



# LED Replacement Lamps



In the US residential sector, there are 4.7 billion Edison base lamp sockets. 3.9 billion contain an incandescent lamp.

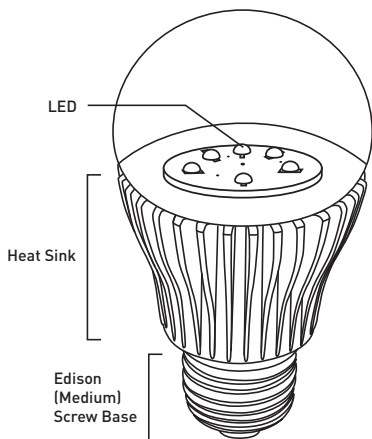
*D&R International, Ltd., 2009*

## Current Solid State Lighting Options for Existing Luminaires

Pacific Gas and Electric Company (PG&E) shares in the growing enthusiasm for light-emitting diodes (LEDs) and believes LED lighting has the potential to help customers save energy in both residential and commercial applications. To stay abreast of the rapid advances in LED technology and help guide its support of the technology, PG&E works closely with the LED industry, US Department of Energy (DOE), Environmental Protection Agency (EPA), and the standards and testing community. The result of these partnerships is evidenced by our recent launch of incentives for example: LED Street Lighting and LED Refrigerated and Frozen Food Case Lighting. PG&E is working with the LED community to ensure LED lighting becomes a widely used option that provides long-term energy savings for our customers. Experience has taught us the importance of first impressions in achieving this goal. As product labeling and industry-adopted testing standards come into effect, PG&E will work with our colleagues nationwide to develop incentive programs for LEDs in specific applications.

### Solid State Lighting Basics

- **Solid State Lighting (SSL):** Lighting that uses semiconductors to convert electricity into light. Other lighting technologies use filaments, gas, or plasma. Light-emitting diodes (LEDs) are an example of SSL technology.
- **Lamp:** Lighting industry term used to describe a device that transforms electricity into light, also known as a light bulb and/or light source.
- **Lumen:** Measurement of the amount of light, or luminous flux, produced by a light source.
- **Watt:** Measurement of power required to produce light from a source.
- **Driver:** A driver takes a power input and delivers a constant current to an LED light source to ensure a constant light output.
- **Heat sink:** A heat sink is a means of dissipating heat. Appropriate thermal management is critical in LED systems to reach the expected product lifespan.
- **Efficacy (lumens per watt):** A measure of how effectively a desired result is achieved. For example, how effectively lamps transform electrical power (watts) into visible light (lumens). A lamp that consumes 100 watts of power and produces 2000 lumens has an efficacy of 20 lumens per watt.
- **Life (hours):** For LED products, lamp life is considered to be the point at which the light output has depreciated to some percentage of the initial output. Most manufacturers consider 70% lumen output to be the functional end of LED lamp life.
- **IESNA LM-79 and LM-80:** Two industry standard testing procedures recommended by the Illuminating Engineering Society of North America (IESNA) to evaluate solid state lighting products. LM-79 specifies procedures for measuring total flux, electrical power, and chromaticity. LM-80 is used to measure lumen depreciation over time.



Not all LED replacement lamps contain the same configuration of LEDs. The LEDs can be different shapes, quantities, sizes, and arranged in various ways.

“... the number of products that clearly represent viable replacements for incumbent products is increasing, although not always at levels claimed by manufacturers.”

US Department of Energy, CALiPER Summary Report, Summary of Results: Round 9 of Product Testing

## Measuring Performance

To address the need for reliable, unbiased product performance information and to foster the developing market for high-performance SSL products, the DOE launched the Commercially Available LED Product Evaluation and Reporting (CALiPER) program ([ssl.energy.gov/caliper.html](http://ssl.energy.gov/caliper.html)). To ensure the continuation of California’s leadership in advancing new lighting technology, PG&E leverages lamp testing capabilities of both the Southern California Lighting Technology Center (SCLTC) at Southern California Edison (SCE) and California Lighting Technology Center (CLTC) at the University of California, Davis to test an array of SSL products available for general illumination.

## Test Results




The Department of Energy CALiPER program has completed testing on a variety of LED replacement technologies. The research indicated wide ranges in light output, efficacy, color temperature, and color rendering index. However, increasing numbers of SSL products are now approaching, matching, and sometimes exceeding the light output levels, distribution, and color quality of comparative technologies using traditional sources.

Despite this upward trend, comparisons to incandescent and fluorescent lamps are often misleading. Misinformation makes buying decisions difficult, and leads to consumer distrust. Although a few SSL replacement lamps meet the expected performance levels, most do not. Recent CALiPER reports indicate that the greatest discrepancies between measured performance and manufacturer claims were observed in small omni-directional replacement lamps such as the A series.

