Pacific Gas and Electric Company

Emerging Technologies Program

Application Assessment Report #0717

LED Cove, Accent, and Spot Lighting: Hospitality Sector

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Table of Contents

Appendices

Table of Tables

Table of Figures

Preface

EMCOR Energy Services, under contract to Pacific Gas & Electric Company (PG&E), conducted this study of an Emerging Technology Project at a project host site, Hilton's Doubletree Hotel located in San Jose, California. The purpose of this project is to assist PG&E with the evaluation of the application of LED lighting systems to cove, accent, and spot lighting in the hospitality sector, as discussed herein.

This report is the result of an emerging technology demonstration project performed as a part of the Customer Energy Efficiency (CEE) Program administered by PG&E. This program is part of PG&E's commitment to meeting new demand growth through energy efficiency by providing technical assistance directly to electric service customers.

EMCOR Energy Services of San Francisco, California, prepared this document for PG&E under the CEE Program. The PG&E Emerging Technologies Program Lead is Lee Cooper. The PG&E Project Manager for this project is Daryl DeJean.

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1 Executive Summary

This report summarizes the installation and assessment of light emitting diode (LED) luminaires at a full service hospitality center in Northern California. Relying primarily on field testing, the project team conducted photometric and power measurements, as well as employee satisfaction surveys and economic payback calculations.[1] This application assessment study was designed to verify the brightness and quality of light currently achievable with LED lighting systems in order to aid the acceleration of their mainstream adoption in the hospitality end-use.

The baseline equipment for this study consisted of various types of lighting systems common to the hospitality setting; an entryway alcove area was lit by linear T8 fluorescent fixtures, a restaurant atrium by clear decorative medium-base incandescent lamps, and a bar area by suspended MR16 halogen spot lamps. These lighting systems were replaced as follows:

- **Entranceway cove lighting**
  Nominal 32 W T8 fluorescent fixtures were replaced by LED light bars and associated drivers.
- **Restaurant atrium lighting**
  Nominal 11 W medium-screw-base incandescent lamps were replaced by ~2 W prototype medium-screw-base LED luminaries.
- **Bar lighting**
  Nominal 50 W pin-based MR-16 lamps were replaced by pin-based LED MR16 luminaries. Two models from two manufacturers were evaluated, one of 3 W and one of 4.7 W.

Results of the photometric field measurements are tabulated in Table 1.1.[2] Since illuminance is a measure of incident light, this report deems illuminance most capable of expressing customer and hotelier perception, ultimately the most important criteria in hospitality facility lighting.

This study details the unique performance of LED MR16 luminaires as compared to previously reported trends on the application of LED lighting systems: both luminance and illuminance measurements were increased by the LED MR16s in the application, which

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1 Throughout this report, “employee” or “project host” refers to the host site (who may otherwise be referred to as a customer of PG&E’s electricity service). “Customer” will refer only to customers of the host facility.

2 The restaurant atrium lighting system was removed during the test period and existing lamps were essentially of decorative nature; therefore, photometric results are not available for this area. (See Section 4.3.2 for more details.) Additionally, LED cove measurements are not presented (see Section 7.1).

called for a focused distribution of light. Generally, uniformity, in terms of illuminance and luminance, was maintained or improved with replacement LED luminaires; formal maximum to minimum ratios were not calculated, however.

Field measurements in the bar area reveal increased light levels, at least in terms of light delivered to the task: results reveal an increase of 74% in average measured illuminance along the bar countertop. These results indicate the aptness of LED lighting to such niche applications. Importantly, and again consistent with other application assessment studies, customer feedback related to all three of the field tests was positive despite variances in illumination levels.

Table 1.1 Summary of Photometric Measurements

Lighting System	Average Luminance (cd/m2)	Average Illuminance (fc)
Bar Spot Lighting		
MR-16 Halogen	2.6	8.9
MR-16 LED	6.6	15.5
Δ (%)	154%	74%

Electric demand was measured before and after project installation. This information was used to quantify energy savings resulting from installation of the LED lighting systems. Measurements indicate that the projects overall reduced the electric demand of the baseline lighting systems by approximately 71 percent. The combined annual lighting energy savings for these projects were 3,691 kWh.

The overall performance of each LED luminaire was examined in terms of level of illuminance provided and electric demand reduced, since formal efficacy values were not available. The directional quality of light provided by the LED light sources in the bar area exaggerated their performance. While, photometric measurements were not comparable in the entranceway, distribution needs were noted as broad and unfocused, and project results reveal the importance of aligning LEDs to provide directional light, rather than the up-light commonly expected of cove lighting.

Table 1.2 Summary of Overall Luminaire Performance

Lighting System	Average Baseline Power (kW)	Average LED Power (kW)	Energy Savings (kWh/yr)	Demand Reduction (%)	Δ Illuminance (%)*
Entrance Cove 4' LED light bars	0.152	0.116	316	24%	
Bar lighting MR16 LED	0.414	0.054	3,154	87%	74%
Restaurant Atrium LED medium base	0.072	0.016	491	78%	
		Project Energy Savings	3,961		

* Illuminance measurements not available for the restaurant atrium. (See Section 4.3.2 for more details.)

It is also important to note that the baseline T8 fluorescent lighting system replaced in this study was relatively modern and efficient. The savings estimates for this application are, thus, conservative relative to older, less efficient baseline equipment. The bar and restaurant atrium systems use incandescent sources, which are deemed typical lighting systems for accent lighting applications in the hospitality sector.

The costs of electricity and electrical demand were calculated based on the time-based occurrence of project savings using PG&E's E-20S rate, typical for large hotels and hospitality centers. Additionally, LED luminaires have been shown to demonstrate a much greater effective useful life than fluorescent or other conventional lighting systems.[3] This results in fewer equipment replacements and lower maintenance costs. More than two cycles of fluorescent lamp replacements will be avoided during the expected life of the cove LED system, and more than 16 incandescent lamp replacements will be avoided during the expected life of the bar and restaurant atrium lighting system. Annual energy use and maintenance cost savings are detailed in the table below.

Table 1.3 Annual Energy and Maintenance Cost Savings

Lighting system	Annual Cost Savings			Project Cost	Payback (yrs)	
	Energy ($/yr)	Maint. ($/yr)	Total ($/yr)		Energy Savings Only	Energy and Maintenance Savings
Entrance Cove 4' LED light bars	$31.51	$82.12	$113.63	$676.88	21.5	6.0
Restaurant Atrium Medium base LED luminaire	$48.95	$177.36	$226.31	$181.20	3.7	0.8
Bar lighting MR16 LED luminaire	$314.45	$348.57	$663.02	$330.93	1.1	0.5
Total	$394.91	$608.05	$1,002.96	$1,189.01	3.0	1.2

Given current market conditions, the combined installation cost of the three applications is estimated to be approximately $1,189, resulting in a simple payback period of 3.0 years based on energy savings alone. When maintenance savings are included, the overall simple payback period is calculated to be 1.2 years. Based on an effective useful life of 5.7 years, the project life-cycle cost is positive overall.

LED lighting is a rapidly advancing technology. It is anticipated that on-going improvements in materials science, thermal efficiencies, optical design, and installation methods will lead to continuing price reductions and higher energy savings. Economies of scale are also predicted to drive manufacturing prices down. In the near term, utility incentive programs can reduce initial cost to the retailer and potentially accelerate market adoption of this promising energy efficient technology.

3 (Building Technologies Program 2007)

2 Project Background

2.1 LED Technology Overview

A light emitting diode (LED) is a semiconductor diode that emits light from a p-n junction when electric current is applied in the forward direction. A p-n junction is formed when a P-type semi-conductor (a semi-conductor doped to increase the amount of positive free charge carriers) is connected to a N-type semiconductor (a semi-conductor doped to increase the amount negative free charge carriers). The wavelength of the emitted light, and therefore its perceived color, depends on the semi-conductor materials of which the p-n junction consists. Additionally, the lens of the LED can be coated in order to further effect the wavelength of light emitted.

Although developed in the 1960s, application of LEDs has been limited due to color and performance restrictions imposed by the availability of primary usable elements within the diode: initially red only. LEDs developed in the 1980s incorporated new materials that allowed flexibility in the design of LED output color, and engendered commercial applications such as exit signs, indicators, and traffic signals. The 1990s saw the advent of blue and consequently of white LED sources (white light from LEDs is produced by combining red, green, and blue LED sources or by coating a blue LED with yellow phosphor). This was a breakthrough that offered a much broader range of applications than previously available. Due to continuous research and development in the technologies of semiconductors and optics, LEDs are now well known as efficient lighting technologies. Recent advances in the technology’s materials science have also extended LED expected life, brightness, and efficacy. Today’s technology affords a burgeoning array of LED applications, many of which are gaining acceptance in the marketplace.

2.2 Application Assessment Studies

Few application assessment studies have been completed on the application of LED cove or spot-lighting to the lodging and hospitality end-use. This section discusses some relevant studies into LED lighting that are completed or pending.

Southern California Edison is currently conducting studies of a variety of LED applications through the Energy Technologies Coordinating Council (ETCC), a utility consortium operating in coordination with the California Energy Commission to promote developments in energy efficient technologies. One such study deals with under-cabinet lighting (publication ET 07.03). It aims to evaluate energy savings and demand reductions of LEDs over incandescent and fluorescent lighting systems. A related study (ET 07.14) is being conducted to investigate the use of LED systems as replacements for MR16 low voltage lighting apparatus. A third study (ET 07.12) is underway to investigate the use of screw-based modular LED assemblies as direct replacements for directional incandescent display lighting, such as afforded by R and PAR lamps.

The Department of Energy Solid-State Lighting Gateway Demonstration is sponsoring ongoing studies in residential under-cabinet lighting. These studies hope to confirm the efficacy of available LED lighting solutions and improved customer acceptance as compared to fluorescent lighting. Importantly, these studies will seek to gain data on the directional quality of LED light:

> *Light sources that emit in 360 degrees lose a fair portion of their lumen output (typically 30% or higher) in directional lighting applications due to the required reflection (and partial absorption) of those lumens emitted outside of the desired pattern. LEDs can deliver light more efficiently to the desired surface.*[4]

2.3 Current Technical and Market Status

Lighting of indoor public spaces spans a number of lighting categories, primarily cove, spot, and accent lighting, which have traditionally been provided by a combination of fluorescent and incandescent sources. Halogen lamps with narrow beam focus are often used to provide the intensity and accuracy of light necessary for detailed or noticeable displays.

The application of LED lighting technology to indoor public spaces, such as the common areas within a hotel, offers many opportunities for technology penetration in this field. IESNA summarizes the basic goal for hospitality facility lighting:

> *In designing lighting for hospitality facilities, which include hotels, motels, and food service facilities, the first task is to identify those items that the staff and users want or need to see. Both groups must be able to see and comprehend their environment in order to move about and work within it. In addition, they should enjoy the environment. In facilities such as hotels and restaurants, the psychological effects of lighting are particularly important. By creating an attractive, comfortable, and functional environment, the lighting design becomes a marketing tool. Moreover, the lighting design must be integrated with the overall architectural design.*[5]

The emphasis on comfort implies an interest in creating mood rather than emphasis on product sales, as is the case in retail lighting applications.

Although current design and manufacturing processes can employ LED lighting in a number of traditional form factors and applications, LED lighting offers promise for innovative design

[4] (DOE 2008)

[5] (IESNA 2000, 13-1)

in the ability to deliver light in non-traditional forms, the multitude of possible color and intensity choices, and the inherent directionality and uniformity of light provided by solid-state lighting.

LED sources are more efficacious than incandescent and halogen sources, but less so than fluorescent sources. While current LED products generally emit less total flux (light output) than the baseline products they are replacing, uniformity and directionality have been shown in various application assessment studies to demonstrate acceptable replacement strategies. LED light sources are continuing to improve in terms of efficacy, and luminaire design is also undergoing refinement in terms of thermal and optical efficiency; luminaire efficacies have reached approximately 50 lumens per watt (lm/W).

Multipurpose LED light bars (a linear track of individual LEDs that mimics the form and distribution of fluorescent fixtures) and medium-base and pin-based MR16 luminaires are available from several manufacturers, including Lighting Systems Group (LSG), LED Power, and IMS. Manufacturers typically claim a minimum of 50,000 hours of unit life, along with additional benefits of safe low-voltage operation, non-product-deteriorating light (LED sources do not emit ultraviolet light), cool operation ideal for heat sensitive products, and mercury free, environmentally friendly technology.

Light bar design is currently integrated, forcing the replacement of the entire light bar with the failure of LED components. Self-ballasted assemblies, for example an LED luminaire manufactured to replace an incandescent lamp, integrate heat sink and driver; these are replaced completely upon failure. LED MR16 and other lamp-like assemblies offer the advantage that they can be obtained for use with standard MR-16 or medium base sockets to meet the requirements of existing conditions but must be tested to ensure compatibility with the existing track transformer.

3 Project Objectives

PG&E's Emerging Technologies Program seeks to accelerate the market penetration of energy-efficient technologies, applications, and tools that are not widely adopted in California. Application assessment studies, such as this serve to measure, verify, analyze, and document the potential energy savings and electric demand reduction of specific technologies and applications in different market segments.

This study focused on the following objectives in order to gauge the current feasibility and performance of the application of LED light sources to the hospitality environment, categorized as the Lodging-Hotel and Lodging-Motel end-uses in the Database for Energy Efficient Resources (DEER):

- The quantitative comparison of the luminance, illuminance, and correlated color temperature measured in the field application of three different LED luminaires and baseline lighting systems to three different lighting scenarios.
- The quantification of potential energy savings. This study incorporated data logs from isolated lighting circuits and in-house product bench testing to determine the level of demand and energy savings currently achievable by LED luminaires.
- The solicitation of feedback from the hotel staff and management regarding the project implementation and outcome.

4 Experimental Design and Procedure

4.1 Project Background and Timeline

Prior to this study, PG&E had identified LED sources as an emerging technology application for hospitality display lighting, developed test objectives and conditions, and identified a project host, Hilton's Doubletree Hotel in San Jose, Northern California, to participate in the study.

This application assessment study was designed to measure the performance of three lighting systems in three different lighting applications. PG&E worked with the project host to identify the following lighting systems and applications:

- **Linear fluorescent lighting providing ambient light in hotel entranceway coves**
  Four linear 4' T8 fluorescent lamps powered by solid-state ballasts were replaced four 4' LED light bars and associated drivers.

- **Incandescent lamps providing accent light for an atrium in a hotel restaurant**
  Eight 11 W screw-based incandescent lamps were replaced by eight LED luminaires with a screw-based, lamp-like form factor.

- **Halogen lamps suspended to provide spot light above the hotel bar**
  Nine 50 W halogen MR16 lamps were replaced by nine LED luminaires with a pin-based, MR16 form factor.

Photographs of sample baseline and LED lighting systems for the bar lighting are shown in Figure 4.1 and Figure 4.2, respectively. Photographs including superimposed photometric data from in-field photometric measurements areas are included in Appendix B.

Figure 4.1 Baseline Bar Lighting (Halogen MR16 lamps)

Figure 4.2 LED Bar Lighting (LED MR16 luminaires)

PG&E accordingly drafted a scope of work outlining the basic steps required for a field evaluation of this technology. The project team drafted a test protocol to be used in planning for and conducting the field-testing of the baseline and LED lighting systems.[6]

The following are key dates and milestones of the project:

October 30, 2007
Project kick-off meeting. PG&E, project host, and project evaluation team were present to identify test sites and discuss project parameters.

March 06, 2008
Baseline photometric testing performed and electric demand data logger installed to record baseline power measurements for baseline fluorescent lighting.

March 10 to March 19, 2008
In-house power testing performed for baseline and LED medium-base lamp and MR16 luminaires.

March 7 to March 21, 2008
Electric demand data logger installed on the fluorescent entranceway lighting system.

March 15, 2008
Replacement LED lighting systems installed.

March 21, 2008
Photometric testing of LED lighting systems performed. Electric demand data logger disconnected and power measurements collected.

March 24, 2008
Project host provided with Customer Feedback Survey.

May 30, 2008
Customer Feedback Surveys returned.

September 23, 2008
Follow-on photometric testing of baseline and replacement LED lighting systems performed for fluorescent and halogen lighting systems in the entranceway and bar.

