**Work Paper WPSDGENRLG0044**

**Interior Linear Fluorescent Fixture**

**Revision # 3**

**San Diego Gas & Electric**

**Energy Efficiency Engineering**

**Interior Linear Fluorescent Fixture**

**Measure Codes: L-H11-61**

# At-a-Glance Summary

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Applicable Measure Codes:** | **L-H11** | **L-H21** | **L-H31** | | **L-H41** | **L-H51** | **L-H61** |
| **Measure Description:** | Replace, one-for-one, existing Incandescent, Mercury Vapor, T12/High Output Fluorescent, Standard Metal Halide, or High Pressure Sodium fixtures in interior applications, with complete new T8 or T5 or High Output T5 fixtures, with a lower wattage than the fixture being replaced. | | | | | | |
|  | >400 Watt lamp base case, up to 600 Watt replacement fixture | 400 Watt lamp basecase, up to 244 Watt replacement fixture (Tier 1) | 400 Watt lamp basecase, 245 to 360 Watt replacement fixture (Tier 2) | 176-399 Watt lamp basecase, up to 192 Watt replacement fixture | | 101-175 Watt lamp basecase, up to 128 Watt replacement fixture | ≤100 Watt lamp basecase, up to 64 Watt replacement fixture |
| **Energy Impact Common Units:** | Per fixture. | | | | | | |
| **Base Case Description:** | Standard Metal Halide fixture, 1080 W (based on 1000 W lamp) | Standard Metal Halide fixture, 458 W (based on 400 W lamp) | Standard Metal Halide fixture, 458 W (based on 400 W lamp) | Standard Metal Halide fixture, 295 W (based on 250 W lamp) | | Standard Metal Halide fixture, 190 W (based on 150 W lamp) | Standard Metal Halide fixture, 128 W (based on 100 W lamp) |
| **Code Baseline** |  | Pulse Start Metal Halide fixture, 365 W (based on 320 W lamp) | Pulse Start Metal Halide fixture, 400W (based on 350 W lamp) | Pulse Start Metal Halide fixture, 232 W (based on 200 W lamp) | |  |  |
| **Replacement fixture assumed for savings calculations:** | HO T5 585 W  (based on 8’ fixture with 10 lamps) | HO T5 234 W  (based on 4’ fixture with 4 lamps) | HO T5 351 W  (based on 4’ fixture with 6 lamps) | | HO T5 179 W  (based on 4’ fixture with 3 lamps) | HO T5 117 W  (based on 4’ fixture with 2 lamps) | HO T5 62 W  (based on 4’ fixture with 1 lamp) |
| **Base Case Energy Consumption:** | Refer to calculation sheet | Refer to calculation sheet | Refer to calculation sheet | | Refer to calculation sheet | Refer to calculation sheet | Refer to calculation sheet |
| **Measure Energy Consumption:** | Refer to calculation sheet | Refer to calculation sheet | Refer to calculation sheet | | Refer to calculation sheet | Refer to calculation sheet | Refer to calculation sheet |
| **Energy Savings ((Base Case – Measure) x Interactive Effects)** | Refer to calculation sheet | Refer to calculation sheet | Refer to calculation sheet | | Refer to calculation sheet | Refer to calculation sheet | Refer to calculation sheet |
| **Costs Common Units:** | $ per fixture | | | | | | |
| **Base Case Equipment Cost ($/unit):** | $0 | $0 | $0 | | $0 | $0 | $0 |
| **Code Base Case Equipment Cost ($/unit):** |  | $93 | $93 | | $73.88 |  |  |
| **Measure Equipment Cost ($/unit):** | $500  Source: RS Means Electrical 2005 | $275.71  DEER 2008 | $275.71  DEER 2008 | | $253  Source: RS Means Electrical 2005 | $207  Source: RS Means Electrical 2005 | $145  Source: RS Means Electrical 2005 |
| **Measure Incremental Cost ($/unit): RUL** | $500 | $275.71 | $275.71 | | $253 | $207 | $145 |
| **Measure Incremental Cost ($/unit): EUL-RUL** |  | $182.71 | $182.71 | |  |  |  |
| **Effective Useful Life (years):** | 15 years | | | | | | |
| **Program Type:** | Retrofit | | | | | | |
| **Net-to-Gross Ratios:** | Various | | | | | | |
| **Updates:** | See WPSDGENRLG0999 for detailed savings | | | | | | |

# Work Paper Approvals

|  |  |
| --- | --- |
| Charles Harmstead  **Harmstead Charles**  Engineering | 8/11/2011  Date |
|  | Date |
|  | Date |