In a recent test at Southern California Edison focusing on the MR16, a popular choice for track lighting and retail applications, the light output of LED MR16 lamps ranged from 29 – 246 lumens. This wide range allows for the possibility that the lumen output would be less than the existing halogen lamp, leading to disappointment in the quantity of light from the LED MR16. Manufacturer claims for the tested lamps were largely inaccurate. Buyers should be cautious when reviewing claims and look for alternate reviews on the product from independent sources. Before purchasing new lamps, buyers should research the lumen output of their current lamps, then buy replacements with similar stated lumen outputs and compare the new and old lamps in their intended installation location. Buyers should look for a robust warranty and return policy in case the product does not meet expectations.

## Lamp Comparison Charts

The following shows a comparison between three lamp sizes and five technologies, all from the same major manufacturer. The variation in lumen output and lifespan is notable across technologies. Buyers should select a lamp technology based on the specific light requirements of where it will be installed.

|                 | MR 16  |            |       | A 19  |             |         |       | PAR 38  |            |             |       |
|-----------------|---|------------|-------|--|-------------|---------|-------|--|------------|-------------|-------|
|                 | Halogen   | Halogen-IR | LED*  | Incandescent   | Fluorescent | Halogen | LED*  | Halogen  | Halogen-IR | Fluorescent | LED*  |
| Life (hours)    | 3000  | 5000       | 45000 | 1500   | 8000        | 3000    | 40000 | 3000   | 4200       | 8000        | 45000 |
| Lumens          | 240   | 320        | 130   | 505  | 675         | 800     | 155   | 1050   | 1120       | 850         | 600   |
| Power (W)       | 20  | 20         | 4     | 40   | 11          | 40      | 7     | 75   | 60         | 20          | 16    |
| Efficacy (lm/W) | 12  | 16         | 33    | 13   | 61          | 20      | 22    | 14   | 19         | 43          | 38    |
| Price**         | \$3   | \$6        | \$28  | \$1  | \$3         | \$6     | \$32  | \$6  | \$10       | \$20        | \$63  |

\*LEDs do not fail in the same manner as incandescent and fluorescent lamps so LED life is defined as the time at which light output has decreased to 70% of initial lumen output.

\*\*All prices are approximate and rounded to the nearest whole number.

## CALiPER Testing of LED T8/T12 Replacement Lamps

SSL replacements for linear fluorescent lamps consist of a rectilinear LED array mounted in a tubular format, typically with bi-pin bases that are compatible with standard fluorescent lamp holders. Unlike linear fluorescent lamps, which emit light in all directions (omnidirectional), LED replacements are directional sources intended to emit light in a limited beam angle (e.g., downward in the case of a ceiling troffer).

Manufacturer claims for these products generally focus on energy savings, long life, reduced maintenance, and mercury-free composition. If provided, photometric data ranges from lumen output to illuminance values, to claims of general equivalency with fluorescent lamps. It should also be noted that rewiring an existing light fixture to bypass the ballast could void the light fixture's UL listing and present a hazard if done incorrectly. Most LED replacements require bypassing the existing fluorescent ballast and wiring the LED lamps to a line voltage (e.g., 120V or 277V) circuit. Despite the relative ease of installing properly sized LED replacement lamps in fluorescent lamp holders, the additional labor for electrical connections could incur significant expenses, depending on the scale of the project. The added labor for installing LED lamps with a clip-based mounting system also contributes to retrofit project costs.

## Linear Replacement Testing Results

- To date, the majority of LED linear replacement lamps tested by the DOE have been found to have inaccurate or misleading manufacturer information regarding efficacy. Some promised up to 50% more lumens than they delivered.
- Fluorescent T12 and T8 fluorescent lamp-ballast systems achieve higher luminaire efficacies than the LED replacement products tested.
- Only one 4' linear replacement achieved an efficacy above 60 lm/W
- The comparatively low light output of LED replacement T8/T12 lamps could result in unacceptably low illumination levels in retrofit applications. To maintain existing light levels, it would be necessary to install additional LED replacement lamps, thereby diminishing potential energy savings and requiring additional fixtures or fixture modifications.
- LED linear replacement lamps may present a safety hazard, as some lamps require fixture rewiring so that line voltage is running directly to the bi-pin socket, allowing for the possibility of accidentally energizing the fixture during lamp placement.