6 See Appendix A.

4.2 Product Information and Installation

The LED luminaires were provided by two manufacturers. Light bar, 3 W pin-based MR16, and 2 W medium-screw-base luminaires were provided by LEDPower. The medium-base luminaire was provided as a prototype, and, therefore no product specifications or information are available.

An additional 4.7 W pin-based MR16 luminaire was provided by IMS.

All projects were installed by the project host facilities staff. Product specifications are provided in Appendix D.

4.3 Photometric Field Measurements

4.3.1 General Approach

The project team devised a testing protocol for the purpose of characterizing the lighting system performance.[7] Lighting performance was measured and assessed in terms of three main attributes: luminance, illuminance, and correlated color temperature. The Lighting Design Lab provides an online glossary of lighting terms; key terms are described below as a background to the test parameters.[8]

- **Luminance:** The luminous intensity of a surface in a given direction per unit area of that surface as viewed from that direction; often incorrectly referred to as "brightness."
- **Illuminance:** The density of incident luminous flux on a surface; illuminance is the standard metric for light levels, and is measured in lux (lx) or footcandles (fc).
- **Correlated color temperature (CCT):** The absolute temperature of a blackbody radiator having a chromaticity equal to that of the light source; measured in Kelvin.

One of the requests that preceded this study was for existing fluorescent lamps to be replaced with new fluorescent lamps and to ensure they operated prior to testing (burned in) for at least 100 hours to stabilize the baseline condition. This adjustment to the baseline condition was intended to allow the comparison of the light output of existing and replacement light sources at the same point of depreciation, in this case as new. However, actual testing did not take place under these conditions due to alterations in the testing schedule and the need for retesting (discussed below).

All measurements were performed at night in order to minimize the impact of outside light. The ambient light levels are considered to equally impact the baseline and the replacement lighting.

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7 See Appendix A for the full testing protocol.

8 (Lighting Design Lab n.d.)

4.3.2 Measurement Locations

Photometric measurements were to be taken at discrete, repeatable locations on nearby surfaces. These were roughly gauged as the wall near the entrance way for the fluorescent lighting system, the bartender's surface for the halogen lighting system, and the wall directly above the incandescent lamps in the restaurant atrium. For consistency between pre- and post-installation conditions, luminance measurements were performed at the same positions and from the same viewing angles in both cases (luminance maps are provided for review in Appendix B).

The recorded luminance and illuminance levels of the decorative incandescent lamps in the restaurant atrium were minimal in comparison with surrounding lighting systems. Essentially, the existing lamps only provided visual interest to the surface. Therefore, photometric measurements from this application were not included in this study. Measurements of luminance and illuminance were recorded from the fluorescent and halogen lighting systems. Initial measurements were reviewed and it was determined that additional measurements would be required to complete the evaluation; specific measurements were retaken to confirm initial findings. However, due to the installation of the replacement LED light bars, comparison of photometric data from baseline and LED lighting systems in the entranceway was deemed of limited value.[9]

All measurements reported in this study are based on the most recent set of measurements.

4.3.3 Luminance Measurements

Luminance was measured in candela per square meter (cd/m^2). For the fluorescent and replacement LED lighting systems in the entranceways, luminance readings were recorded at a distance of 4' from the surface of the wall, horizontally, at four distinct wall positions.

For the halogen and replacement LED lighting systems in the bar, the merchandise itself (i.e. three different bottles on the bar display) as well as the bar counter were measured. Luminance readings were performed at approximately 3' from the targets. Luminance measurements were performed within the breadth of the beam spread.

4.3.4 Illuminance Measurements

Illuminance values for this study were recorded in footcandles (fc). For the fluorescent and replacement LED lighting systems, four vertical illuminance readings were performed at a height of 30" and 67" at the left and right side of the side wall with the sensor of the light meter placed vertical to the horizon. One more reading, of horizontal illuminance, was recorded at a height of 30", with the sensor of the light meter placed parallel to the horizon.

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[9] See Section 7.1 for a full discussion of the installation of the replacement LED light bars.

For the halogen lighting and replacement LED lighting systems, all illuminance readings were performed along the bar counter with the sensor of the light meter placed parallel to the horizon. Illuminance measurements were performed within the breadth of the beam spread.

4.3.5 Correlated Color Measurements

Correlated color measurements were recorded approximately 3' from the source and measured in Kelvin (K).

4.4 Electric Demand Measurements

The project team developed an electric demand measurement protocol for the purpose of determining the electric demand and the energy use of the baseline and LED lighting systems.

An electric demand data logger was installed, pre-programmed to record voltage, current, power factor, and electric demand at 15-minute intervals. The circuit associated with the cove lighting was identified in the lighting control panel as Breaker #22. The incandescent lighting system and the halogen lighting system circuits could not be isolated; therefore, the power measurements for single lamps from each application were performed in-house.

4.5 Testing Equipment

The following monitoring equipment used in the execution of this Monitoring Plan:

- **Correlated Color Temperature Meter/Illuminance Meter**
  Konica Minolta CL-200 Chroma Meter with ±2% accuracy; last calibrated October 2007.

- **Luminance Meter**

  Konica Minolta LS-100 Spot Luminance Meter with ±2% accuracy, last calibrated 10/2007

- **Electric Demand Meter**
  DENT ElitePro Data Logger with less than ±0.5% accuracy typical; last calibrated April 2007.

5 Facility Information

The host facility is the Doubletree Hotel in San Jose. PG&E provides electrical service. Hotels in PG&E's service territory normally qualify for an E-20S time-of-use electricity rate because electric demand often exceeds 1,000 kW. The actual utility information for this site is held confidential by the owner and was not used in the development of this report.

The E-20S rate schedule is a time-of-use tariff, which means that electricity is provided at different rates depending on the time of day it is used. Based on PG&E E-20S rate schedule information, the average electricity cost during the occurrence of project savings was calculated to be $0.0997/kWh; this figure includes demand charges.[10]

[10] Please refer to Appendix C-2 for rate information and time-of-use rate calculations.

6 Project Results

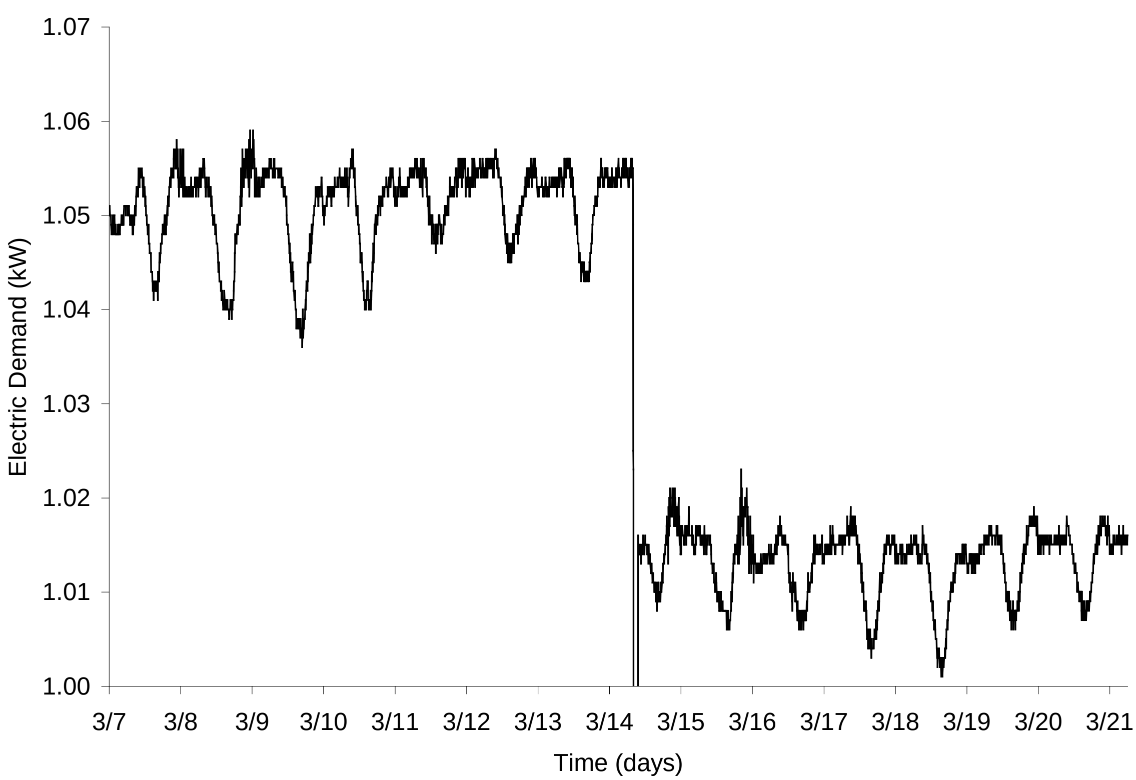
6.1 Electrical Energy and Demand Savings

Calculations of electrical energy and demand savings are based on electric demand measurements from baseline and LED luminaires.[11] Savings from the LED light bars are calculated based on electric demand logged for the entire isolated lighting circuit. Since the circuits for the medium-base incandescent and halogen MR16 lamps could not be isolated, calculations are based on the extrapolation of in-house electric demand measurements.

6.1.1 Electric Demand Measurements

Figure 6.1 shows data from the 15-day testing period during which the electric demand data logger was installed. The logged circuit included 28 fluorescent fixtures, four of which were replaced by LED light bars. The reduction in power observable on March 14 demonstrates the demand savings achieved with the installation of the LED light bars; the reduction in electric demand for the entire circuit was calculated at 0.038 kW.

Figure 6.1 Cove Lighting Electric Demand Profile



[11] Complete electrical energy and demand savings calculations can be found in Appendix C-2.

Figure 6.2 and Figure 6.3 show recorded data from in-house testing of the halogen MR16 and medium-base incandescent lamps and the replacement LED luminaires. Measurements were recorded using the same electric demand data logger installed on-site, and the comparison of the two hour-long test periods reveals the recorded reduction in electric demand.

The recorded demand reduction achieved by the LED medium-base luminaire was calculated at 0.007 kW. Both MR16 lamps were tested in house: the LEDPower and IMS MR16 luminaires drew an average of 0.005 kW and 0.006 kW, respectively. Electric demand savings were calculated using the average of the measured electric demand for each luminaire, weighted based on the proportion of each lamp (LEDPower or IMS) installed.

Figure 6.2 Atrium Lighting Electric Demand Profile

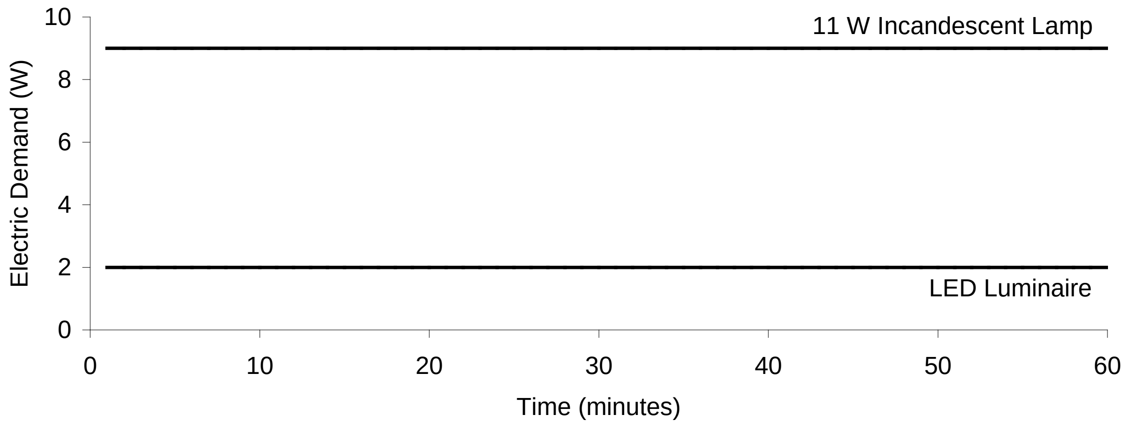
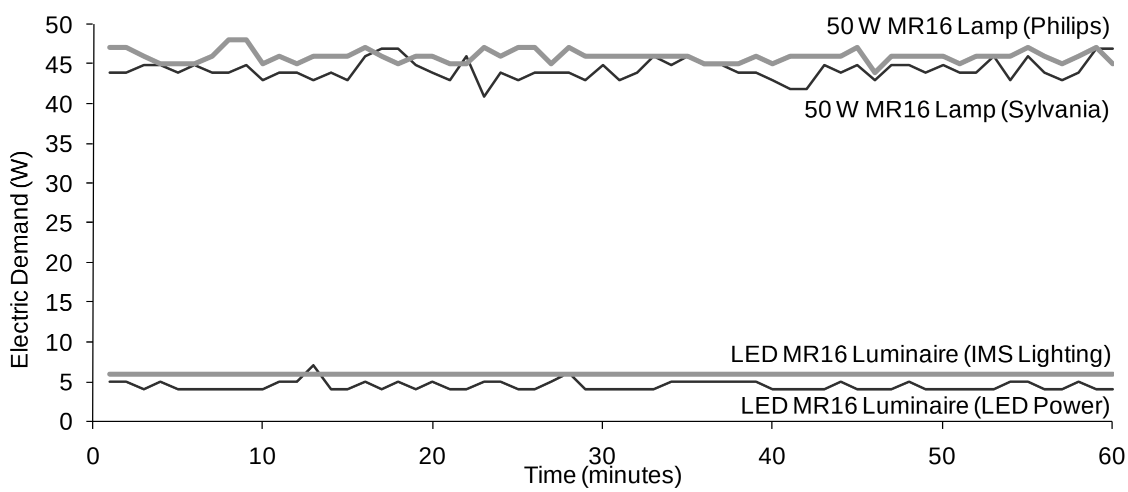


Figure 6.3 Bar Lighting Electric Demand Profile



6.1.2 Demand Savings

The total electric demand savings for the entire project were calculated at 0.452 kW. The average measured power and calculated demand savings per fixture and per application are summarized in Table 6.1. For the cove lighting application, post-case electric demand data had to be normalized to reflect the average power draw for the four LED light bars installed, since 24 fluorescent fixtures remained on the lighting circuit.

Table 6.1 Project Demand Savings

Lighting Application/ Lighting System	Average Measured Power (kW)	Electric Demand Reduction/Luminaire (kW)	Total Electric Demand Savings (kW)
Entranceway lighting			
(4) T8 fluorescent lamps	1.051	0.038	0.152
(4) LED light bars	1.013	0.029	0.116
Δ	0.038	0.009	0.036
Δ (%)	-	-	23.7%
Atrium lighting			
(8) 11 W incandescent lamps	-	0.009	0.072
(8) LED luminaires	-	0.002	0.016
Δ	-	0.007	0.056
Δ (%)	-	-	77.8%
Bar lighting			
(9) 50 W halogen MR16 lamps	-	0.046	0.414
(9) LED MR16 luminaires	-	0.006	0.054
Δ	-	0.040	0.360
Δ (%)	-	-	87.0%
		Total Project Demand Savings (kW)	0.452
		Total Project Demand Savings (%)	70.9%

The project host uses a lighting control system to control the lighting; however, all three test areas operate continuously, including throughout the utility peak electricity rate period, which extends through the hours 12 pm to 6 pm. The recorded data support the assumption that cove lighting operates continuously during the regularly scheduled intervals. Based on observations while on site and discussions with facilities staff, operations are listed as continuous. Therefore, the demand savings for this project are coincident, because they reduce the electric load during the utility peak demand period.

The base-case lighting sources in this study are relatively modern and efficient. The estimated reductions in electrical load are, thus, conservative, relative to older, less efficient baseline equipment that may be present in other facilities.

6.1.3 Annual Energy Savings

As described in the previous section, the base case lighting systems operate continuously, as reported by facilities staff and on-site observations. No operational changes were made to the evaluated lighting systems during the course of the study.

Replacement of the three base-case lighting systems with test-case lighting resulted in a combined savings of 3,961 kWh per year in lighting energy savings.

