**Work Paper WPSDGENRLG0002**

**Interior Induction Fixtures**

**Revision # 3**

**San Diego Gas & Electric**

**Energy Efficiency Engineering**

**Interior Induction Fixtures**

**Measure Codes L-D11-51**

# Work Paper Approvals

|  |  |
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Document Revision History

Revision # Date Description Author (Company)

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| --- | --- | --- | --- |
| **Revision 0** | **09/11/2008** | **Work paper short version with limited base cases and wattage ranges** | **Unknown, PGE** |
| **Revision 1** | **11/12/2009** | **Interior Induction Fixtures**  **Adopted form PGECOLTG113R0, Revision0** | **Unknown PGE** |
| **Revision 2** | **11/19/2009** | 1. **Updated NTG to reflect Deer 2008 changes** 2. **Saving Calculation was redone to reflect SDGE weighted Service Territory data and climate zone data** | **Lucie Sidibe, SDGE** |
| **Revision 3** | **6/15/12** | **Updated NTGRs for DEER 2011(Removed hours of operation table as document references WPSDGENRLG0999, updated August 28, 2012)** | **Charles harmstead (SDGE)** |

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# At-a-Glance Summary

|  |  |
| --- | --- |
| **Applicable Measure Codes:** | **LD11-51** |
| **Measure Description:** | Interior Induction Fixtures. |
| **Energy Impact Common Units:** | Per Fixture |
| **Base Case Description:** | No lighting (new installation) or existing Mercury Vapor, T-12 High/ Very High Output Fluorescent, Standard Metal Halide, High Pressure Sodium fixtures in interior installations. Lamp Wattage must be greater than 175W. |
| **Base Case Energy Consumption:** | Varies (depends on the existing fixture) |
| **Measure Energy Consumption:** | kWh |
| **Energy Savings (Base Case – Measure)** | Varies (depends on the measure) |
| **Costs Common Units:** | $ per fixture |
| **Base Case Equipment Cost ($/unit):** | Varies (depends on the type of measure) |
| **Measure Equipment Cost ($/unit):** | Varies (depends on the type of measure) |
| **Measure Incremental Cost ($/unit):** | Varies (depends on the type of measure) |
| **Effective Useful Life (years):** | 15 years |
| **Program Type:** | Retrofit or New |
| **Net-to-Gross Ratios:** | .70 and .89 |
| **Important Comments:** | N/A |

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

***Catalog Description***

Only Complete new induction fixtures qualify as replacements. New fixtures must not exceed the maximum Wattage listed in the table below for each range of lamp Wattage being replaced and must have a lower Wattage than the fixture being replaced. Fixtures must be equipped with Induction lamps and drivers. New fixtures must replace, one for one, existing Incandescent, Mercury Vapor, T12/High Output Fluorescent, T12/Very High Output Fluorescent, Standard Metal Halide (HID), High Pressure Sodium, or Cold Cathode, fixtures in interior installations. Existing Pulse Start Metal Halide installations do not qualify. Exterior installations do not qualify. All fixtures must be hardwired. Fixtures may qualify for an occupancy sensor rebate under the Occupancy Sensor category, provided all requirements are met. To qualify for the 400 Watt category, fixtures must be installed at a height over 12’ above the finished floor.

Table 1 Ranges of maximum Lamp Wattage identified for replacement:

|  |  |
| --- | --- |
| **Product Code** | **Description** |
| L-D11 | 100 Watt lamp basecase, up to 70Watt replacement fixture |
| L-D31 | 176-399 Watt lamp basecase, up to 180 Watt replacement fixture |
| L-D21 | 101-175 Watt lamp base case, up to 120 Watt replacement fixture |
| L-D41 | 400 Watt lamp base case, up to 250 Watt replacement fixture (Tier I) |
| L-D51 | 400 Watt lamp base case, up to 360 Watt replacement fixture (Tier II) |

***Program Restrictions and Guidelines***

***Terms and Conditions:***

The current work paper documents the energy savings that could be achieved by the replacement of the existing interior lighting fixtures to induction fixtures. Only Complete new induction fixtures qualify as replacements. All installations for this measure are for interior applications only. Exterior Installations do not qualify.