## LED Product Labeling

To help ensure the public acceptance of LED lighting products, the DOE recently founded the SSL Quality Advocates program. The program includes a voluntary labeling initiative, Lighting Facts ([www.lightingfacts.com](http://www.lightingfacts.com)), which is beginning to be adopted by manufacturers. The label was designed to indicate the expected performance level of the lamp using terms that are ubiquitous across technologies. SSL, fluorescent, and incandescent products differ significantly in the way they produce light, but the measurable qualities of the light output are the same, and form a base for comparison. The objective of the label is to assist buyers in making informed decisions about the color, quantity of light output, and amount of energy used by the product being considered. The label is intended to be featured on product packaging, online and in printed materials where would-be buyers will see it when making purchasing decisions.



Linear fluorescent lamps are used in many applications from lighting for the home, workplace, and in retail settings.

## ENERGY STAR LED REPLACEMENT LAMP REQUIREMENTS:

- 50 lm/W
- Minimum CRI of 75
- 3 year warranty covering material repair or replacement

Manufacturers must participate in DOE's Quality Advocates program and use the Lighting Facts label

Read more: [energystar.gov](http://energystar.gov)

| <b>Lighting Facts™</b>   |                          |       |       |
|--|--------------------------|-------|-------|
| LED Product  |                          |       |       |
| <b>Light Output (Lumens)</b>   | <b>840</b>               |       |       |
| <b>Watts</b>   | <b>9</b>                 |       |       |
| <b>Lumens per Watt (Efficacy)</b>  | <b>93</b>                |       |       |
| <b>Color Accuracy</b><br>Color Rendering Index (CRI)   | <b>87</b>                |       |       |
| <b>Light Color</b><br>Correlated Color Temperature (CCT)   | <b>2900 (Warm White)</b> |       |       |
|  |                          |       |       |
| 2700K  | 3000K                    | 4500K | 6500K |
| Visit <a href="http://www.lightingfacts.com">www.lightingfacts.com</a> for the <b>Label Reference Guide</b> .  |                          |       |       |
| <small>All results are according to IESNA LM-79-2008: Approved Method for the Electrical and Photometric Testing of Solid-State Lighting. Brand X, 18756CH156428954RGH123456</small> |                          |       |       |



*LED replacement lamps and the existing technologies they are intended to replace.*

## Conclusions

LED Replacement lamps are an emerging technology and therefore carry risks. To mitigate these risks, PG&E recommends professional guidance before purchasing LED replacement lamps. In lieu of guidance, the ENERGY STAR program provides online advice for evaluating LED products online ([energystar.gov](http://energystar.gov)). PG&E anticipates market availability of ENERGY STAR listed LED replacement lamps in 2010. Lighting fixtures designed for LEDs tend to work better than LED replacement lamps as LEDs are sensitive to heat, and the best way to dissipate that heat is to design heat-sinking capabilities into the fixture. Existing fixtures were designed for light sources other than LED, so consider replacing fixtures instead of lamps. For a list of qualified LED fixtures, go to [www.pge.com](http://www.pge.com). In summary, there are a number of issues that should be weighed when considering a switch to LED replacement lamps:

- **Application/Form Factor:** Does the replacement lamp fit in the existing fixture? Does it provide the right kind of light (total brightness, hue, beam spread, etc.)?
- **Efficacy:** Does the efficacy (lumens per watt) of the new lamp exceed that of the one being replaced?
- **Lamp Longevity:** What is the rated life of the LED lamp? Is there a warranty of at least 3 years to support longevity claims?
- **Weight:** LED lamps typically have large, heavy heat sinks to dissipate heat. Can the fixture support this additional weight?
- **Dimming Circuits:** LED replacement lamps include integrated electronics and may not function properly on an existing dimming circuit. Check with both the dimming switch supplier and the LED lamp supplier for compatibility.
- **Environmental Disposal Issues:** Fluorescent lamps contain mercury and should be disposed of properly through dedicated recycling channels. LED lamps contain no mercury, but should be disposed of through e-waste recycling programs.

## Online Resources

Pacific Gas and Electric Company  
[www.pge.com](http://www.pge.com)

California Lighting Technology Center (CLTC)  
[cltc.ucdavis.edu](http://cltc.ucdavis.edu)

US Department of Energy (DOE), CALiPER  
[www1.eere.energy.gov/buildings/ssl/caliper.html](http://www1.eere.energy.gov/buildings/ssl/caliper.html)

DOE Fact Sheet: LED Replacements for Incandescent Omnidirectional  
[apps1.eere.energy.gov/buildings/publications/pdfs/ssl/led\\_replacements.pdf](http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/led_replacements.pdf)

Emerging Technologies Coordinating Council  
[www.etcc-ca.com](http://www.etcc-ca.com)

ENERGY STAR®  
[www.energystar.gov/index.cfm?c=ssl.pr\\_commercial](http://www.energystar.gov/index.cfm?c=ssl.pr_commercial)