Table 6.2 Project Energy Savings

Lighting Application/LED Lighting System	Total Electric Demand Savings (kW)	Operating Hours (hr/yr)	Annual Energy Savings (kWh/yr)
Entranceway lighting (fluorescent) 4 LED light bars	0.036	8,760	316
Atrium lighting (incandescent) 8 LED medium-base lamp luminaires	0.056	8,760	491
Bar lighting (halogen) 9 LED MR16 luminaires	0.360	8,760	3,154
	Total Project Annual Energy Savings (kWh/yr)		3,961
	Total Project Annual Energy Savings (%)		70.9%

6.2 Maintenance Savings

6.2.1 Effective Useful Life

Manufacturers, including the manufacturers who provided the products for use in this study, tend to report an effective useful life (EUL) for LED lighting systems of at least 50,000 hours in product specifications. At the continuous operating hours (8,760 hr/yr) in this study, EUL calculates to 5.7 years, over twice the lifetime of the fluorescent lighting system, and over 16 times the lifetime of the incandescent lighting systems.

Nonetheless, actual system lifetime for LED luminaires has yet to be verified by formal testing. LED performance and lifetime is heavily affected by drive current, thermal management, and ambient temperature. The DOE has reported testing at the LRC which demonstrates the significant deficit in lifetime of an LED source caused by an 11 °C difference in operating temperature.[12] This information is now dated, especially considering the quickening development of LED technology, but demonstrates the need for conservative estimates of EUL given the current instability of the market, lack of independent laboratory product testing, and influence of thermal management and ambient temperature.

Additionally, recent standard LM-80, issued by the IESNA in October 2008, defines end of life at 70% of initial lumen output. Therefore, manufacturer's estimates may require even further qualification before they can be readily employed to estimate system lifetime.

6.2.2 Lifecycle Impacts

Replacement of fluorescent and incandescent lighting systems with LED lighting systems will typically result in avoided maintenance costs over the life of the new LED system. Since the LED lighting systems have a longer EUL, they will incur fewer equipment replacements and lower maintenance costs over life.

Maintenance savings are based on more than two cycles of avoided fluorescent lamp replacement and more than 16 cycles of avoided incandescent lamp replacement during the lifetime of the LED lighting system. Maintenance savings also assume that a small percentage (14.6 percent) of ballasts for the fluorescent lighting systems will fail annually; the percentage of actual failures will likely be higher or lower depending on the age of the ballasts.[13]

The avoided costs due to maintenance are calculated to average approximately $608.05/yr over the life cycle of the LED source. These savings are included in the project economics as shown in Table 1.3.

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[12] (Building Technologies Program 2007)

[13] The overall avoided maintenance costs during the expected life of the LED system are calculated in Appendix C-2.

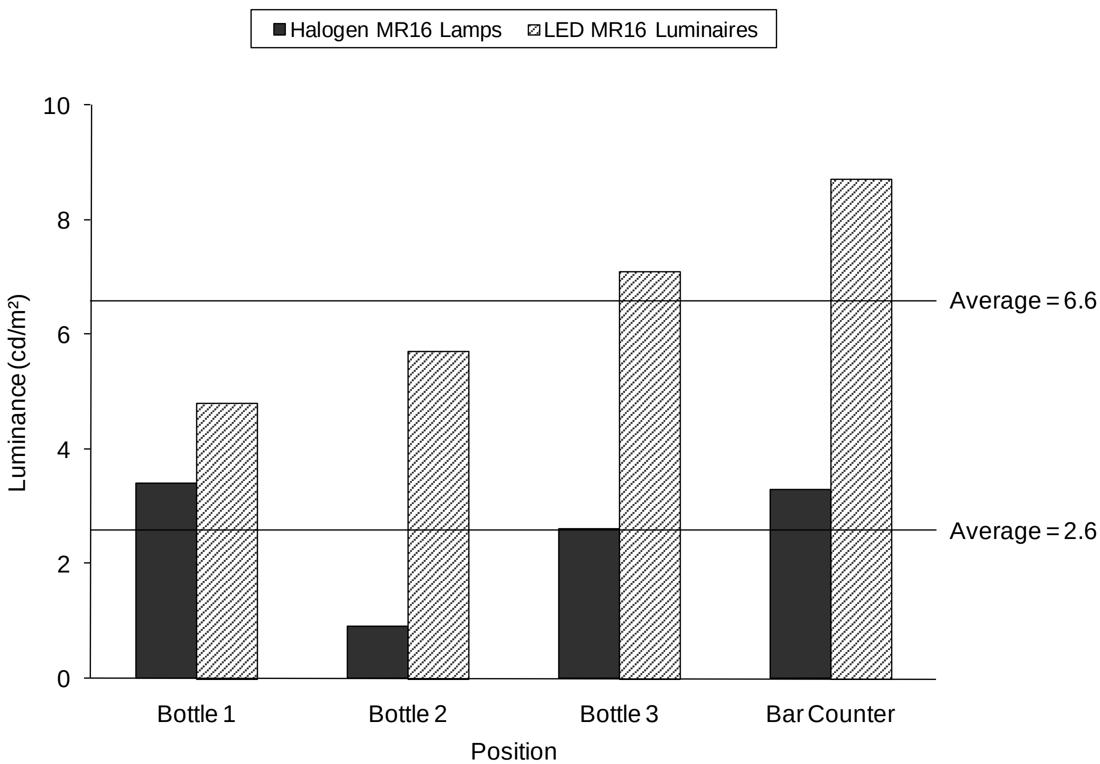
6.3 Photometric Performance

As discussed in Section 4.3.2, photometric field measurements were only established for the halogen lighting system in the hotel bar. A summary of prominent project findings is included below; detailed information is provided in Appendix B (luminance and illuminance maps) and Appendix C (calculations).

6.3.1 Luminance

Figure 6.4 compares the luminous intensity of the baseline and LED luminaires. In the case of the MR16 luminaires in the bar, Figure 6.4 shows the higher levels of luminance achieved by the LED luminaires.

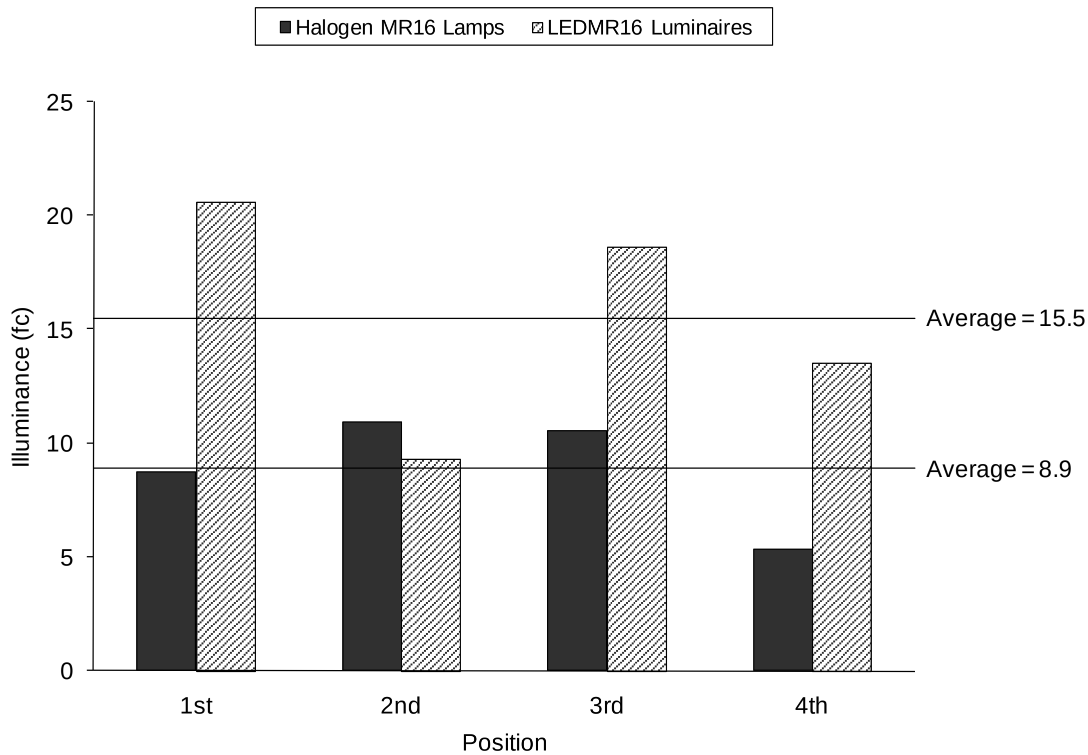
Figure 6.4 Bar Luminance Measurements



6.3.2 Illuminance

Figure 6.5 compare illuminance measurements for the baseline and LED lighting systems. Similarly to the results from the luminance testing, higher illuminance levels were measured for the LED MR16 luminaires than for the halogen MR16 lamps.

Figure 6.5 Bar Illuminance Measurements



6.3.3 Correlated Color Temperature

The baseline halogen MR16 lamps used at the bar recorded a CCT that varied between approximately 2,350 K and 2,800 K. The baseline MR16 halogen lamps were rated at 3,000 K by their manufacturers.

The manufacturers selected replacement LED products to match the baseline color temperature. Their CCT measured at approximately 3,200 K; they were rated by the manufacturers at 3,500 K.

6.4 Incremental Cost for Materials and Installation

The projects undertaken for this demonstration and assessment replaced lighting systems with new LED lighting systems. For the retrofit of existing lighting systems with replacement lighting systems, the incremental cost of the project is the actual installed cost of the new lighting systems. The incremental cost basis for economic evaluation should be the actual installed cost. However, in this case, the material was provided at no cost to the end user, and the host customer provided the installation labor.

The manufacturer provided a sample cost basis for the materials used in the three test areas: LED light bars at $152.00 per four-foot light bar section [including power supply], MR16 replacements at $31.00 per unit, and LED medium-base lamp replacements at $18.00 per unit.

The labor cost used in the economic analysis for light bar installation was based on an analysis of the labor hours (0.185 hours per unit) required for similar work performed during a previous application assessment performed for the Emerging Technologies Program, Report #0617. For the MR16 and medium-base lamp replacements, Means Electrical Cost Data was used to estimate the time required for lamp replacement. The labor cost for each project was calculated based on the total unit labor hours for the project multiplied by the burdened labor rate for an electrician performing work in the local area. See Table 1.3 for a summary of project economics.[14]

[14] Additional information is provided in Appendix C-2.

6.5 Customer Feedback

Feedback was gathered from employees at the bell desk, the cafe, and the events department. The survey asked respondents to rate their level of satisfaction with the replacement lighting system, with regards to the following factors, among others:[15]

- Visual interest in the merchandise
- Amount of light
- Personal preference

6.5.1 Entranceway lighting (fluorescent baseline)

Surveys completed: 2

The respondents reported a slight increase in the perceived level of light and were satisfied with the replacement LED lighting system.

6.5.2 Restaurant atrium lighting (incandescent baseline)

Surveys completed: 3

Generally, respondents thought the replacement LED lighting system produced about the same amount as the baseline lighting system and reported moderate satisfaction.

6.5.3 Bar lighting (halogen baseline)

Surveys completed: 1

Although the respondent thought the replacement LED lighting system provided less light than the baseline lighting system, they were very satisfied and would recommend it.

[15] The completed surveys are available as Appendix E.

7 Discussion

7.1 Site Coordination and Product Installation

Significant lessons were learned during this assessment project related to site coordination and field installation, which affected to equipment performance and evaluation.

Firstly, the restaurant atrium selected for evaluation was renovated during the test period; the test lighting system was removed. For this reason, photometric analysis of this system could not be included. Study areas should be carefully coordinated with planned host site facility changes.

Figure 7.1 illustrates installation issues related to the replacement LED light bars in the entranceway that may have affected in-field photometric measurements and may have compromised the direct comparison of baseline and LED lighting systems (figures are referred to in alphabetical order, from (a) to (c), in order from top to bottom). Figure (a) depicts the original orientation of the fluorescent fixtures. In order to mitigate the effect of the direct glare experienced with the LED system, the replacement LED light bars were installed at rotation of 90 degrees as compared to the baseline fluorescent fixtures, as shown in figure (b). Additionally, some LED light bars became misaligned during the test period due to the method used to affix the light bars to the ceiling during the installation process. The faltering alignment of the light bars was responsible for sub-optimal distribution of light (shifting mainly towards the ceiling and upper wall as depicted in figure (c)) and may have affected the resultant reduction of measured illuminance levels as compared to optimal placement. Because of these uncertainties regarding the comparison, photometric analysis of this area was not included.

More detailed project design may mitigate the need for field adjustments. Future field tests should include greater feedback and coordination when modifications to the design intent are manifested during implementation.

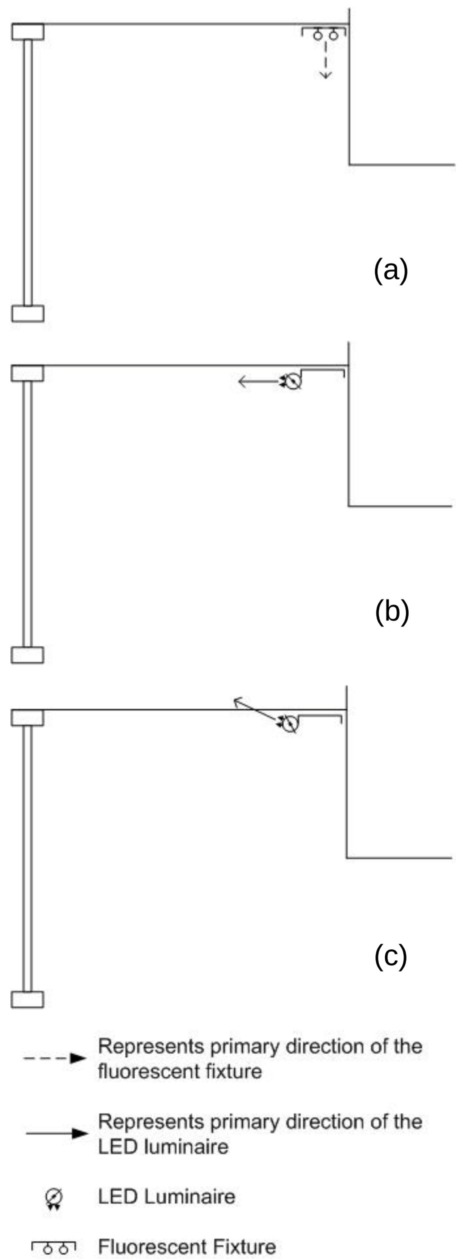


Figure 7.1 Orientation of Baseline Fluorescent and Replacement LED Light Bars

7.2 Product Evaluation

7.2.1 Comparison of Baseline and LED Lighting System Performance

At the bar, higher illuminance and luminance levels were measured for the LED MR-16 luminaires than for the baseline halogen lamps. This is likely due to the highly directional nature of the LEDs, and that the main task area (the bar countertop) was a narrow enough surface to receive the full distribution of light from the narrow beam spread of the LED MR16 luminaires.[16]

Table 7.1 LED MR16 Lighting System Performance

	Baseline Fluorescent Lamps	Replacement LED Light Bars	Δ Average (%)
Luminance (cd/m²)	2.6	6.6	154%
Illuminance (fc)	8.9	15.5	74%

These findings differ from the general performance trends of LED lighting systems observed in other application assessment studies. Both luminance and illuminance measurements were increased by the LED MR16s in the application; this is attributed to the focused distribution of light required form the task.

7.2.2 Manufacturer's Claims and Product Performance

Since LED lighting technology is still emerging and evolving, much inconsistency has been observed in the industry. Even as of 2008, testing results are at variance with manufacturer's claims:

> *"CALiPER testing continues to reveal that many SSL [solid-state lighting] products do not meet manufacturer performance claims, although a few high-performing products are emerging on the market and definite progress can be seen in some product categories."*[17]

Round 4 of CALiPER testing, in January of 2008, revealed that for about 9 out of 15 SSL products tested, "information published by manufacturers regarding product output and/or efficacy overstated performance (by factors ranging from 30–600%)."[18]

Since independent laboratory testing of the products used in this assessment was not available (see Section 7.2.3) comparison between product specifications and project results are difficult to draw. Of note, power measurements generally align with product

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16 According to manufacturers' specification, beam spread was 15 and 24 degrees for the LEDPower and IMS products, respectively. See Appendix D for details.