***Market Applicability:***

The measures discussed in this work paper is applicable to Commercial market sectors

***Technical Description***

Metal Halide Lamps generally offer higher efficiency than mercury vapor lamps and better light quality than either mercury vapor or sodium lamps. A Pulse Start Metal Halide Lamp offers longer life and more stable operation due to the elimination of the starter probe and bimetal strip which often causes the standard metal halide lamps to fail[[1]](#endnote-1). This work paper focuses on the assumption of replacing the existing Standard Metal Halide fixtures. All existing fixtures (Incandescent, Mercury Vapor, T12/High Output (HO) Fluorescent, T12/Very High Output (VHO) Fluorescent, Standard Metal Halide (HID), Cold Cathode or High Pressure Sodium Fixtures) considered for replacement with a Pulse Start Metal Halide are assumed to be of Standard Metal Halide Fixtures type. Lamp Wattages below 175W do not qualify under this category. Existing Incandescent, Mercury Vapor, T12 HO, T12 VHO, and High Pressure Sodium (HPS) fixtures with at least the same wattage as the assumed existing Standard Metal Halide fixture also qualify. Savings for each wattage range listed in this work paper are based on the most applicable induction fixture to achieve similar output as the assumed existing standard fixture. To qualify, induction fixtures must have a maximum wattage as stipulated in the table below and less than the fixture being replaced and must be hardwired.

Table 2 Maximum Wattage of Replacement fixture allowed for the five measures

|  |  |  |
| --- | --- | --- |
| **Product Code** | **Existing Standard MH (or HPS, Merc, T12 HO, T12 VHO or Inc)** | **Maximum Wattage of Replacement Induction, Including Ballast (W)** |
| L-D11-51 | 400W | 360W |
| 400 W | 250W |
| 176-399W | 180W |
| 101-175W | 120W |
| 100W | 70W |

## 1.2 DEER Differences Analysis

This work paper contains five different measures. None of these measures appear in the 2004-05 Database for Energy Efficient Resources (DEER).[[2]](#endnote-2) However, the DEER lists one similar measure for an exterior lighting system with measure ID D03-847. This measure has a 250W Standard Metal Halide exterior lighting fixture as its base case and is being replaced by a 175W Pulse Start Metal Halide fixture. Other DEER measures similar to the ones being reported here include D03-848 and D03-849 where the base cases are 500W Incandescent and 400W Mercury Vapor respectively which are being replaced by 175W and 250W Pulse Start Metal Halide fixtures. The energy savings reported by these DEER measures are specified in Table 3 below.

These are shown in the Table 3 below.

Table 3 Existing DEER measures for Exterior Pulse Metal Halide fixtures replacement

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **MeasureID** | **Measure**  **Description** | **Base**  **Description** | **Energy Savings (kWh/yr)** | **Demand Savings (Watts/yr)** | **EUL (yr)** | **Measure**  **Cost**  **($)** | **Base Cost ($)** |
| D03-847 | 175W PS Metal Halide | 250W Standard Metal Halide | 348.5 | 0 | 16 | $196.855 | $196.855 |
| D03-848 | 175W PS Metal Halide | 500W Incandescent | 1,189 | 0 | 16 | $196.855 | $196.855 |
| D03-849 | 250W PS Metal Halide | 400W Mercury Vapor | 651.9 | 0 | 16 | $219.919 | $219.919 |

The main differences between the measures discussed in the current work paper and the DEER measures listed in the above table is that all the measures here apply to interior lighting fixtures whereas the above DEER measures are applicable only to exterior lighting fixtures, also the proposed replacement considered in this paper is for induction lighting while the DEER measures consider PS MH lighting. It is due to these reasons that the Peak Demand Savings prescribed by the three DEER measures are zero as the co-incident diversity factor for exterior lighting applications is zero.[[3]](#endnote-3) Another difference is that this work paper targets at replacing all types of existing fixtures which are greater than 100W instead of just a single type fixture as suggested by the above DEER measures.

## 1.3 Codes & Standards Requirements Analysis

***Title 20:*** This measure is not governed by Title 20, Public Utilities and Energy, of the California Code of Regulations.

***Title 24:*** This specific category includes the installation of induction fixtures as a replacement for existing Incandescent/ Mercury Vapor/ T12/High Output (HO) Fluorescent, T12/Very High Output (VHO) Fluorescent/ Standard Metal Halide or High Pressure Sodium fixtures, which in general may be considered an alteration. As per Title 24 requirements, a measure can be considered an alteration if and only if more than 50% of the existing fixture is replaced. Here, the current work paper assumes that the installation of induction fixtures is more than that limit of 50% and hence by Title 24 standards, this measure is considered an Alteration. As a result of the alterations to the lighting control system, the measure must comply with Section 5.14 of the California Building Energy Efficiency Standard (Title 24).[[4]](#endnote-4) The pertaining rules and regulations from Title 24 as applied to this measure are shown in the Figure 1 below.

***5.14 Additions and Alterations***

Altered lighting components must also meet applicable mandatory measures described below. Prescriptive requirements apply if in a permitted space (The Basis for the Alteration Area is discussed in Section 5.12.3, Prescriptive Measure – Alterations below) more than 50% of the fixtures are replaced, or if the connected lighting load is increased. These requirements are discussed in the following sections.