# Document Revision History

Revision # Date Description Author (Company)

|  |  |  |  |
| --- | --- | --- | --- |
| Revision 0 | 12/2003 | **Short version** | PGE |
| Revision 1 | 09/10/09 | Linear Fluorescent Interior Fixture SDGEWPNRL044  adopted from PGE Work Paper Revision0, April 01, 2008, PGECOLTG114 | Lucie Sidibe , SDG&E |
| Revision 2 | 8/12/2011 | Updated NTG value to DEER08  Updated Cost values  Saving calculations were adjusted to meet DEER 3.02 Lighting Work Book hours and interactive effects. Dual baselines were added, where applicable | Charles Harmstead, SDG&E |
| Revision 3 | 6/26/12 | Updated NTGR value to DEER 2011  Updated savings calculations to workpaper WPSDGENRLG0999 | Charles Harmstead, SDG&E |

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# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

***Catalog Description***

Only complete new T8 or T5 or High Output (HO) T5 fixtures qualify. New fixtures must not exceed the maximum wattage listed in the rebate table below for each range of lamp wattage being replaced and must have a lower wattage than the new fixture. (Note: In all cases, the wattage of the replacement fixture must be less than the wattage of the existing lamp. The maximum replacement wattage listed in the table for each category is typically associated with the highest wattage in the base case range.) Fixtures must be equipped with linear fluorescent lamps and ballasts that meet the specifications defined in the T8 or T5 Linear Fluorescent Lamps with Electronic Ballasts category. New fixtures must replace one-for-one, existing Incandescent, Mercury Vapor, T12/High Output Fluorescent, T12/Very High Output Fluorescent, Standard Metal Halide, or High Pressure Sodium Fixtures in interior installations.

Table 1. Measures addressed in this work paper

|  |  |  |
| --- | --- | --- |
| **Measure Code** | **Existing Lamp (Wattage Base case)** | **Maximum Wattage of replacement Fixture** |
| L-H11 | >400 Watt lamp base case | up to 600 Watt replacement fixture |
| L-H21 | 400 Watt lamp base case | up to 244 Watt replacement fixture(Tier 1) |
| L-H31 | 400 Watt lamp base case | 245 to 360 Watt replacement fixture (Tier 2) |
| L-H41 | 176-399 Watt lamp base case | up to 192 Watt replacement fixture |
| L-H51 | 101-175 Watt lamp base case | up to 128 Watt replacement fixture |
| L-H61 | ≤100 Watt lamp base case | up to 64 Watt replacement fixture |

***Program Restrictions and Guidelines***

***Terms and Conditions:***

Existing Pulse Start Metal Halide installations do not qualify. Exterior installations do not qualify. All fixtures must be hardwired. Fixtures are not eligible for additional rebates under the Compact Fluorescent Fixtures and T8 or T5 Linear Fluorescent Lamps with Electronic Ballasts categories, but may qualify for an occupancy sensor rebate under the Occupancy Sensor category, provided all requirements are met. To qualify for the 400 Watt and >400 Watt categories, fixtures must be installed at a height over 12’ above the finished floor.

***Market Applicability:***

400 W and greater: Warehouse, Process Industrial, Assembly Industrial for Installations over 15’

Less than 400 W: All building types

***Technical Description***

High Output (HO) T5, Standard Output T5 and T8 technologies may be used interchangeably in many interior installations since the efficacy of these lamps and ballasts is similar. T8 and T5 Fixture installations would use the same number of lamps for equivalent light output while HO T5 Fixture installations would use proportionally fewer lamps to achieve similar light output. This category is based on replacing existing Standard Metal Halide fixtures. Existing Pulse Start Metal Halide installations do not qualify. Existing Incandescent, Mercury Vapor, T12 HO, T12 VHO, and High Pressure Sodium fixtures with at least the same wattage as the assumed existing Standard Metal Halide fixture also qualify. Savings for each wattage range listed in the table below is based on the most applicable High Output T5 fixture lamp/ballast combination to achieve similar light output as the assumed existing Standard Metal Halide fixtures. The maximum wattage of the replacement HO T5, Standard T5 or T8 Fixtures is adjusted slightly upward to allow for the interchangeability of these lamp/ballast combinations. Only hardwired HO T5, Standard Output T5 or T8 Fixtures, with a total wattage that is less than the equipment being replaced and no greater than the maximum wattage stipulated in the table below, qualify.

## 1.2 DEER Differences Analysis

DEER 3.02 Interactive Effects Lighting Workbook will be used to determine energy savings, demand reductions and therm offsets.

Non-CFL operating hours will be used. Based on the new operating hours, building types, weather zones, and the interactive effects, the energy savings is calculated (SDG&E calculations); The NTG, and other values used in this work paper are from DEER 2008.