17 (CALiPER Round 6)

18 (DOE 2008)

specifications with the exception of the light bars. When combined with the demand of the driver, the difference as compared to reported electric demand is considerable.

Table 7.2 Demand Performance

Lighting System	Reported Electric Demand (W)	Average Measured Electric Demand (W)
LEDPower: LED Light Bar 4' section	16	29
LEDPower: MR16 Luminaire	3.0	4.5
IMS: MR16 Luminaire	4.7	6.0

7.2.3 Independent Product Laboratory Testing

The manufacturers were unable to provide independent laboratory test data for the products tested in this study.

Independent testing usually includes the measure of total luminous flux, input electrical power, luminaire efficacy, luminous intensity distribution, lumen maintenance, correlated color temperature, and other standardized performance characteristics.

Independently verified distribution data would have been particularly useful in interpreting field measurements and end user perceptions. Since LED lighting system performance is often amplified by the accurate delivery of light from source to application, this information is especially useful. Independent laboratory efficacy ratings would also have been integral to a thorough evaluation of luminaire efficacy as a comparison with manufacturer’s claims. It is recommended for future studies of this type that lighting samples be provided to independent agencies for laboratory testing during the initial phases of implementation. IESNA LM-79-08 details electrical and photometric testing methodology specifically addressed to the unique requirements of solid-state lighting.[19] This standard is quickly being adopted by the industry, and, along with IESNA-80-08 and ANSI C78.377-2008, which address lumen depreciation and chromaticity, respectively, will become more and more necessary for the evaluation of LED lighting systems.

7.2.4 Luminaire Performance

Efficacy is the standard definition for lighting performance, defined as “the ratio of light from a lamp to the electrical power consumed, including ballast losses, expressed as lumens per watt.”[20]

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[19] (IESNA 2008)

[20] (Nebraska Energy Office n.d.)

This study approaches lighting performance differently, since only field measurements of photometric and electric demand data were available. Illuminance ratings were adopted as the primary indicator of luminaire performance, as this rating reflects the incident light important to customer and retailer perception. While not as controlled as laboratory measurements, illuminance measurements also offer insight into luminaire optics and other environmental factors.

Table 7.3 summarizes the performance of the LED MR16 luminaires in terms of illuminance and electric demand.

Table 7.3 Summary of Luminaire Performance

Lighting System	∆ Average Illuminance (%)	∆ Electric Demand (%)
Bar lighting LED MR-16 luminaire replaces 50W halogen MR-16 lamp	75%	(87%)

7.2.5 Comparison of Luminaire Performance against DOE CALiPER Testing

Although no LED MR-16 luminaire tested by the CALiPER program directly matches the luminaires tested in this study, general comparisons can be drawn regarding performance trends. As of publication of this report, six rounds of CALiPER testing have been published with efficacy results for various LED applications and their “standard” (fluorescent or incandescent) counterparts.

Table 7.4 provides a representation of CALiPER testing used as points of comparison in the discussion of system performance. Since few products have been tested *in situ*, this sample data takes bare lamp photometric readings as indications of the expected performance of the products used in this study. In addition, comparisons of light output between CALiPER data (luminous flux, measured in lumens) and the measurements recorded in this field study (luminous exitance, measured in footcandles) are limited.

Table 7.4 DOE CALiPER Testing of LED MR16 and Light Bar Luminaires

Test Description	DOE CALiPER Test ID	Efficacy (lm/W) difference* (%)	Demand difference* (%)	Initial lumen output difference* (%)
SSL Light Bars (32 W T8 Fluorescent)	07-56, 08-17, 08-19, 08-37	(59%)	(36%)	(73%)
SSL MR16 (20 W Halogen MR16)	07-53, 07-59, 07-64, 07-17, 07-58, 08-07, 08-83, 08-84, 08-97, 08-98	96%	(80%)	(64%)

* Results represent mean data from entire testing series. All values are rounded to the nearest integer.

As of Round 6, ten different MR-16 LED luminaires have been tested alongside six baseline 20 W halogen MR-16 lamps.[21] Testing concludes that, although the LED luminaires have less average lumen output compared to the 20 W halogen lamps, lumen output as well as efficacy (lm/W) of the LEDs has increased as testing rounds progress. The efficacy of the LEDs ranges between two and three times the average efficacy of the halogen lamps (~25 lm/W as compared to ~12 lm/W). Nonetheless, these efficacy levels do not reach the levels claimed by the product manufacturers.

Round 5 of the program compared four different 4' LED light bars against a baseline of 4' 32 W linear fluorescent T8 lamps. Generally, these results demonstrate higher reductions in initial lumen output and lower reductions in electric demand as compared to more directional fixtures like the MR16 luminaires.

Field testing of the luminaires generally agree with the performance trends revealed by CALiPER testing, with the notable exception that the niche application of LED MR16 luminaires in the bar resulted in an overall increase in luminance and illuminance levels over the application area.

7.3 Measure Feasibility and Market Potential

7.3.1 Current Feasibility and Potential

The measures are technically feasible but range in cost-effectiveness at current market conditions. Projected simple payback periods (including the impact of maintenance savings) range from less than one year for the bar and restaurant lighting replacements, to approximately six years for the entryway cove lighting, which is roughly equivalent to EUL.[22]

The reduction of energy use in the lodging and hospitality sector can be a challenging task because services are driven by a need for customer satisfaction, in turn dependent on their visual and physical comfort. Although lighting does not account for the main portion of a hotel's energy use, significant savings can be accomplished through energy efficient lighting technologies. According to the DOE Efficiency and Renewable Energy Building Technologies Program, "renovations to existing hotels—replacement of inefficient boilers, lighting, and other systems—can save up to 30 percent on annual energy costs."

This demonstration project achieves reduction in lighting energy usage, while maintaining customer acceptance. The adoption of this technology in the lodging and hospitality industry depends mainly on its integration with each building's architecture and interior design and its ability to provide a comfortable and welcoming customer environment. LED technology offers multiple design solutions that can help create the atmosphere required by each specific lighting application.

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[21] In the current study, the input power of the halogen MR-16 lamp was 50 W.

[22] These estimates are based on an effective useful life of 50,000 hours and associated maintenance savings. See Appendix C for cost-effectiveness calculations.

7.3.2 Cost and Performance Projections

Widespread adoption of solid-state lighting rests both on suitability of application and cost effectiveness. Suitability issues are largely performance issues, including color, distribution, product life, and power requirement, and are discussed elsewhere in this report.

Cost effectiveness criteria vary, but life-cycle cost analysis, for example, generally consider first costs, operating costs, useful life, cost of disposal, and economic factors such as depreciation and escalation. The industry generally measures lighting cost effectiveness in terms of the first cost associated with a given level of lumen output, as reported in dollars per kilolumen ($/klm). In reporting and projecting future trends in cost effectiveness, this metric accounts for change in production cost and source efficacy, that is to say, dollars or kilolumens, respectively. The potential of LED technology for rapid change is expressed in general terms by Haitz's Law, which predicts that every 10 years efficacy will increase by a factor of 20, while cost will decrease by a factor of 10.

The DOE projects the market penetration for white LED lighting applications based on technological development and materials and manufacturing cost improvements.[23] The modeling system is based on the state of the industry in 2001, at which time market penetration was defined as zero, and the cost of medium CRI LED technology was set at $275/klm.[24, 25] The most conservative projection for 2010 predicted efficacy would reach 45 lm/W and cost would reduce to $36/klm; the report's most conservative scenario predicted a cost of approximately $8/klm by 2020, while the least conservative model predicted a cost of approximately $0.50/klm.[26]

A comparison of the predictive models can be drawn against the current state of the industry as a partial validation of the models. LED efficacy testing in accordance with LM-79 protocol has already exceeded the predicted efficacy of 45 lm/W in numerous applications including a 2007 DOE typical performance value of 54 lm/W for medium CRI LED technology.[27]

The same multi-year program plan for solid-state lighting research and development, issued by the DOE in 2008, offers updated pricing prediction models. These models demonstrate that the 2001 study's projected performance has already been exceeded; the pricing for a 1 W cool-white LED source was reported to be $35/klm in 2006 and $25/klm in 2007: cost reductions beyond Little's prediction of $36/klm in 2010.[28] This more recent DOE model further predicts LED source technology to reach price points of $10/klm in 2010, $5/klm in

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23 (Little 2001)

24 *Ibid.*

25 CRI becomes a determining factor in cost effectiveness due to the expense of the phosphor coating needed to achieve a given CRI level.

26 *Ibid*.

27 (Navigant 2008)

28 *Ibid.*

2012, and $2/klm in 2015. It should be noted, however, that the full price of an LED luminaire (~$100/klm in 2008) is greater than that of the device.[29]

7.4 Future Technology Improvements

7.4.1 Increasing Industry Standardization

The development of LED lighting standards is continuing at a rapid pace; 2008 saw the release of:

- ANSI C78-377-2008. *Specifications for the Chromaticity of Solid-State Lighting Products for Electric Lamps*. February 2008.
- IESNA LM-79. *Approved Method: Electrical and Photometric Testing of Solid-State Lighting Products*. May 2008.
- IESNA LM-80. *Approved Method for Measuring Lumen Depreciation of LED Light Sources*. October 2008.

Furthermore, ENERGY STAR criteria for solid-state lighting luminaries, which went into effect on September 30, 2008, stipulate minimum linear flux levels. Importantly, this represents the increasing acceptance of the directionality and focus of LED lighting, which bears relevance to this application study.

Major standards in development include IESNA RP-16 (Definitions), ANSI C82-.XX1 (Power Supply), and UL 8750 LED (Safety). These standards will help coalesce the industry's offerings in terms of quality and performance, which should in turn bring a greater reliability of performance in the marketplace.

7.4.2 Projected Improvements in Manufacturing and Materials Science

LED lighting is a rapidly advancing technology. It is anticipated that on-going improvements to the LED technology, power supplies and installation methods will lead to continuing price reductions and increased energy savings. Manufacturers are working to improve thermal efficiency to enhance expected life and light output.

The combination of advancements in materials science, luminaire design, technology adoption, and market stabilization is expected to result in continued improvement in the viability and cost-effectiveness of LED lighting technology.

[29] *Ibid.*

8 Conclusions

A full-service hospitality center provides a challenging test environment in that the laboratory is also a place of business, thus any changes in operations or appearance are scrutinized by hotelier and customer alike. The survey results support general acceptance of the demonstration project by the project host. This suggests that one of the major barriers to implementation, user satisfaction, is surmountable for the application.

The other major traditional barrier to implementation is cost-effectiveness. The data support a significant savings opportunity for the applications included in this assessment, however, the level of cost-effectiveness varies. The direct replacement of MR-16 and decorative medium-base incandescent lamps was cost effective in this demonstration: the cost of implementation was significantly less than the value of the energy savings available over the product's expected life. For the fluorescent cove lighting replacement application, the cost of implementation barely exceeded the combined value of the energy and maintenance savings available over the product's expected life.

It is important to note that the cost-effectiveness of LED technology in these types of applications will vary according to actual site conditions. These include actual baseline lighting system configuration, lighting wattage, system operating hours, and utility rate structure. Decorative accent and focused directional applications, which permit reduced light output relative to the baseline lighting systems, produce higher levels of energy savings than those applications for which no reduction in light output is warranted. The bar and restaurant atrium lighting systems are examples of the types of application that are more likely to be more cost effective than applications which require ambient lighting.

In general, the cost-effectiveness barrier is expected to be overcome with maturing market conditions. Various incentive programs could accelerate cost-effectiveness.

PG&E uses this and other Emerging Technologies assessments to support the development of potential incentives for emerging energy efficient solutions. Because the performance and quality of the LED fixtures are critical to the long-term delivery of energy savings, it is important that incentive programs include quality control mechanisms. Incentive programs should include performance standards for qualifying products that include minimum criteria for warranty, efficacy, light distribution, and other important criteria.

9 Recommendations for Future Work

There is definite need for independent research to further develop the performance, potential application, and adoption of LED lighting sources. Recent implementation of standards for LED chromaticity, electrical testing, photometry, and lumen depreciation have provided the industry with a set of laboratory test protocols and metrics. The development of these standards marks the beginning of a maturing solid-sate lighting technology by leveling performance metrics in the laboratory.

Nonetheless, this study outlines areas in two general categories which would help to accelerate the adoption of LED light sources.

9.1 Field Performance

The cornerstone of customer acceptance and technology adoption is field performance; evaluation of field performance is the domain of the application assessment study. Two substantial, broad areas of performance are suggested by customer concerns and by the availability of emerging standards.

1) *Lumen depreciation in solid-state lighting.*
   The project team noted the implications of lumen depreciation in LED sources to lifecycle cost analysis and customer adoption. While life is currently assessed by laboratory testing, an extended in-field study would be a useful tool in assessing the actual long-term performance of LED light sources, especially in respect to manufacturer's claims. A thorough study would require several years, but would yield actual results on the implications of alterations to drive current and thermal management to lumen depreciation. These implications relate to life cycle cost and therefore customer acceptance.

2) *Conventional and LED lighting system design.*
   Detailed photometric analysis of the effect of the nano-optics would offer insight into the proper fixture placement and orientation. Since there is much variation in the current market in regards to form factor and optical design, and solid-state lighting technology differs so inherently from conventional lighting, such a study would offer an initial outline of design guidelines for these emerging systems. Results would benefit application assessment and other in-field studies, while offering preliminary design guidance to early adopters.

9.2 Market Assessment

Equally important to market acceptance and adoption is the perception of value. Two related areas in market research are recommended for further evaluation.

1) *Trends and projections in the end-user cost of LED lighting systems.*
   While Section 7.3.2 provides general estimates of future affordability from DOE research, this research is primarily based upon the cost of the source material. An analysis of recent cost trends in PG&E service territory would be useful to the utility in projecting the short term pricing of LED lighting, including consideration of other system components, and thus to estimate end-user demand for LED products.

2) *End-user reaction to and evaluation of LED lighting systems.*
   The design and implementation of expanded end-user surveys would provide valuable information on the potential for equipment adoption. While some studies have included extensive surveys on perception and aesthetics, of both project hosts and customers, systematic surveys would generate more generalized results and may be used to pose questions related to cost and value.

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Appendices

Appendix A

Test Protocol

PG&E Emerging Technologies Lighting Demonstration Project
LED Low Wattage Lighting (CWA 07 CEE-T-4376)
Testing and Monitoring Plan - Doubletree Hotel

Testing Protocol for Light Emitting Diode (LED) Lighting in Low Wattage Applications

I. Objective

This test protocol is intended to define a test procedure that will be applied to LED lighting in various low wattage applications as part of the Emerging Technologies Program evaluation process. Testing will consist of first recording existing (baseline) conditions, then recording conditions following the implementation of the emerging technology.

II. Project Design Plan

Prior to conducting on-site testing, a project design plan will be required that minimally indicates the quantity of fixtures and specific locations for each test. The responsibility for developing the project design plan will be as agreed between project stakeholders. The project design plan should be made available to Pacific Gas and Electric Company (PG&E), EMCOR Energy Services (EES), the site, the vendor, and the installer prior to initiation of baseline testing.

III. Proposed Testing Areas

1. LED replacement lighting systems will be tested at various locations in the Doubletree Hotel located at 2050 Gateway Place in San Jose, California as follows:
    a. Wall-mounted sconce fixtures provide illumination in hallway areas adjacent to guest rooms. Each fixture contains two 7-Watt compact fluorescent lamps with two-pin plug-in connectors. The project will replace compact fluorescent lamps with custom LED sources in two or more of these fixtures.
    b. Screw-based, low wattage, decorative LED lamps will replace clear incandescent lamps in one of the skylight wells located in the Coffee Garden Restaurant. The project will replace 8 of 64 incandescent lamps from a single section of one of the skylight wells with 8 LED lamps.
    c. Continuous LED light bars will replace fluorescent lighting installed in the "cove" fixtures located over the front door. The cove is approximately 16 feet long and currently contains four single-lamp F32T8 strip fixtures.
    d. Approximately nine MR-16 style LED lamps will replace an equal quantity of low voltage MR-16 halogen lamps suspended over the bar portion of the entertainment lounge.

