Section 1605.3(n).

The test method for metal halide luminaires is ANSI C82.6-2005. Ballasts may be tested separately, outside the luminaire. A sample of at least five ballasts shall be tested for each lamp wattage for which the luminaire and ballasts are rated. The average of these tests shall be used for certification and compliance purposes.

***Title 24 [2013]:*** Title 24 requires that lamps over 40 W have a minimum efficacy of 90 lumens per watt.[[6]](#endnote-6)



Section 141.0(b)2.J details the requirements for alterations to existing outdoor lighting systems. Some lighting controls may be required by Title 24 that is detailed in Section 130.2. An excerpt of the mandatory controls is below:





***Federal Standards:*** Metal Halide lamps are governed by the Federal standard CFR 21 1040.30. EPA has added mercury-containing equipment to the federal list of universal wastes regulated under the Resource Conservation and Recovery Act (RCRA) hazardous waste regulation.[[7]](#endnote-7). Handlers of universal wastes are subject to less stringent standards for storing, transporting, and collecting these wastes. EPA has concluded that regulating spent mercury-containing equipment as a universal waste will lead to better management of this equipment and will facilitate compliance with hazardous waste requirements.

**California Codes and Standards:** The California State standards and California Appliance Efficiency Regulations require that all 150 – 500W Metal Halide lamps use a pulse-start ballast instead of a probe-start ballast.

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

***1.4.3.1 Induction lighting Demonstration and Survey for Car Dealerships Exterior Display Lighting[[8]](#endnote-8)***

In 2006, Clanton & Associates, Inc. with sub-consultant RLW Analytics, Geltz Communications, and contractor Quality Light and Electric worked with Southern California Edison to conduct a survey of 100 respondents to assess whether customers perceive any difference in light quality between metal halide lamps and induction lamps in a car dealership. The survey results did not show a significant difference between a metal halide system and an induction lighting system that uses 62% less energy. Note that this is an exploratory market research study, not a rigidly controlled experiment; it is therefore not possible to make any definitive statements about the specific performance of each system.

***1.4.3.2 PIER Solutions for Parking Lots and Garages[[9]](#endnote-9)***

PIER has sponsored case studies involving retrofits of induction lighting with integrated bi-level and occupancy-based controls in parking garages.

## 1.4.4 Assumptions and Calculations from other sources—Base and Measure Cases

**Energy Savings Assumption (ΔW, ΔTherms):** The delta wattage values were obtained from the READI tool version 2.3.0.

# Section 2. Calculation Methods

## 2.1 Electric Energy Savings Estimation Methodologies

The power reduction in ∆Watts/unit is the basis for calculating the change in energy use from the Induction Fixture measure. (This is also a demand difference, but is not used for calculating a peak demand savings, since the savings occur outdoors at night during hours not included in the utility peak.)

*∆Watts/unit:*

The difference in watts per unit is simply the difference between the electric power draw of the base unit and the electric power draw of the energy-efficient unit.

*∆Watts/unit = (Base Watts/unit) - ( Energy-Efficient Measure Watts/Unit)*

L0262 assumes a baseline fixture wattage of 120 W. The measure fixture wattage is 70. For this example, the delta Wattage is:

*∆Watts/unit = 120 – 70 = 50 Watts*

*Annual Electric Savings:*

To calculate the annual electric savings from the measure, we multiply the ∆Watts/unit by the annual hours of operation:

*Energy Savings [kWh/Unit] = (∆Watts/unit) x (hours/day)x(days/year)*

*1,000 Watts / kW*

For the 70 Watt fixture example, the savings are

*Energy Savings = 50W \* 4100 hours/year*

*1000W/kW*

*= 205 kWh/year*

## 2.2. Demand Reduction Estimation Methodologies

As mentioned in Section 2.1, there are no demand savings associated with this exterior lighting measure, because its hours of operation are outside of the peak.

## 2.3. Gas Energy Savings Estimation Methodologies

There are no gas energy savings associated with this exterior lighting measure.

# *Section 3. Load Shapes*

Load Shapes are an important part of the life-cycle cost analysis of any energy efficiency program portfolio. The net benefits associated with a measure are based on the amount of energy saved and the avoided cost per unit of energy saved. For electricity, the avoided cost varies hourly over an entire year. Thus, the net benefits calculation for a measure requires both the total annual energy savings (kWh) of the measure and the distribution of that savings over the year. The distribution of savings over the year is represented by the measure’s load shape. The measure’s load shape indicates what fraction of annual energy savings occurs in each time period of the year. An hourly load shape indicates what fraction of annual savings occurs for each hour of the year. A Time-of-Use (TOU) load shape indicates what fraction occurs within five or six broad time-of-use periods, typically defined by a specific utility rate tariff. Formally, a load shape is a set of fractions summing to unity, one fraction for each hour or for each TOU period. Multiplying the measure load shape with the hourly avoided cost stream determines the average avoided cost per kWh for use in the life cycle cost analysis that determines a measure’s Total Resource Cost (TRC) benefit.