## 1.3 Codes & Standards Requirements Analysis

In Section 149(b) of California’s Title 24 2008[[1]](#endnote-1) Non-Residential Building Energy Efficiency Standards, the Alteration codes and standards language states:

I. Alterations to existing indoor lighting systems shall meet the following requirements:

1. Alterations that increase the connected lighting load, replace, or remove and re-install a total of 50 percent or more of the luminaries in an enclosed space, shall meet the requirements of Sections 130 and 146; and

2. The following wiring alterations shall meet the requirements of Sections 119, 131, and 134:

i. Where new or moved wiring is being installed to serve added or moved luminaries; or

ii. Where conductor wiring from the panel or from a light switch to the luminaries is being replaced, or

iii. Where a lighting panel is installed or relocated.

3. For an alteration where an existing enclosed space is subdivided into two or more spaces, the new enclosed spaces shall meet the requirements of Sections 131(a) and (d); and

4. Alterations that have less than 0.5 watts per square foot and increase the existing lighting power density to 0.5 watts per square foot or greater shall meet the requirements of Sections 119, 130, 131, 134,143(c), and 146.

This measure is not affected by the alteration above code requirements because the measure does not increase the connected lighting load.

Federal Energy and Independence Act of 2007 sets new requirements for Metal Halide lamps between 150 and 500 watts when replaced. Consideration for these replacement lamps will receive Dual Baseline cost and energy savings adjustments.

## 1.4 Measure Effective Useful Lives and hours of operations

According to Federal requirements, Measure coded L-H1,L-H5, and L-H6 measure life will not be affected by dual baseline. Measure Codes L-H2, L-H3, and L-H4 will be affected by dual baseline, with RUL of 5 years (evaluated with existing lamps as baseline) and (EUL- RUL) of 10 years (evaluated at current code baseline). Hours of operation are provided in the DEER 3.02 Work Book.

**Table1: Effective Hours of Operations for Indoor Fixtures only**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| DEER 2008 |  | Equivalent Full Load Hours | | |
| Lighting Hours of Use |  | Indoor | Indoor | Outdoor |
| See DEER 3.02 Lighting Workbook calculations, attached |  |  |  |  |

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

Table-2 below NTGR are from DEER 2011

Table-2: Net-to-Gross Ratio

|  |  |  |
| --- | --- | --- |
| Delivery Method | Program Name | NTG |
| Downstream | Express Efficiency | .7 |
| Direct Install | Direct Install | .89 |

**Section 2. Calculation Methods**

## 2.1 Electric Energy Savings and Demand Reduction Calculation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **SDGE Measure code** | **Existing Standard MH**  **(or HPS, Mercury, T12 HO, T12 VHO or Inc)**  **Lamp Wattage** | **Maximum Wattage of Replacement HO T5, T5 or T8 Fixture, Including Ballast** | **Assumed Base Case Standard MH Wattage, Including Ballast** | **Assumed Measure HO T5/T8 Replacement Wattage, Including Ballast** | **∆ Watts/ fixture** |
| L-H1 | Greater than  400 W | 600 W | Fixture wattage: 1080 W (based on 1000 W lamp) | 585 W  (based on 8’ fixture with 10 lamps) | 1080 W – 585 W = 495 W |
| L-H2 (RUL) | 400 W – Tier 1 | 244 W | Fixture wattage: 458 W | 234 W  (based on 4’ fixture with 4 lamps) | 458 W – 234 W = 224 W |
| L-H2  (EUL-RUL) code baseline | 400 W – Tier 1 | 244 W | Fixture wattage: 365 W (based on 320W lamp) | 234 W  (based on 4’ fixture with 4 lamps) | 365 W – 234 W = 131 W |
| L-H3  (RUL) | 400 W – Tier 2 | 360 W | Fixture wattage: 458 W (based on 400W lamp) | 351 W  (based on 4’ fixture with 6 lamps) | 458 W – 351 W = 107 W |
| L-H3  (EUL-RUL) code | 400 W – Tier 2 | 360 W | Fixture wattage: 400 W (based on 350W lamp) | 351 W  (based on 4’ fixture with 6 lamps) | 400 W – 351 W = 49 W |
| L-H4  (RUL) | 176 – 399 W | 192 W | Fixture wattage: 295 W (based on 250W lamp) | 179 W  (based on 4’ fixture with 3 lamps) | 295 W – 179 W = 116 W |
| L-H4  (EUL-RUL) code | 176 – 399 W | 192 W | Fixture wattage: 232 W (based on 200W lamp) | 179 W  (based on 4’ fixture with 3 lamps) | 232 W – 179 W = 53 W |
| L-H5 | 101 – 175 W | 128 W | Fixture wattage: 190 W (based on 150W lamp) | 117 W  (based on 4’ fixture with 2 lamps) | 190 W – 117 W = 73 W |
| L-H6 | 100 W or Below | 64 W | Fixture wattage: 128 W (based on 100W lamp) | 62 W  (based on 4’ fixture with 1 lamp) | 128 W – 62 W = 66 W |

Assumed Wattage for both measure and base cases were taken for the SDGE Standard Performance Contract (SPC) Table of Standard Fixture Wattages (appendix B)

Table 3: Base case Wattage Assumptions

∆Watts/unit= Base Watts/unit - Energy Efficient Unit Watts

Energy Savings = (∆Watts/lamp) x (hours /year) x (Interactive Effects) **Equation 1**

1,000 Watts / kW

*Demand Reduction* *= (∆Watts/unit) x (Interactive Effects)* **Equation 2**

*1,000 Watts / kW*

Gas Savings = (∆Watts/unit) x Interactive Effects **Equation 3**

# For Detailed energy savings, demand reduction and interactive effects see SDGE workpaper 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 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 non-residential market sector and the lighting end-use.