IV. Performance Issues

The following issues have been recognized as critical to energy savings and long-term customer acceptance.

- Power consumption
- Lifetime and reliability
- Brightness and light quality

V. Setup Protocol

1. Request, receive, and review the Project Design Plan prior to site visit.

2. Existing lamps serving the test area must be replaced prior to baseline testing. The purpose for the adjustment to the baseline condition is to ensure that the light output of both existing and replacement light sources is compared at the same point of depreciation, in this case as "new".
    a. Fluorescent lamps must be replaced with new fluorescent lamps of wattage equivalent to the existing case, and the new lamps must be "burned in" for at least 100 hours to stabilize the baseline condition.
    b. Failed ballasts in test areas should likewise be replaced.
    c. Incandescent, halogen, and low voltage lamps must be replaced with new lamps of wattage equivalent to the existing case.

3. Prior to taking lighting measurements, EES will designate measurement points in each test area by marking out a grid comprising at least three rows and three columns with an identifiable marker.
    a. The actual measurement grids will be determined at the time the tests are performed and will include vertical and/or horizontal components depending on the visual tasks being performed (e.g., circulation, signage, display functions).
    b. EES will take a digital image of each test area and measurements will be superimposed onto the digital image in order to create a measurement map.

4. Prior to taking lighting measurements, EES will document the specific measures taken to isolate the effect of changes to the test lighting systems from general lighting systems that are not subject to change.

VI. Tests Performed

The following tests shall be performed on existing lighting systems and the emerging technology (LED), with the exception of Task 5 of the test. Task 5 will be performed only for the emerging technology.

Due to the substantial presence of natural light through vertical glazing and skylights, illuminance and luminance testing will be conducted during non-daylight hours in most of the test areas.

1. Validate Scope of Project
    a. Base Case: Refer to the Project Design Plan. Validate and record existing light fixture types, quantities, and locations that are intended for replacement or retrofit.
    b. Test Case: Refer to the Project Design Plan. Validate and record light fixture types, quantities, and locations of new LED sources.

2. Measure Luminance
    a. Measure luminance values on the test grid using a Konica Minolta LS100 Luminance Meter.
    b. Record and report the characteristics of the surface of objects on which the luminance measurements were performed, and the distance at which the measurements were taken.
    c. Luminance values will be indicated on luminance maps.

3. Measure Vertical and/or Horizontal Illuminance
    a. Measure and record illuminance values on the test grid area using a Konica Minolta CL200 Chroma Meter.
    b. Measurements will be taken in accordance with viewing angles applicable to the task typically performed.

4. Determine Correlated Color Temperature
    a. Measure and record correlated color temperature on the test grid using a Konica Minolta CL200 Chroma Meter.

5. Determine Color Rendering Index (CRI)
    a. PG&E will coordinate with the California Lighting Technology Center (CLTC) to provide a sample lighting source to the CLTC lab for testing.
    b. EES will coordinate with the CLTC to obtain CRI test results and incorporate results into the report.

6. Determine Power Usage and System Run-Time (Isolated Circuits)
    a. Work with the host site to identify the circuit or circuits powering the test area. Note that in some instances, the test area may include only a portion of a circuit; in others, the test area may include more than one circuit. Selection of the circuit(s) to monitor will be a field decision made at the time that the monitoring equipment is configured.
    b. EES will note all loads present on the circuit(s) being monitored and will also note which additional circuits, if any, are part of the test area but are not being monitored.
    c. Oversee installation of a Dent Elite-Pro data logger by a licensed electrician. System power draw for existing fixtures and the emerging technology (LED) will each be monitored for approximately 7 days.
    d. EES will note the dates of the system changeover.
    e. Oversee removal of the Dent Elite-Pro and evaluate the data collected.

7. Spot Measurement and Run-time Logging (Non-isolated Circuits)
    a. Where EES determines that lighting circuits do not correlate well with the test fixtures, perform and record spot power measurements for selected test area fixtures.
    b. Install lighting loggers at test area light fixtures to record fixture runtime operating information.

8. Photo Documentation
    a. For each lighting system being evaluated, use high resolution digital photography to document baseline lighting systems, including the effect of lighting on selected task areas, visual images of the light source as applicable, and general images of the surrounding area.

9. Customer Satisfaction
    a. EES will draft a brief written survey to help determine the level of customer satisfaction with the test installation.
    b. EES will present the survey to the host site management for approval.
    c. Upon management's approval, the survey will be administered to the host site's staff, management, and maintenance personnel.

VII. Evaluation

Upon completion of testing, collected data will be evaluated to determine the energy savings and lighting performance of the emerging technology.

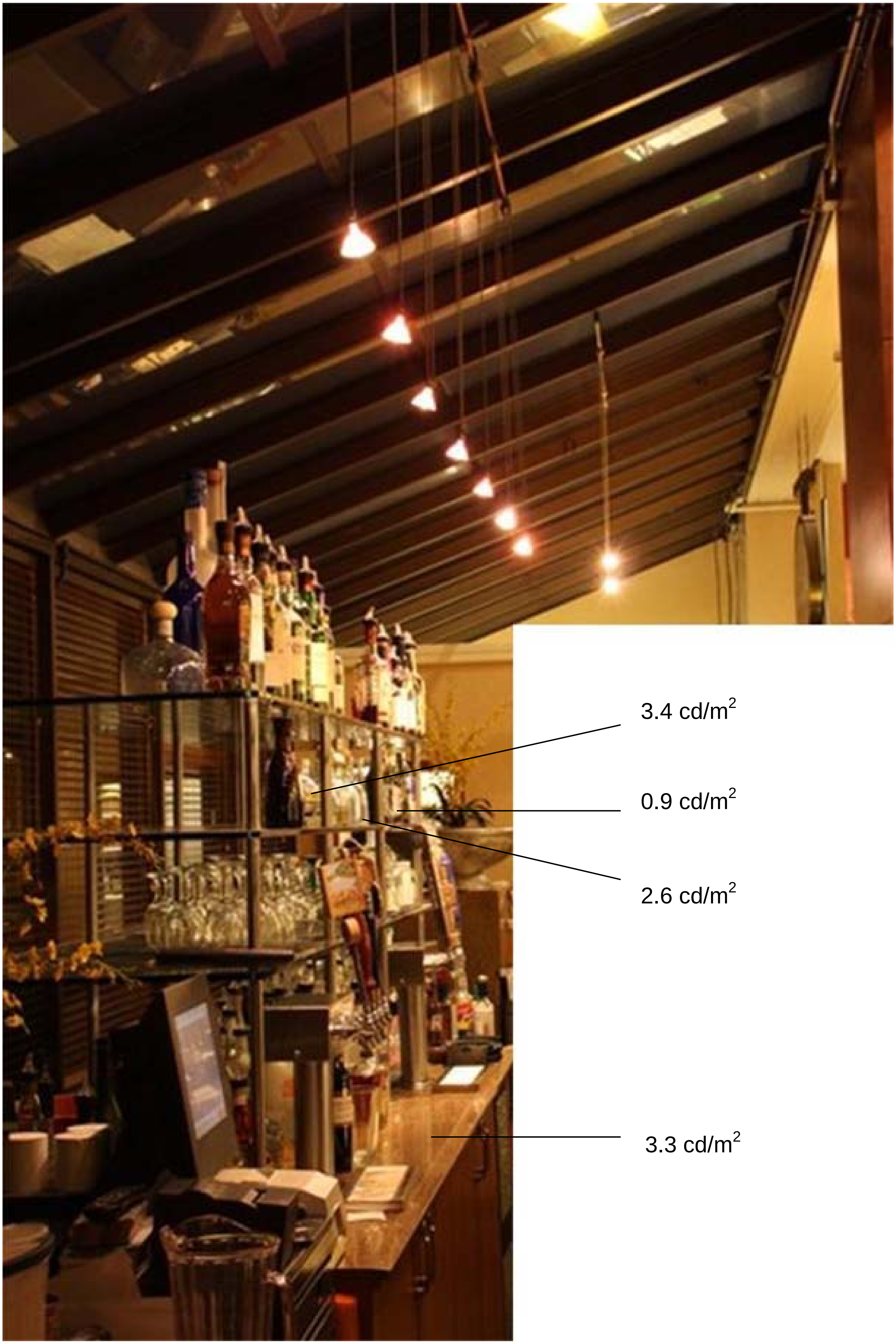
Appendix B

Luminance and Illuminance Maps

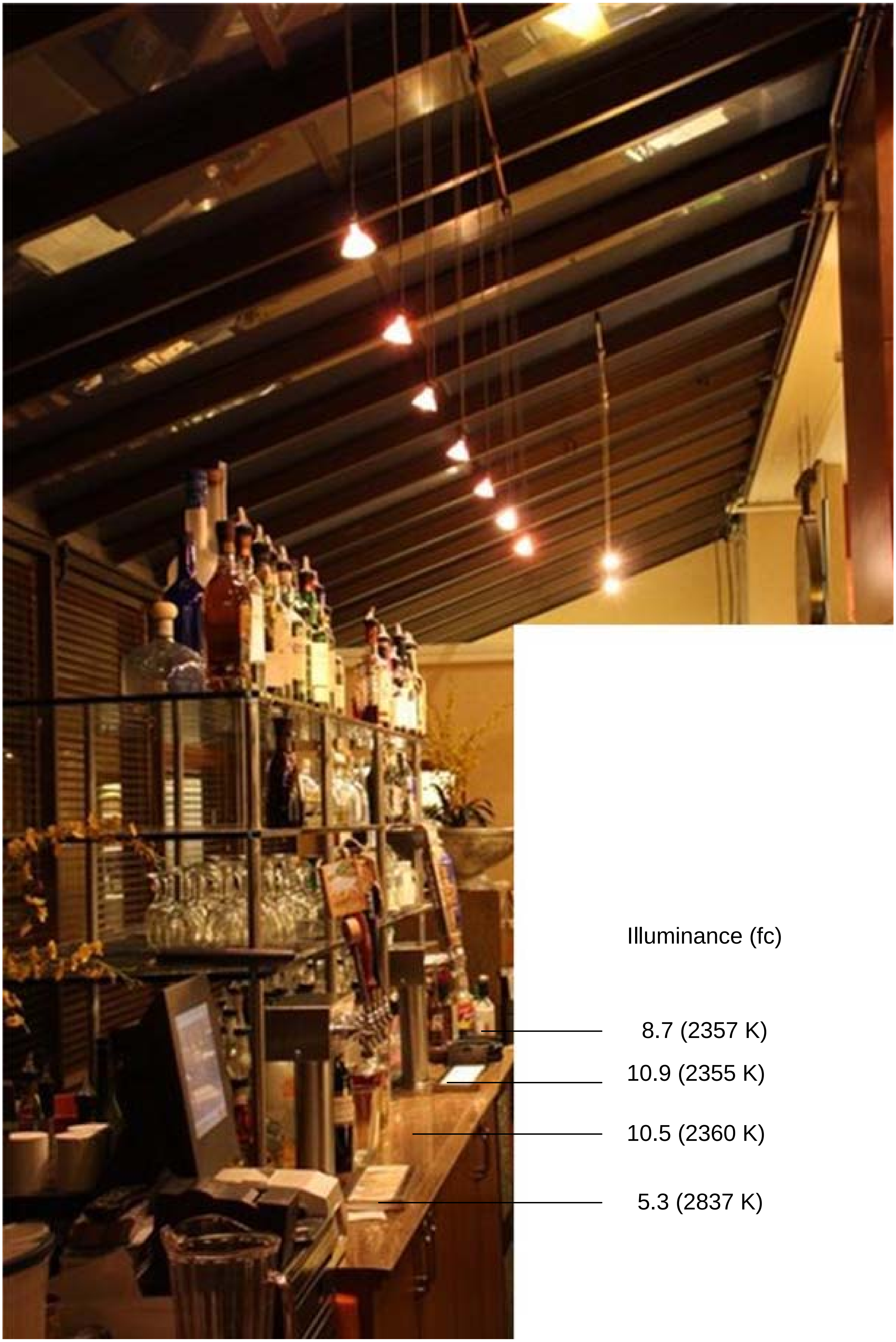
Base Case: Entry Way Luminance

Base Case: Entry Way Illuminance (fc)

Base Case: Bar Luminance



Base Case: Bar Illuminance



Test Case: Entry Way Luminance

Test Case: Entry Way Illuminance (fc)

Test Case: Bar Luminance

Test Case: Bar Illuminance

Appendix C

Calculations

Appendix C-1

System Efficacy

PG&E Emerging Technology Study: Retail LED Lighting
Doubletree (San Jose Airport)

DOE CALiPER Laboratory Testing Summary

DOE CALiPer efficacy values provided on the basis of lumens per watt

MR16								
Base Efficacy (i)	Test Efficacy (ii)	Δ Efficacy (%)	Base Initial Lumens	Test Initial Lumens	Δ Intial Lumens (%)	Base Power	Test Power	Δ Power (%)
12.7	24.9	96%	255	91	-64%	19.8	3.9	-80%

T8								
Base Efficacy (iii)	Test Efficacy (iv)	Δ Efficacy (%)	Base Initial Lumens	Test Initial Lumens	Δ Intial Lumens (%)	Base Power	Test Power	Δ Power (%)
96.0	39.0	-59%	3081	817	-73%	32.0	20.5	-36%

Doubletree Testing Summary (v)

Test measurements for efficacy were not available for the installed product. The average illuminance values from the field tests are provided below.

MR16 (Bar)					
Base Average Illuminance (fc)	Test Average Illuminance (fc)	Δ Illuminance (%)	Base Power (W)	Test Power (LED Power fixture) (W)	Δ Power (%)
8.9	15.5	74%	46	6	-87%

Notes:

(i) Base case values are derived from CALiPER testing on six 20W Halogen MR-16 lamps. (CALiPER round 6 - Table 1c)
(ii) Test case values are derived from CALiPER testing on ten SSL MR-16 lamps (CALiPER round 6 - Table 2)
(iii) Base case values are derived from CALiPER testing on a 32W, 4ft. linear fluorescent lamp (CALiPER round 5 - Table 1b.)
(iv) Test case values are derived from CALiPER bare lamp testing on four 4ft. SSL linear replacement lamps (CALiPER round 5 - Table 1b.)
(v) Base and test case values are derived from photometric and power measurements on the project site.

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PG&E Emerging Technology Study: Retail LED Lighting
Doubletree (San Jose Airport)

Illuminance Results (fc)

	Position	MR-16	LED	Avg. MR-16	Avg. LED
Bar	1st	8.7	20.6	8.9	15.5
	2nd	10.9	9.3	8.9	15.5
	3rd	10.5	18.6	8.9	15.5
	4th	5.3	13.5	8.9	15.5
	Max:	10.9	20.6	8.9	15.5
	Min:	5.3	9.3		
	Average:	**8.9**	**15.5**		
			∆ Average (%)	74%	

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PG&E Emerging Technology Study: Retail LED Lighting
Doubletree (San Jose Airport)

Luminance results (cd/m²)

	Position	MR-16	LED	Avg. MR-16	Avg. LED
Bar	Bottle 1	3.4	4.8	2.6	6.6
	Bottle 2	0.9	5.7	2.6	6.6
	Bottle 3	2.6	7.1	2.6	6.6
	Bar Counter	3.3	8.7	2.6	6.6
	Max:	3.4	8.7		
	Min:	0.9	4.8		
	Average:	**2.6**	**6.6**		
			∆ Average (%)	154%	

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Appendix C-2

Project Savings and Economics

Project: ELECTRICITY RATE ANALYSIS - DEFINITIONS
Customer: PG&E
Facility: Doubletree
Building: San Jose
Utility: PG&E
Rate Schedule E-20S
Effective Date: October 29, 2008

Background

This sheet summarizes the energy and demand charges during summer and winter for peak, partial-peak, and off-peak periods for time-of-use rate schedules.

Approach

The user enters the appropriate utility period definitions and rates on this sheet. Average electric rates are calculated for various use profiles on the following sheets.

Assumptions

Holidays as defined in this rate schedule are assigned to the legally observed dates. When a billing month includes both summer and winter days, demand charges are calculated by prorating separately calculated winter and summer demand charges by the appropriate number of days in each season during the billing period. This spreadsheet does not calculate this proration; billing periods are assumed to coincide with season changeover dates. This spreadsheet does not include customer charges or state and local taxes. The calculations assume peak and maximum demand are concurrent.