## 3.1 Base Case Load Shapes

The base case load shape would be expected to follow a typical nonresidential exterior lighting end use load shape.

## 3.2 Measure Load Shapes

For purposes of the net benefits estimates in the E3 calculator, what is required is the load shape that ideally represents the *difference* between the base equipment and the installed energy efficiency measure. This *difference* load profile is what is called the Measure Load Shape and would be the preferred load shape for use in the net benefits calculations.

The measure load shape for this measure is determined by the E3 calculator based on the applicable nonresidential market sector and the exterior lighting end-use.

Table Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| Exterior - Commercial | PGE:2 = Commercial Outdoor Lighting | COMMERCIAL |

# Section 4. Base Case & Measure Costs

A joint effort was made between SCE and PG&E to update base case and measure costs for DEER 2016 affected measures. The same methodology was used to update costs. Please refer to the cost spreadsheet for detailed information.

## 4.1 Base Case(s) Costs

Base Case Costs were calculated using an equation created from data points collected from multiple online retailers.

The labor cost for these measures are $187.14, per WO017[[10]](#endnote-10). It was assumed that the labor hours required to retrofit indoor fixtures are approximately the same as retrofitting outdoor fixtures.

## 4.2 Measure Case Costs

The Measure Costs were taken from multiple online retailers and calculated using an equation created from data points collected from multiple online retailers.

## 4.3 Incremental & Full Measure Costs

Table 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 |
| NEW/NC |
| RET/ER | (MEC + MLC) – (BEC + BLC) | MEC + MLC | (MEC + MLC) – (BEC + BLC) |
| REF | (MEC + MLC) – (BEC + BLC) | MEC + MLC | N/A |
| REA | MEC + MLC | MEC + MLC | N/A |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

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

Incremental Measure Cost is the premium cost to install an energy efficient measure over a standard efficiency measure or code baseline measure. For ROB, the IMC is the same value as GMC. The incremental cost is only used to help determine program incentives. In the case of ROB, the equipment being replaced is assumed to have failed in place or is past its useful life. The customer is faced with either purchasing standard efficiency or code baseline equipment versus energy efficient equipment. Therefore, gross measure cost (GMC) means the cost premium required to install the energy efficient measure over a less efficient piece of equipment.

# References

1. Philips “QL Induction Lighting Systems Information for Original Equipment Manufacturers, July 2007” October 2006, Philips Lighting B.V.

   Photo courtesy [↑](#endnote-ref-1)
2. United States Patent Office, “High Frequency Electrodeless Fluorescent Lamp Assembly” US Patent 3,521,120, granted July 21, 1970. [↑](#endnote-ref-2)
3. The DEER Measure Cost Data Users Guide found on [www.deeresources.com](http://www.deeresources.com) under *DEER2011 Database Format* hyperlink, DEER2011 for 13-14, spreadsheet *SPTdata\_format-V0.97.xls.* [↑](#endnote-ref-3)
4. *Electric Schedule LS-2*. Customer-Owned Street and Highway Lighting. Pacific Gas and Electric Company. April 2, 2008. [↑](#endnote-ref-4)
5. California Energy Commission, Title 20, California Appliance Efficiency Regulations, p.160, Section 1605.1(n)(2), July 2015. [↑](#endnote-ref-5)
6. California Energy Commission, Title 24, California Code of Regulations, p. 226, Table 150.0-B, Minimum Requirements for Other Light Sources to Qualify as High Efficacy, May 2012. [↑](#endnote-ref-6)
7. Federal Standard, 21CFR CH1 §1040.30, Edition 4-1-02, page 644 [↑](#endnote-ref-7)
8. Southern California Edison Design and Engineering Services, “Induction Lighting Demonstration and Survey for Car Dealerships Exterior Display Lighting,” March 3, 2008. [↑](#endnote-ref-8)
9. California Lighting Technology Center, “PIER Solutions for Parking Lots and Garages,” funded by The California Energy Commission’s Public Interest Energy Research (PIER) Program [↑](#endnote-ref-9)
10. 2010-2012 WO017 Ex Ante Measure Cost Study Final Report. Submitted by: Itron, Inc. May 27, 2014. Table 4-6. Page 4-12. *HID to T5 Fixtures high bay, lift accessible.* [↑](#endnote-ref-10)