Lighting alterations generally refers to replacing the entire luminaire, which includes the housing, lamps, ballasts, and louvers or lenses. Simply replacing the lamps and ballasts in an existing fixture is not considered a lighting alteration. Replacing or installing new wiring that connects the luminaires to switches, relays, branch circuits, and other control devices represents a lighting alteration and therefore must meet the applicable mandatory requirements as described below.

***5.14.1 Mandatory Measures – Additions and Alterations***

All “altered” lighting components in alterations must comply with applicable mandatory requirements of §119, §130, §131, and §132. Although these mandatory requirements apply only to altered lighting components, it is recommended that mandatory measures be considered for the entire space to achieve maximum energy savings.

* All altered luminaires in a space must meet the automatic shut-off controls requirements of §131 (d).

For lighting alterations purposes, rewiring refers to replacement or installation of new wires that serve the circuit between the switches, relays, branch circuits, other control devices, and rewired luminaire(s). In the case where only the wiring in a circuit that connects the switch and the luminaire(s) is being replaced without any alterations to the luminaire(s), the wiring system itself is considered the altered component and must therefore meet the lighting control requirements.

***5.14.3 Prescriptive Measures – Alterations***

Alterations that involve the following must comply with §146:

* Replacing more than 50% of the luminaires, or
* An increase in the connected lighting load.

When it is necessary to calculate the existing wattage to demonstrate that the alteration does not result in an increased lighting level, use the same methodology used for new lighting installations found in this chapter.

Figure . Title 24, Section 5.14, Selections Pertaining to Alterations

***Federal Standards:*** This measure is not governed by Federal Standards or Department of Energy regulations.

## 1.4 EM&V, Market Potential, and Other Studies

**Delta Wattage Assumption (ΔW):** Base cases for the five measures discussed in this work paper were provided by PG&E engineers. The delta W for each measure is based on the most applicable induction fixtures that would help to achieve similar light output (in lumens) as the assumed existing fixtures.

**Hours of Operation**: The hours of operation depends on the building type. For the purpose of this work paper, Annual hours of operation were obtained from the Energy Efficient Resources (DEER) 2011. Hours of operation within this workpaper are found in WPSDGENRLG0999 and that workpaper should be referenced by the reader.

## 1.5 Base Cases for Savings Estimates: Existing & Above Code

The current work paper categorizes five different measures. The difference between these measures is the difference in the wattage levels of the existing fixture. The fixture replacement can be new or a retrofit. Retrofit kits may be either one of these which includes: Incandescent, Mercury Vapor, T12-High Output (HO) Fluorescent, T12-Very High Output (VHO) Fluorescent, Standard Metal Halide or High Pressure Sodium fixtures. Existing interior fixtures considered for replacement must be categorized in any one of the measures below. For the purpose of calculating the energy savings due to each measure, it would be assumed that the base case is always a standard metal halide (irrespective of the existing fixture type). Table 5 below shows the base cases for the five measures discussed in this work paper and their assumed base wattage levels.

Table 5 Base Case description for the different measures prescribed by this program

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Code** | **Existing Base Case description** | **Maximum Wattage of replacement** | **Assumed Base Case (Standard MH Wattage Including Ballast)** |
| LD11-51 | 400 Watt Lamp | 360W | 458W (based on a 400W lamp)not in used |
| 400 Watt Lamp | 250W | 458W (based on a 400W lamp) |
| 176-399 Watt lamp | 180W | 295W (based on a 250W lamp) |
| 101-175 Watt lamp | 160W | 190W (based on a 150W lamp) |
| 100 Watt lamp | 95W | 128W (based on a 100W lamp) |

## 1.6 Measure Effective Useful Lives

See WPSDGENRLG0999 for EUL. The effective useful life 7(EUL) for induction fixture is calculated using the manufacturer advised Rated Life and the hours of operation or 15 years (whichever is less). Most well known manufacturer specifies 100,000 hours for induction lamps as an average rated life. The calculation shown below:

EUL= = 24.39 years

EUL = 15 YEARS

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

Net-to-Gross (NTG) Ratios are used to estimate free-ridership occurring in energy efficiency programs. Free riders are program participants who would have undertaken an activity whether or not there was an energy efficiency program promoting that activity. An NTG Ratio is a factor that represents the net program load impact divided by the gross program load impact. This factor is applied to gross program savings to determine the program's net impact.

The recommended Net-to-Gross Ratio (NTGR) for these measures are from DEER 2011. Interior Induction lighting is used for general area lighting, similar to Linear fluorescent. NTGR should be similar

Table 6 below specifies the NTG ratio to be used for these measures.