Analysis

UTILITY PERIOD DEFINITIONS

SUMMER May 1-October 31 6 months

period	daily hours			days per week		hr/day	wk/yr	hr/yr	on-peak	mid peak	off-peak
	PERIOD DEFINITIONS					BREAKDOWN			SUMMARY BY PERIOD		
peak	1200	to	1800	5	M/F	6	26.07	782	782		
partial-peak	830	to	1200	5	M/F	3.5	26.07	456		456	
	1800	to	2130	5	M/F	3.5	26.07	456		456	
off-peak	2130	to	830	5	M/F	11	26.07	1,434			1,434
	-	to	2400	2	S/S	24	26.07	1,251			1,251
Weekday holidays which are completely off-peak:						(	3)		(18)	(21)	39

WINTER Nov 1-April 30 6 months

period	daily hours			days per week		hr/day	wk/yr	hr/yr			
	PERIOD DEFINITIONS					BREAKDOWN					
peak	-	to	-	5	M/F	0	26.07	0	0		
partial-peak	830	to	2130	5	M/F	13	26.07	1,695		1,695	
	-	to	-	5	M/F	0	26.07	0		0	
off-peak	2130	to	830	5	M/F	11	26.07	1,434			1,434
	-	to	2400	2	S/S	24	26.07	1,251			1,251
Weekday holidays which are completely off-peak:						(	5)		0	(65)	65
								TOTAL ==>	764	2,521	5,474
								% total	8.7%	28.8%	62.5%

UTILITY RATE STRUCTURE (Non-FTA)

		ENERGY $/kWh	DEMAND $/kW peak	$/kW max
SUMMER:	May 1-October 31			
	peak	0.12842	11.27	7.13
	partial-peak	0.08898	2.51	
	off-peak	0.07272	0.00	
WINTER:	Nov 1-April 30			
	peak	0.00000	0.00	
	partial-peak	0.07963	1.00	7.13
	off-peak	0.07031	0.00	

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Project: ELECTRICITY RATE ANALYSIS - PROJECT RATE
Customer: PG&E
Facility: Doubletree
Building: San Jose
Utility: PG&E
Rate Schedule E-20S
Effective Date: October 29, 2008

Background
This worksheet calculates the marginal cost of electricity with and without demand, for a particular operating use profile.

Approach
This sheet calculates the number of hours per year a given building operates during peak, partial-peak, and off-peak periods. It then uses the data from the TOU Utility Definitions tab to calculate the marginal cost of electricity.

Assumptions
Holidays as defined in this rate schedule are assigned to the legally observed dates. When a billing month includes both summer and winter days, demand charges are calculated by prorating separately calculated winter and summer demand charges by the appropriate number of days in each season during the billing period. This spreadsheet does not calculate this proration; billing periods are assumed to coincide with season changeover dates. This spreadsheet does not include customer charges or state and local taxes. The calculations assume peak and maximum demand are concurrent.

Analysis

TIME PERIOD: Hotel lighting operating hours

OCCURRENCE OF PROJECT SAVINGS: 24/7

SUMMER May 1-October 31 6 months

period	daily hours			days per week		hr/day	wk/yr	hr/yr	on-peak	mid peak	off-peak
peak	1200	to	1800	5	M/F	6.0	26.07	782	782		
partial-peak	830	to	1200	5	M/F	3.5	26.07	456		456	
	1800	to	2130	5	M/F	3.5	26.07	456		456	
off-peak	2130	to	830	5	M/F	11.0	26.07	1,434			1,434
	-	to	2400	2	S/S	24.0	26.07	1,251			1,251
Weekday holidays which are completely off-peak:						(	3)		(18)	(21)	39

WINTER Nov 1-April 30 6 months

period	daily hours			days per week		hr/day	wk/yr	hr/yr	on-peak	mid peak	off-peak
peak	-	to	-	5	M/F	0.0	26.07	0	0.0		
partial-peak	830	to	2130	5	M/F	13.0	26.07	1,695		1,694.6	
	-	to	-	5	M/F	0.0	26.07	0		0.0	
off-peak	2130	to	830	5	M/F	11.0	26.07	1,434			1,433.9
	-	to	2400	2	S/S	24.0	26.07	1,251			1,251.4
						0.0					
Weekday holidays which are completely off-peak:						(	5)		0.0	(65.0)	65.0
								TOTAL ==>	764.1	2521.0	5474.6
								% total	8.7%	28.8%	62.5%

PROJECT UTILITY RATE:
Energy Savings: 1 additional kW saved x 8,760 hrs/yr = 8,760 kWh/yr
Demand Savings: 1 kW per month

	ENERGY $/kW	DEMAND $/kW peak	DEMAND $/kW max
SUMMER period			
peak	98.13	67.62	42.78
partial-peak	79.32	15.06	0.00
off-peak	198.11	0.00	0.00
subtotal	375.56	82.68	42.78
WINTER period			
peak	0.00	0.00	0.00
partial-peak	129.77	6.00	42.78
off-peak	193.37	0.00	0.00
subtotal	323.14	6.00	42.78

AVERAGE RATE CALCULATION

$698.70	/yr avoided energy charges
$88.68	/yr avoided time-related demand charges
$85.56	/yr avoided nontime-related demand charges
$872.94	/yr
$0.0997	/kWh average annual electric rate INCLUDING demand *
$0.0798	/kWh average annual elec rate NOT INCLUDING demand

* correct project rate for load reducing project includes demand

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PG&E Emerging Technology Study: Hotel LED Lighting
Doubletree (San Jose) Energy Savings

The calculated savings is based on 3 separate lighting replacement projects as described in detail below and summarized.

Entrance Cove Lighting Retrofit Energy Savings

This project replaced (4) 4' T8 fluorescent lamps and associated ballasts with (4) 4' LED light bars in the cove lighting above the hotel's entry doorway. The "average measured power" data is determined from (1) metered circuit, consisting of (24) additional 4' T8 fluorescent lamps and associated ballasts, which were not part of the project scope. The "calculated kW/fixture", "calculated demand (kW)" and "calculated energy (kWh/yr)" data is calculated for the (4) test fixtures based on the kW demand per fixture . Operating hours for this circuit are (24 hours/day * 365 days/year) 8,760 hours/year. This operating schedule was provided by facility operations and is supported by the data collected from the measured circuit.

	Annual Operating Hours (hrs/yr)	Average Measured Power (kW)	Existing Fixture Quantity	LED Fixture Quantity	Calculated kW/fixture	Calculated Demand (kW) *	Calculated Energy (kWh/yr) *	% reduction in kWh from base case
T8 Fluorescent	8,760	1.051	28	-	0.038	0.152	1,332	
LED Light Bar	8,760	1.013	24	4	0.029	0.116	1,016	
Savings		0.038			0.009	0.036	316	24%

Electric Demand Savings: 0.036 kW
Electric Energy Savings: 316 kWh/yr

* for the (4) fixtures replaced.

Restaurant Skylight Retrofit Energy Savings

This project replaced (8) 11-Watt incandescent screw-in lamps with (8) screw-in LED lamps, which accent an octagonal skylight in the "Coffee Garden Café". There are (2) of these octagonal skylights in the café, each side of the skylights was accented by (8) 11-Watt incandescent lamps for a total of (128) lamps. The circuit that serves these lamps could not be properly isolated, so the lamps were bench tested and data was recorded for 1 hour. The "Average Measured kW/fixture" data is determined from the monitored data. The "Calculated Demand" and "Calculated Energy" data is extrapolated from the monitored data to calculate the savings available from replacing the (8) skylight accent lamps. Operating hours for these lamps were (24 hours/day * 365 days/year) 8,760 hours/year. This operating schedule was provided by facility operations.

	Annual Operating Hours (hrs/yr)	Average Measured kW/fixture	Existing Fixture Quantity	LED Fixture Quantity	Calculated Demand (kW) *	Calculated Energy (kWh/yr) *	% reduction in kWh
11 W Incand.	8,760	0.009	8	-	0.072	631	
LED Lamp	8,760	0.002	-	8	0.016	140	
Savings		0.007			0.056	491	78%

Electric Demand Savings: 0.056 kW
Electric Energy Savings: 491 kWh/yr

* for the (8) lamps replaced.

Bar Retrofit Energy Savings

This project replaced (9) 50-Watt halogen MR16 lamps with (9) LED MR16 lamps, which are used as overhead task lighting for the bartenders and sushi chefs in the bar. The circuit that serves these lamps could not be properly isolated, so the lamps were bench tested and data was recorded for 1 hour. Unit load data represents a weighted average of (4) LEDPower and (5) IMS units installed. The "Average Measured kW/fixture" data is determined from the monitored data. The "Calculated Demand" and "Calculated Energy" data is extrapolated from the monitored data to account for the project fixtures. Operating hours for these lamps are (24 hours/day * 365 days/year) 8,760 hours/year. This operating schedule was provided by facility operations.

	Annual Operating Hours (hrs/yr)	Average Measured (kW/fixt.)	Existing Fixture Quantity	LED Fixture Quantity	Calculated Demand (kW) *	Calculated Energy (kWh/yr) *	% reduction in kWh
50 W Hal. MR16	8,760	0.046	9	-	0.414	3,627	
LED MR16	8,760	0.006	-	9	0.054	473	
Savings		0.040			0.360	3,154	87%

Electric Demand Savings: 0.360 kW
Electric Energy Savings: 3,154 kWh/yr

* for the (9) lamps replaced.

Energy Savings Summary, Total for (3) Demonstation Projects

Total Demand Savings:	**0.452**	**kW**	
Total Energy Savings:	**3,961**	**kWh/yr**	
Energy Rate:	**$ 0.09970**	**/kWh**	per rate calculation for continuous use, schedule E-20S
Annual Dollar Savings, Energy:	**$ 394.91**	**/yr.**	
Annual Avoided Maint. Cost:	**$ 608.05**	**/yr.**	per avoided cost calculation
Total Annual Savings:	**$ 1,002.96**	**/yr.**	

Recap of Load Reduction and Energy Savings

Base Case Electrical Load	**0.638**	**kW**	Existing Base Case Energy Use	**5,590**	**kW**
Test Case Electrical Load	**0.186**	**kW**	Test Case Energy Use	**1,629**	**kW**
Load Reduction	**70.8%**		Reduction in Energy Use:	**70.9%**	

Recap of Cost and Payback, Total for (3) Demonstration Projects

Project Cost	**$ 1,189.01**	
Payback, Energy	**3.0**	**yrs**
Payback, Energy & Maintenance	**1.2**	**yrs**

PG&E Emerging Technology Study: Hotel LED Lighting
Doubletree (San Jose) Cost Summary and Payback

The economic analysis shown below indicates the anticipated cost and savings for current market conditions. The "payback period with avoided cost" scenarios include additional maintenance savings from eliminating the need to replace fluorescent system components (as calculated elsewhere).

ENTRANCE COVE LIGHTING PROJECT:

	LED Bars:	Notes:
Quantity:	4	
$/4' Bar	$ 152.00	
Material Cost:	$ 608.00	
	Labor:	
Quantity	4	
Cost/bar	$ 17.22	As observed at similar installation.
Labor Cost:	$ 68.88	
	Total:	
Total Cost:	$676.88	

Entrance Cove Lighting Project Payback Summary	
Annual Energy Savings $ 31.51 /yr	**Simple Payback Period, Current Market** **21.5 years**
Total Annual Savings $ 113.63 /yr	**Payback Period w/Avoided Cost, Current Market** **6 years**

Cost Details

$ 152.00	Source LEDPower, for 36 LED/foot ($34/foot in high volume), plus 20% of a driver, Cary Aberg, 6/25/08.

SIMPLE PAYBACK VS. RATED LIFE: Entrance Cove Lighting

Useful Life:	50,000	hrs
Operation	8,760	hrs/yr
Expected Life	5.7	yrs, based on annual operation over useful life.
Project Payback	21.5	yrs (based on energy alone, current market conditions)

PG&E Emerging Technology Study: Hotel LED Lighting
Doubletree (San Jose) Cost Summary and Payback

The economic analysis shown below indicates the anticipated cost and savings for current market conditions. The "payback period with avoided cost" scenarios include additional maintenance savings from eliminating the need to replace fluorescent system components (as calculated elsewhere).

RESTAURANT SKYLIGHT PROJECT:

		LED Lamp	Notes:
Quantity:		8	
Lamp	$	18.00	
Material Cost:	$	144.00	
		Labor:	
Quantity		8	
Cost/lamp	$	4.65	Uses Means labor hours to replace lamp.
Labor Cost:	$	37.20	
		Total:	
Total Cost:		$181.20	

Restaurant Skylight Project Payback Summary	
Annual Energy Savings $ 48.95 /yr	**Simple Payback Period, Current Market** **3.7 years**
Total Annual Savings $ 226.31 /yr	**Payback Period w/Avoided Cost, Current Market** **0.8 year**

Cost Details

$ 18.00 Source LEDPower, Cary Aberg, 6/25/08.

SIMPLE PAYBACK VS. RATED LIFE: Restaurant Skylight

Useful Life:	50,000	hrs
Operation	8,760	hrs/yr
Expected Life	5.7	yrs, based on annual operation over useful life.
Project Payback	3.7	yrs (based on energy alone, current market conditions)

PG&E Emerging Technology Study: Hotel LED Lighting
Doubletree (San Jose) Cost Summary and Payback

The economic analysis shown below indicates the anticipated cost and savings for current market conditions. The "payback period with avoided cost" scenarios include additional maintenance savings from eliminating the need to replace fluorescent system components (as calculated elsewhere).

BAR MR16 PROJECT:

	LED MR16:	Notes:
Quantity:	9	
Lamp	$ 31.00	
Material Cost:	$ 279.00	
	Labor:	
Quantity	9	
Cost/bar	$ 5.77	Uses Means labor hours to replace lamp.
Labor Cost:	$ 51.93	
	Total:	
Total Cost:	$330.93	

Bar MR16 Project Payback Summary	
Annual Energy Savings $ 314.45 /yr	**Simple Payback Period, Current Market** **1.1 years**
Total Annual Savings $ 663.02 /yr	**Payback Period w/Avoided Cost, Current Market** **0.5 years**

Cost Details

$ 31.00 Source LEDPower, for MR16 Cary Aberg, 6/25/08.

SIMPLE PAYBACK VS. RATED LIFE: BAR MR16

Useful Life:	50,000	hrs
Operation	8,760	hrs/yr
Expected Life	5.7	yrs, based on annual operation over useful life.
Project Payback	1.1	yrs (based on energy alone, current market conditions)

INITIAL MAINTENANCE SAVINGS FOR REPLACEMENT OF FLUORESCENT SOURCES WITH LED SOURCES

Replacement of existing lighting systems with new LED systems will typically result in avoided maintenance costs over the life of the new LED system because of the longer rated life of LED systems compared to existing lighting systems. Based on average life characteristics of the current and proposed equipment, more than 2 cycles of existing lamp replacement will be avoided during the expected life of the LED system. During that period, it is predicted that a small percentage of fluorescent ballasts will fail based on the calculated annual failure rate; actual failures will likely be higher or lower depending on the age of the existing ballasts. The overall avoided maintenance costs during the expected life of the LED system are calculated below:

Equipment	Type	Expected Life (hrs) (1)	Annual Failure Rate (2)	Unit Labor Hrs (3)	Unit Labor Cost (4)	Unit Material Cost (5)	Unit Replacement cost	Total Unit Replacements in LED life	Unit Replacement Cost per LED life cycle			Annualized Cost	Quantity of Existing Units	Total Net Annualized Savings
							Energy		Cove	Restaurant	Bar			
GE F32T8-SP30-ECO	lamp	20,000	43.8%	0.089	$ 8.28	$ 2.53	$ 10.81	2.50	$ 27.03					
Sylvania QTP4x32T8	ballast	60,000	14.6%	0.851	$ 79.21	$ 29.41	$ 108.62	0.83	$ 90.15					
GE 11 W 12575-11S14	lamp	3,000	292.0%	0.050	$ 4.65	$ 2.94	$ 7.59	16.67		$ 126.53				
Phillips MR16	lamp	3,000	292.0%	0.062	$ 5.77	$ 7.49	$ 13.26	16.67			$ 221.04			
LED light bar (4') for cove	unit	50,000	17.5%	0.185	$ 17.22	$ 152.00	$ 169.22	-	$ 169.22					
LED Lamp	unit	50,000	17.5%	0.050	$ 4.65	$ 18.00	$ 22.65	-		$ 22.65				
LED MR16	unit	50,000	17.5%	0.062	$ 5.77	$ 31.00	$ 36.77	-			$ 36.77			
TOTALS:								**Cove:**	**$ 117.18**			**$ 20.53**	**4**	**$ 82.12**
								Restaurant:		**$ 126.53**		**$ 22.17**	**8**	**$ 177.36**
								Bar:			**$ 221.04**	**$ 38.73**	**9**	**$ 348.57**

(1) Assume Rated lamp life at 3 Hrs/Start per industry standard rating; ballast and LED system life of 50,000 hours per manufacturer.