# Section 4. Base Case & Measure Costs[[2]](#endnote-2)

## 4.1 Base Case(s) Costs

Code Base Case costs are applicable for Measures L-H2, L-H3, and L-H4 with Dual Baseline. Code Compliance Costs are for pulse start metal-halide lamp and ballast retrofit

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measure Code | Lamp | Lamp Cost | Ballast Cost | Total Retrofit kit cost |
| L-H2 | PSMH 320 | $24 | $69 | $93 |
| L-H3 | PS MH 350 | $24 | $69 | $93 |
| L-H4 | PSMH 200 | $18.88 | $55 | $73.88 |

## 4.2 Measure Costs[[3]](#footnote-1)

Table . Measure costs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Code** | **Replacement Fixture Description** | **Materials Cost** | **Installation Labor Cost -** | **Measure Cost** |
| L-H1 | Surface mounted fixture, acrylic lens[[4]](#footnote-2) with hinged and latched door frame, 2’W x 8’L, ten lamp  Means Electrical Cost Data 2005 16510 440 1800 | $187 | $105 | $500 |
| **L-H2**  **(DEER Cost )** | **FL, (4) 46in, T5HO lamp, (2) Programmed Start Ballast, (BF: 1.00), Lumens=19000, W/fixt=234**  **DEER2008 Cost Table** | **206.03** | **$72.17** | **$278.20** |
| **L-H3**  **(DEER Cost)** | **FL, (6) 46in, T5HO lamp, (3) Programmed Start Ballast, (BF: 1.00), Lumens=28500, W/fixt=351**  **DEER2008 Cost Table** | **$283.06** | **$72.17** | **$355.23** |
| L-H4 | Surface mounted fixture, acrylic lens with hinged and latched door frame, 2’W x 4’L, three lamps Means Electrical Cost Data 2005 16510 440 1400 | $91.5 | $57 | $253 |
| L-H5 | Surface mounted fixture, acrylic lens with hinged and latched door frame, 1’W x 4’L, two lamps Means Electrical Cost Data 2005 16510 440 1100 | $73.5 | $46.5 | $207 |
| L-H6 | Strip fixture, surface mounted, 4’L, one lamp  Means Electrical Cost Data 2005 16510 440 2400 | $72 | $41 | $145 |

\* City Cost index: 126%

Inflation rate: 2.6% per year[[5]](#endnote-3)

## 4.3 Incremental & Full Measure Costs

For Measures L-H1, L-H5, and L-H6 Measure cost is incremental cost.

For Measures L-H2, L-H3, and L-H4 Measure costs are as follows: For RUL Measure cost is full cost of retrofit fluorescent fixture. For (EUL-RUL) Code baseline, Measure cost is Measure cost – Code Baseline.

# References

1. .

   2 DEER NTG [↑](#endnote-ref-1)
2. RS Means Construction Publishers and Consultants, 2005. *RS Means Electrical Cost Data.* [↑](#endnote-ref-2)
3. Fixture wattages were taken from Source **Error! Bookmark not defined.**. Costs were estimated using the closest available cost information for typical similar fixtures, in Source 2. Costs are not intended to represent any particular manufacturer or specific fixture design, but standard generic assumptions, using the closest available information. [↑](#footnote-ref-1)
4. Lensed fixtures are only used for cost estimating because they are the closest typical representative fixture for which standard cost data was available Source 2. [↑](#footnote-ref-2)
5. CAF 2006. Economic Research Unit of the California Department of Finance, November 2006 CPI Forecast Report. Value listed is a statewide average for the CPI-U forecasted for 2007. <http://www.green.ca.gov/LCCA/model.htm>. Value listed is a statewide average for the CPI-U forecasted for 2007.

   5- Appendix B: Table of Standard Fixture Wattages

   

   6- 2004/2005 Deer Update Study

   

   7- DEER 2008 Cost Table

   

   DEER 3.02 Lighting Table with savings for L-H1, L-H2, L-H3, L-H4, L-H5, and L-H6

   Pulse Start Metal Halide Costs

   

   Federal Baseline Requirements

   

    [↑](#endnote-ref-3)