Table 6 Net-to-Gross Ratios

|  |  |
| --- | --- |
| **Program Approach** | **NTG** |
| NonRes-sAll-mT5T8dn | 0.70 |
| NonRes-sAllmT8-dir | .89 |

# Section 2. Calculation Methods

## 2.1 Electric Energy Savings Estimation Methodologies

All the energy (kWh/fixture) and demand (kW /fixture) savings calculations for each particular sector have been estimated based on the following two applications as prescribed by Pacific Gas& Electric.

1. High Bay Applications – are those places where the lighting fixtures are installed at a height of at least 12’ or higher.
2. Low Bay Applications – are places where the lighting fixtures are installed at a height of less than 12’.

Based on an engineering judgment, the following values have been used for a rough estimate of the square feet illuminated in the different measures in the above two applications:

Table 7 Square Feet Illumination provided by different lighting fixtures

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure** | **Assumed Base Case Standard MH Wattage, including ballast (W)** | **Assumed Induction Replacement Wattage, including ballast (W)** | **Square Feet Illuminated (sq.ft)** | |
| **High Bay** | **Low Bay** |
| LD11-51 | 400 Watt lamp | 354 W | 625 (25’x25’) | 900 (30’x30’) |
| 400 Watt lamp | 250W | 625 (25’x25’) | 900 (30’x30’) |
| 176-399 Watt lamp | 177 W | 225 (15’x15’) | 400 (20’x20’) |
| 101-175 Watt lamp | 160 W | 225 (15’x15’) | 400 (20’x20’) |
| 100 Watt lamp | 95 W | 225 (15’x15’) | 400 (20’x20’) |

It is to be noted here that the above values are based on conversations with some lighting experts and may be subjected to change.

The annual energy savings estimates are calculated making use of the equation1 and 2 below.

[Equation 1]



## 2.2. Demand Reduction Estimation Methodologies

The demand reduction estimates are based upon the DEER methodology for Express Efficiency type programs. The methodology for demand reduction is shown in Equation2 below:

**Formula:**

Demand Reduction =  [**Equation 2**]

(ΔWatts / unit) is the same as described above in the Energy Savings calculation Methodologies section. Demand Interactive Effects and Peak Coincidence Factor are derived from the DEER 2008 Miser tool. For a summary of savings values, refer to embedded excel calculation sheet.

**2.3 Gas Energy Saving Estimation**

Only losses in Gas savings are associated with these measures

*Gas Savings = (∆Watts/unit) x (annual hours* of use) x (3.413 BTU/Watt hours) x Interactive Effects [**Equation 3]**

100,000 (BTU/Therm)

# For a summary of savings values, refer to WPSDGENRLG0999.

# 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 *non-residential* (lghd\_in) end use load shape. (01*-ALC-AllCommercial-INTLIGHT)*

# *3.2 Measure Load Shapes*

The measure Load Shape is assumed to BE: *01-ALC-AllCommercial-IntLight*

# Section 4. Base Case & Measure Costs

## 4.1 Base Case(s) Costs

For this measure category, the base case cost is assumed to be zero because these are discretionary modifications (retrofit) to the customers’ existing equipment. Their alternative is to make no changes to their existing system.

## 4.2 Measure Costs

The measure costs vary depending on the wattage range. The measure cost for the five different measures discussed in this work paper was provided by an SDGE contractor (San Diego Energy Efficient Lighting Co) to the Trade ally, Table 9 below summaries the cost information.

Table 9 Measure costs for the different measures discussed in this work paper

|  |  |
| --- | --- |
| **Measure Code** | **Cost ($ per fixture)** |
| L-D11 | $270 |
| L-D21 | $370 |
| L-D31 | $470 |
| L-D41 | $570 |
| L-D51 | $570 |

## 4.3 Incremental & Full Measure Costs

As the base case cost is zero, the Incremental cost is the same as the measure cost in Table 9.

# Attachments

See WPSDGENRLG0999 for savings results.

# References

1. # . Houghton, D., “Metal Halide – Advances and Improvements”. Architectural Lighting Magazine. 2002.

   [↑](#endnote-ref-1)
2. . 2004-05 Database for Energy Efficient Resources (DEER), Version 2.01, October 26, 2005.

   <http://eega.cpuc.ca.gov/deer/> [↑](#endnote-ref-2)
3. . Itron Inc., “2004-2005 Database for Energy Efficient Resources (DEER) Update Study, Final Report”, December 2005, page 3-10. [↑](#endnote-ref-3)
4. Title 24 2005 Non-Residential Compliance Manual, Section 5.14 Additions & Alterations, March 2005, page 81.

   5 Energy Efficiency Policy Manual v3, Prepared by the California Public Utilities Commission, Energy Division, August, 2005.

   6 Effective Useful Life

   

   7- DEER 2011 NTG

    [↑](#endnote-ref-4)