(2) Annual failure rate = Annual operating hours / expected life. Assume operating hours to be: 8,760 /yr as calculated for this case study.

Total:	$ 608.05

(3) Labor hours per 2007 Means for lighting maintenance activities (spot relamp/reballast); labor hours for LED as follows:

26 61 23.10 0180 - 4' T8 - 32 Watt Energy Saver:	0.089	Labor Hours
26 51 13.50 7540 - Ballast Replacement:	0.851	Labor Hours
26 61 23.10 1800 - Incandescent Lamp, Interior, A21:	0.050	Labor Hours
26 61 23.10 1762 - 50 Watt, Spot, MR16:	0.062	Labor Hours
LED light bar (4') for cove:	0.185	Labor Hours, as observed at similar installation.

(4) Assume Labor Rate at $ 93.08 /hr. (Means Electrical 2007 for Electrician; City modifier San Jose, CA.)

(5) Materials cost for existing systems per www.grainger.com and sylvanialighting.com, 10/06/08. LED systems per LEDPower, Cary Aberg, 6/25/08.

Appendix D

Product Information

Product Information Bulletin

TRU-AIM® MR11 & MR16 FAMILY

Low Voltage Halogen Lamps

- Four families of MR16 lamps to meet the need of virtually any application
- Bright, crisp light throughout lamp life
- UV-filter capsules reduce UV-radiation up to 90%
- Up to 5000-hour average rated life
- Exceptional reflector and filament design provides a superior, smooth beam pattern
- GU4 and GU5.3 base for a solid socket connection

ECOLOGIC® is a comprehensive program of OSRAM SYLVANIA focused on addressing environmental issues at all stages of lamp life.

SYLVANIA's TRU-AIM family of halogen MR16 and MR11 reflector lamps provides a wide variety of extremely compact and highly directional light sources.

TRU-AIM IR MR16

- 5000 hour life
- Exclusive MR16 IR technology – lowers energy consumption compared to standard MR16 lamps
- Hard dichroic reflector – consistent color throughout life
- Cover lens for use in unshielded fixtures

TRU-AIM TITAN® MR11 and MR16

- 4000 hour life
- Hard coated dichroic reflector – consistent color throughout life
- Transmits heat through back of lamp
- Cover lens for use with unshielded fixtures

TRU-AIM BRILLIANT MR16

- Aluminized reflector – consistent color throughout life
- Transmits heat through front of lamp
- 4000 hour life

TRU-AIM MR16

- Economical dichroic reflector
- Transmits heat through back of lamp
- 2000 hour life
- Cover lens for use with unshielded fixtures

Product Availability

	Beam Angle			
Product	**20W**	**35W**	**50W**	**65W**
TRU-AIM MR11 TITAN	SP 10°	SP 10°		
	FL 35°	FL 35°		
TRU-AIM MR16	NSP 10°	NSP 10°	NSP 10°	
		NFL 25°	NFL 25°	
	FL 35°	FL 35°	FL 35°	
			VWFL 60°	
TRU-AIM MR16 BRILLIANT	SP 10°	NSP 10°	NSP 10°	
			NFL 25°	
	FL 35°	FL 35°	FL 35°	
TRU-AIM MR16 TITAN	NSP 10°	NSP 10°	NSP 10°	NSP 10°
		NFL 25°	NFL 25°	NFL 25°
	FL 35°	FL 35°	FL 35°	FL 35°
	VWFL 60°	VWFL 60°	VWFL 60°	
Product	**20W**	**37W**	**50W**	
TRU-AIM MR16 IR	NSP 10°	NSP 10°	NSP 10°	
	NFL 25°	NFL 25°	NFL 25°	
	FL 35°	FL 35°	FL 35°	
	WFL 60°	WFL 60°	WFL 60°	

SEE THE WORLD IN A NEW LIGHT SYLVANIA

HAL008R3 11/06

Sample Specification

Lamp(s) shall be (a) 12V TRU-AIM___(Standard, BRILLIANT, TITAN or IR) halogen lamp(s) with a UV filter capsule, an axial filament, a ____ (consis-tent color-hard dichroic, semi-hard coat dichroic or aluminized) reflector. Lamp(s) shall be___ (20, 35, 37, 50 or 65) watts with a ___ (SP, NFL, FL or VWFL) beam spread.

Application Information

Applications

Highlight merchandise
Accent / display lighting
Highlight heat sensitive merchandise
High end retail
Art galleries
Hotels, restaurants
Decorative room lighting
Ambient lighting

Fixture Availability

Track
Strips for case lighting
Adjustable downlighting
Landscape lighting
Recessed lighting

Application Notes

TITAN

- The best choice when constant crisp white light is required.
- Hard dichroic coating makes these lamps ideal for heat sensitive merchandising.
- UV filter capsule reduces fading on UV-sensitive merchandising and art.

IR

- MR16 IR lamps offer a reduction in energy consumption.
- All the technical advantages and performance of the 50W TRU-AIM TITAN for only 37 watts. The 50W TRU-AIM IR lamp is a replacement for 65W or 71W consistent color reflector lamps.

BRILLIANT

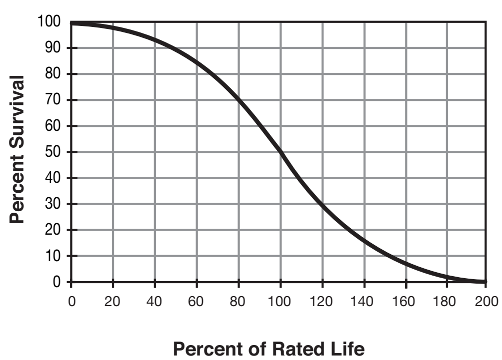
- Prevents fixtures overheating, short transformer life and socket problems.
- At a 5-foot distance the temperature of the beam is the same as dichroic coated lamps.
- UV filter capsule reduces fading on UV-sensitive merchandising and art.

MR11/STANDARD

- A cost competitive product that provides a smooth, even beam.
- UV filter capsule reduces fading on UV-sensitive merchandising and art.

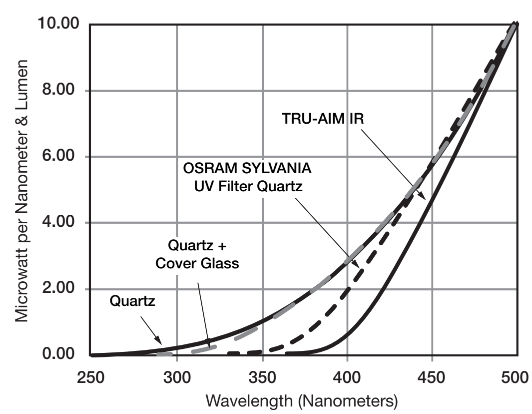
Technical Information

Mortality Curve



This chart shows the expected percentage of lamp failures based on percentage of rated life.

UV-Transmission Curves of Quartz Halogen Capsules



The UV filter quartz capsule in TRU-AIM lamps reduces UV radiation.

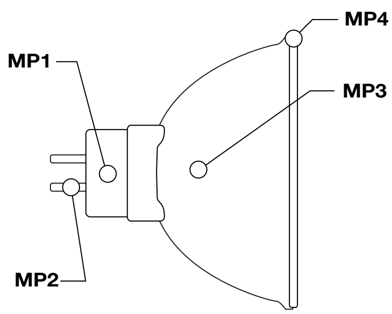
Ordering and Specification Information

	Item Number	Ordering Abbreviation	Watts	Volts	Base	Average Rated Life (hrs.)	CBCP (cd)	Beam Angle
TITAN MR11	55133	20MR11/T/SP10/C/FTB	20	12	GU4	4000	4000	10
	55134	20MR11/T/FL/35/C/FTD	20	12	GU4	4000	700	35
	55135	35MR11/T/SP10/C/FTE	35	12	GU4	4000	6200	10
	55136	35MR11/T/FL35/C/FTH	35	12	GU4	4000	1350	35
Standard MR16	54305	20MR16/NSP10/ESX/C	20	12	GU5.3	2000	3000	10
	54306	20MR16/FL35/BAB/C	20	12	GU5.3	2000	510	35
	54307	35MR16/NSP10/FRB/C	35	12	GU5.3	2000	6000	10
	58322	35MR16/NFL25/FRA/C	35	12	GU5.3	2000	2000	25
	58324	35MR16/FL35/FMW/C	35	12	GU5.3	2000	1000	35
	58325	50MR16/NSP10/EXT/C	50	12	GU5.3	2000	7800	10
	58326	50MR16/NFL25/EXZ/C	50	12	GU5.3	2000	2800	25
	58327	50MR16/FL35/EXN/C	50	12	GU5.3	2000	1450	35
	58328	50MR16/VWFL60/FNV/C	50	12	GU5.3	2000	690	60
BRILLIANT MR16	58314	20MR16/B/NSP10	20	12	GU5.3	4000	5000	10
	58315	20MR16/B/FL35	20	12	GU5.3	4000	700	35
	58316	35MR16/B/NSP10	35	12	GU5.3	4000	9100	10
	58317	35MR16/B/FL35	35	12	GU5.3	4000	1100	35
	58319	50MR16/B/NSP10	50	12	GU5.3	4000	11500	10
	58320	50MR16/B/NFL25	50	12	GU5.3	4000	4400	25
	58321	50MR16/B/FL35	50	12	GU5.3	4000	1800	35
TITAN MR16	58300	20MR16/T/NSP10/ESX/C	20	12	GU5.3	4000	5000	10
	58301	20MR16/T/FL35/BAB/C	20	12	GU5.3	4000	780	35
	58302	20MR16/T/VWFL60/C	20	12	GU5.3	4000	350	60
	58303	35MR16/T/NSP10/FRB/C	35	12	GU5.3	4000	9100	10
	58304	35MR16/T/NFL25/C	35	12	GU5.3	4000	3100	25
	58305	35MR16/T/FL35/FMW/C	35	12	GU5.3	4000	1500	35
	58306	35MR16/T/VWFL60/C	35	12	GU5.3	4000	700	60
	58307	50MR16/T/NSP10/EXT/C	50	12	GU5.3	4000	11500	10
	58308	50MR16/T/NFL25/EXZ/C	50	12	GU5.3	4000	4400	25
	58309	50MR16/T/FL35/EXN/C	50	12	GU5.3	4000	2200	35
	58310	50MR16/T/VWFL60/FNV/C	50	12	GU5.3	4000	1100	60
	58311	65MR16/T/NSP10/FPA/C	65	12	GU5.3	4000	14000	10
	58312	65MR16/T/NFL25/C	65	12	GU5.3	4000	5600	25
	58313	65MR16/T/FL35/FPB/C	65	12	GU5.3	4000	2800	35
IR MR16	58531	20MR16/IR/SP10/C	20	12	GU5.3	5000	6000	10
	58532	20MR16/IR/NFL25/C	20	12	GU5.3	5000	2300	25
	58533	20MR16/IR/FL35/C	20	12	GU5.3	5000	1000	35
	58838	20MR16/IR/WFL60/C	20	12	GU5.3	5000	450	60
	58641	37MR16/IR/SP10/C	37	12	GU5.3	5000	12500	10
	58634	37MR16/IR/NFL25/C	37	12	GU5.3	5000	4400	25
	58633	37MR16/IR/FL35/C	37	12	GU5.3	5000	2200	35
	58837	37MR16/IR/WFL60/C	37	12	GU5.3	5000	1100	60
	54175	50MR16/IR/SP10/C	50	12	GU5.3	5000	15000	10
	54174	50MR16/IR/NFL25/C	50	12	GU5.3	5000	5700	25
	54173	50MR16/IR/FL35/C	50	12	GU5.3	5000	2850	35
	54237	50MR16/IR/WFL60/C	50	12	GU5.3	5000	1430	60

Ordering Guide

50	**MR**	**16**	**/**	**T**	**/**	**SP**	**10**	**/**	**C**
Wattage	Multifaceted Reflector	Diameter 11 = 11/8" 16 = 16/8"		Type IR = Infrared Capsule B = Aluminized Reflector T = Hard Dichroic Reflector __= Standard Reflector		Beam Spread NSP SP NFL FL WFL, VWFL	Beam Angle 10° 20° 25° 35° 60°		Covered

Thermal Performance



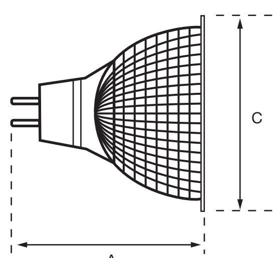
Temperature measurements were made in open air with an ambient temperature of 25°C (77°F) using a Bender & Worth 884 socket. Temperature measurements are provided for reference only.

	Press	Pin	Reflector	Rim
Measurement Point	MP1	MP2	MP3	MP4
Max Allowed	370°C	250°C*	—	240°C+
20W TITAN	160°C	110°C	120°C	110°C
20W IR	170°C	125°C	125°C	115°C
35W TITAN	230°C	150°C	140°C	140°C
37W IR	270°C	170°C	160°C	145°C
50W TITAN	295°C	195°C	165°C	160°C
50W IR	325°C	220°C	200°C	180°C

*20W Max is 220°C + Covered lamps ONLY

50 watt TRU-AIM® IR MR16 lamps should not be used in semi-enclosed or enclosed fixtures that will inhibit air flow in the neck area or in sockets that will inhibit air flow in this area (MP1 above). Infrared conserving halogen capsules recycle their heat by using a coating on the outside of the halogen capsule. Because of this, all the recycled heat must pass through the capsule glass twice, and the IR capsule will operate at a higher temperature than a standard halogen capsule of the same wattage would. Due to this additional heating, 50W TRU-AIM IR MR16 lamps may have short lamp life when the neck of the lamp is not well ventilated, and should not be used as a direct replacement for standard 50W MR16 lamps.

Dimensions



	MOL (A)	Max. Length w/o Pins (B)	Max. Diameter (C)	Max. Pin Spacing (D)
TRU-AIM MR16	1¾"	1½"	2"	7/32" (5.33mm)
TRU-AIM MR11	1 7/16"	1⅛"	1⅜"	5/32" (4mm)

OSRAM SYLVANIA
National Customer
Service and Sales Center
18725 N. Union Street
Westfield, IN 46074

Industrial Commercial

Phone: 1-800-255-5042
Fax: 1-800-255-5043

National Accounts

Phone: 1-800-562-4671
Fax: 1-800-562-4674

OEM/Specialty Markets

Phone: 1-800-762-7191
Fax: 1-800-762-7192

Display/Optic

Phone: 1-888-677-2627
Fax: 1-800-762-7192

In Canada
OSRAM SYLVANIA LTD.
Headquarters
2001 Drew Road
Mississauga, ON L5S 1S4

Industrial Commercial

Phone: 1-800-263-2852
Fax: 1-800-667-6772

Special Markets

Phone: 1-800-265-2852
Fax: 1-800-667-6772

EXT 50W GU5.3 MR16 10D 1CT

Product family description
Low-voltage halogen burner optically positioned in a glass reflector with or without front glass.

Features/Benefits

- Dichroic reflector coating is heat-transmitting and light-reflecting.
- UV-Block burner.
- Color temperature 3000K.
- Lifetime 3000 hours.
- Universal burning position.
- Variety of wattages and beam spreads.

Applications

- Ideal for retail stores, hotels, restaurants, museums and art gallery lighting.

Notes

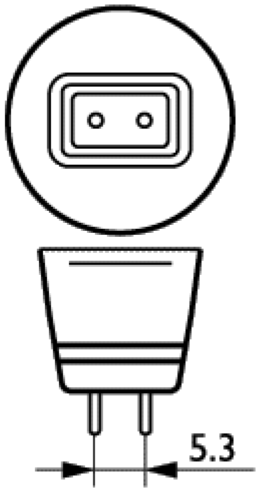
- Rated average life is the length of operation (in hours) at which point an average of 50% of the lamps will still be operational and 50% will not. (93)

Product data	
Product Number	378042
Full product name	EXT 50W GU5.3 MR16 10D 1CT
Ordering Code	50MR16/SP10-EXT
Pack type	1 Lamp in a Folding Carton
Pieces per Sku	1
Skus/Case	50
Pack UPC	046677378042
EAN2US	
Case Bar Code	50046677378047
Successor Product number	
ANSI Code Halogen	EXT
Base	GU5.3
Bulb	MR16 [MR 16inch/50mm]
Execution	Closed

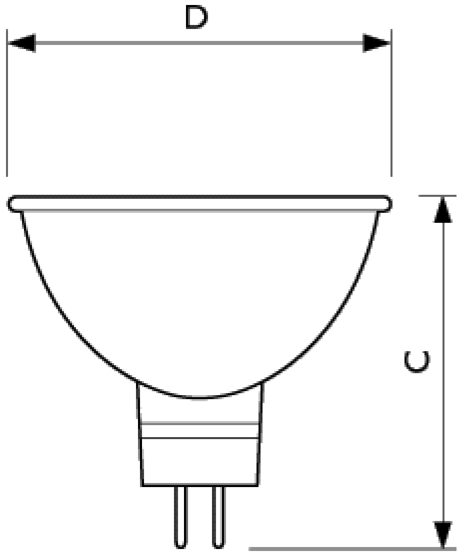
PHILIPS

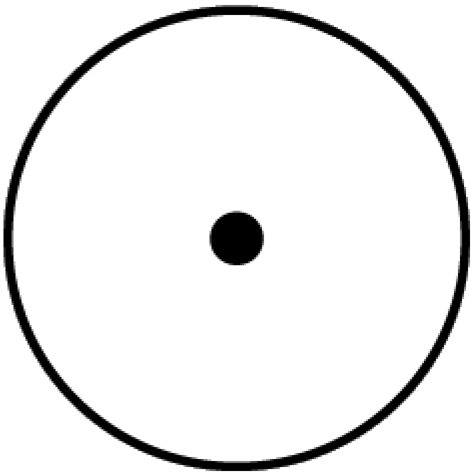
Product data	
Operating Position	Universal [Any or Universal (U)]
Packing Type	1CT [1 Lamp in a Folding Carton]
Packing Configuration	10X5F
Ordering Code	50MR16/SP10-EXT
Pack UPC	046677378042
Case Bar Code	50046677378047
Watts	50W
Voltage	12V
Dimmable	Yes
Beam Angle	10D
Color Rendering Index	100 Ra8
Color Temperature	3000 K
Overall Length C	46 mm
Diameter D	51 mm
Product Number	378042

FIGHTER



Cap-Base GU5.3





FIGHTER GU5.3

Operating Position any

GE Linear Fluorescent Lamps

BRILLIANT

COST-EFFECTIVE

PERFORMANCE

Linear

GE linear fluorescent lamps feature top performance, offering you excellent opportunities to upgrade your lighting for…

HIGHEST EFFICIENCIES

GE T8 lamps and lamp ballast systems reduce energy costs by as much as 38% compared to T12 systems, dramatically lowering electricity expense, which accounts for over 80% of total lighting costs.

QUALITY OF LIGHT

GE T8 lamps with Starcoat™ are the new standard in fluorescent light quality, offering the best color rendering and highest lumen maintenance (95%) in the industry. High lumen maintenance keeps your facilities bright, attractive and productive, even as your lamps age.

GE SP and deluxe SPX colors provide color rendering so true and natural, you won't believe it's fluorescent lighting! Furnishings, decor, merchandise and people look their natural best.

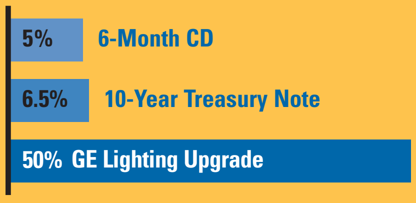
Fluorescent Lamps

LONG LIFE

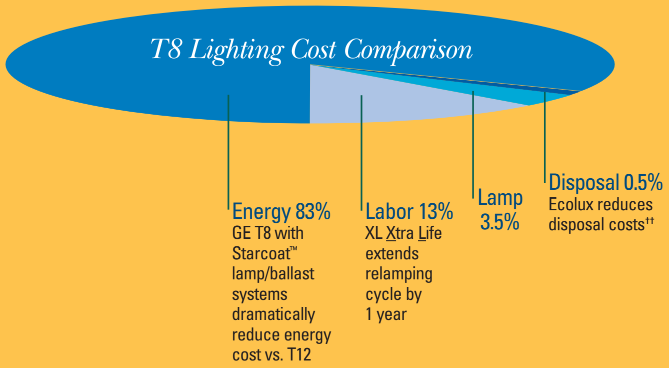
XL (Xtra Life) options can substantially increase the already long life of GE fluorescent lamps. Starcoat™ and Ecolux® T8 XL lamps, for example, last 24,000 hours,† 20% longer than standard T8 lamps. In typical applications that's an extra year of quality lighting. Long life means lower lamp replacement and labor costs.

RETURN ON INVESTMENT (ROI)

An outstanding investment, the right lamp replacement can ensure a 50% payback in two years or less.* That's a significant return when compared to other solid investments like a 10-year treasury note or 6-month CD.



† 30,000 hours, 25% longer at 12-hour cycles.
* Figures based on actual case, your results may vary.
†† In states where applicable.



Cost of Light

The purchase price of a lamp represents only a small fraction of the overall cost of light. Power usage is by far the biggest expense, next is relamping labor. Upgrading your lighting with high technology GE fluorescent lamps can save thousands of dollars each year in electricity, maintenance labor and disposal costs.

Starcoat™ TECHNOLOGY


Starcoat™ XL

STARCOAT™—THE NEW STANDARD IN FLUORESCENT LIGHT QUALITY

Superior Color—More Light Over Life

Starcoat™ Features…

- ***More light over life***
  GE T8 lamps with Starcoat™ now feature 95% lumen maintenance, providing more light than competitive lamps over their long life.
- ***Enhanced color…best in the industry***
  GE T8 lamps with Starcoat™ provide the best color rendering in the industry, giving furnishings, decor and merchandise a truer, more natural appearance. Available in SP color (now 78 CRI), or even better SPX color (now 86 CRI) for superior color rendering. A variety of color temperatures are also available.
- ***High system efficiency delivers significant energy cost savings***
  GE T8 lamps with Starcoat™ teamed with GE electronic ballasts can reduce energy costs by as much as 38% while providing more light than a standard T12 Watt-Miser® system. With a 4-lamp system, you save $134.00 in energy costs (@10¢ per KWH) over lamp life.
- ***Long lamp life***
  GE T8 lamps with Starcoat™ provide the same long 20,000 hour life as the standard lamps they replace.
- ***Variety of sizes to meet application needs***
  GE's T8 Starcoat now includes HO, U6, 2-, 3-, 4-, 5-, and 8-foot types.


Ecolux® XL

System Comparison

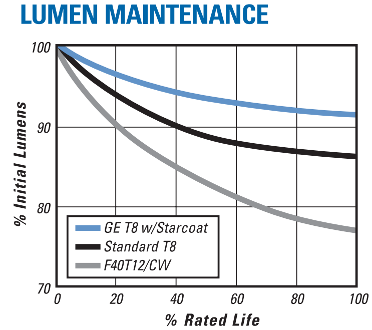
STARCOAT™ T8/ECOLUX® T8
4-LAMP 2X4 TROFFER

Comparison Chart

LAMP REPLACED	ENERGY-SAVING REPLACEMENT	CRI	PERCENTAGE WATT REDUCTION	RELATIVE LIGHT OUTPUT	ENERGY** SAVINGS
F40T12/CW/WM ELECTROMAGNETIC	F32T8/SPX ELECTRONIC	62 vs. 86	38%	123%	$134.00

** $.10 Per KWH over lamp life.

LUMEN MAINTENANCE



Ecolux®

ECOLUX® WITH STARCOAT™—THE SUPERIOR REDUCED MERCURY T8 LAMP

Best Color—More Light Over Life

Ecolux® T8 with Starcoat™ Features...

- ***All the superior performance benefits of Starcoat™ combined with reduced mercury for more economical disposal***
- ***Economical and Ecological***
  Passes the EPA Toxicity Characteristic Leaching Procedure (TCLP) test,* substantially lowering disposal costs where applicable.

  38% Energy Cost Savings. With 4-foot, 4-lamp T8 system you save $134.00 in energy costs over lamp life while maintaining 98% of the light output of a standard F40CW System (@ 10¢ per KWH on electronic ballast).
- ***More light over life***
  Starcoat™ provides the highest lumen maintenance (95%) and the highest mean lumens (2710) of any reduced mercury lamp.
- ***Best color***
  Starcoat™ delivers the best color rendering in the industry, giving furnishings, decor and merchandise a truer, natural look. Available in popular SP color (78 CRI), and even better SPX color (86 CRI) for superior lumen output and color rendering.

Ecolux® 4-foot and 8-foot T12 Watt-Miser®

- ***Energy efficiency***
  15% to 20% energy cost savings vs. standard full wattage T12 lamps, while maintaining 86% to 88% of the light output.
- ***Extra color options***
  Available in popular SP color (70 to 73 CRI), or even better SPX color (80 to 82 CRI) for superior lumen output and color rendering. Economical cool white color also available.

* State regulations vary. Consult your state EPA.

XL

Xtra Life Versions of Premium GE Lamps

- **Lasts up to 25% longer than standard T8 lamps**
  — Provides an extra year of quality lighting
  — Extends relamping cycle
  — Reduces lamp maintenance and labor cost
- **Delivers extraordinary color — best T8 color rendering in the industry**
  — SP version has 78 CRI for better color rendering
  — SPX version has 86 CRI for superior color rendering
- **Provides the highest lumen maintenance (95%) in the industry**
- **GE's full line of XL lamps includes 2-, 3-, and 4-foot T8's and 4- and 8-foot T12's**

Starcoat XL™–*For an extra year of great Starcoat performance*

- **Longest life**
- **Best color**
- **More light over life**

Starcoat XL™

Ecolux® XL–*The ultimate reduced mercury lamp*

- **Longest life**
- **Best color**
- **More light over life**
- **Lower disposal costs through TCLP compliance**

EcoluxXL WITH STARCOAT

T8 MOD-U-LINE® U-SHAPED LAMPS WITH Starcoat TECHNOLOGY

The Choice for Cost-Efficient Operation

- ***Lower energy costs***
  Reduces energy costs by 36% while providing slightly more light than standard F40T12 U-Tubes.
- ***More light over life***
  Starcoat technology provides the highest lumen maintenance (95%) in the industry.
- ***33% longer lamp life…20,000 hours for lower lamp replacement and labor costs***
- ***Same overall length as F40 Mod-U-Line® (F40T12/U/6)***
- ***Enhanced color—best in the industry***
  Available in SP (now 78 CRI) and deluxe SPX (now 86 CRI). GE T8 Mod-U-Line lamps now feature Starcoat that provides the best color rendering in the industry. A choice of color temperatures, ranging from warm to very cool, lets you select just the right atmosphere.

System Comparison

T8 MOD-U-LINE® LAMPS
2-LAMP 2X2 TROFFER

LAMP REPLACED	ENERGY-SAVING REPLACEMENT	CRI	PERCENTAGE WATT REDUCTION	RELATIVE LIGHT OUTPUT	ENERGY** SAVINGS
F40/CW/U/6 ELECTROMAGNETIC	F32T8/U/6/SPX ELECTRONIC	62 vs. 86	36%	104%	$66.00

** $.10 Per KWH over lamp life.

T8 HIGH OUTPUT LAMPS WITH Starcoat TECHNOLOGY

Cost-Efficient T8 Lighting and Long Life

- ***High system efficiency delivers 38% cost savings***
  Uses 38% fewer watts than standard F96 CW/HO systems while providing 92% of the light output. With a 2-lamp system, you save $171.00 in energy costs (@10¢ per KWH).
- ***50% longer life than T12HO lamps (at 3 hours per start)***
  Longer life extends the relamping cycles reducing lamp replacement and maintenance costs.
- ***More light over life***
  Best lumen maintenance (95%) of any standard T8/HO lamp
- ***Best color rendering, wide choice of options***
  T8/HO lamps are available in SP (78 CRI) and deluxe SPX (86 CRI) for superior color rendering, best in the industry. A choice of color temperatures, ranging from warm to cool and including SPX50, provide the most comprehensive T8/HO color family available.

System Comparison

T8 HIGH OUTPUT LAMPS
2-LAMP STRIP FIXTURE

Comparison Chart

LAMP REPLACED	ENERGY-SAVING REPLACEMENT	CRI	PERCENTAGE WATT REDUCTION	RELATIVE LIGHT OUTPUT	ENERGY** SAVINGS
F96T12/CW/HO ELECTROMAGNETIC	F96T8/SPX/HO ELECTRONIC	62 vs. 86	38%	92%	$171.00

** $.10 Per KWH over lamp life.

F25T12 LAMPS WITH T8 ELECTRONIC BALLAST

The Ultimate Low Energy System

- ***Maximum energy cost savings***
  Less energy than T8 or T12 Watt-Miser® with minimal light output reductions
- ***Perfect for offices and schools***
  - Right light level with lowest energy cost
  - Reduced glare on computer screens
  - SP color quality makes furnishings/decor look better
  - Long 20,000 hour life for reduced maintenance costs
- ***Lower energy replacement for F32T8 with no ballast change***

System Comparison

F25T12 LAMPS
4-LAMP 2X4 TROFFER

LAMP REPLACED	ENERGY-SAVING REPLACEMENT	CRI	PERCENTAGE WATT REDUCTION	RELATIVE LIGHT OUTPUT	ENERGY** SAVINGS
F40T12/CW/WM ELECTROMAGNETIC	F25T12 ELECTRONIC	62 vs. 73	34%	90%	$96.00
F32T8 ELECTRONIC	F25T12 ELECTRONIC	78 vs. 73	17%	79%	$38.00

** $.10 Per KWH over lamp life.

SP AND SPX LAMPS

Superior Color Makes All the Difference

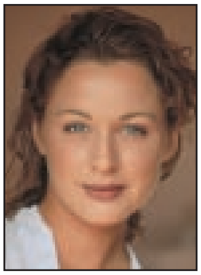
GE SP and SPX color-enhancing fluorescent lamps contain rare-earth phosphors that render colors so true and natural, you won't believe they're fluorescent! Furnishings, decor and merchandise take on a new attractiveness and appeal.

- ***SP lamps use rare-earth phosphors for a moderately priced, good color rendering lamp***
- ***SPX lamps use much more of the rare-earth phosphors for a premium, superior color rendering lamp. Excellent for use in applications where richer, more natural color is important***
- ***No increase in energy costs — lamps use no more electricity than standard tubes***
- ***Lamps provide equal or higher light levels than old standard fluorescents***
- ***Watt-Miser® SP and SPX lamps deliver both improved color and energy cost savings***

Cool White

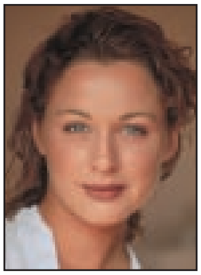
Standard Color

SP35



Good Color

SPX35



Superior Color

covRguard™

SHIELDED FLUORESCENT LAMPS

Sealed for Your Protection

GE CovRguard™ fluorescent lamps are wrapped in a full 15 mil thick casing of polycarbonate plastic, which effectively contains shattered glass particles if the lamp is broken, protecting people and objects.

GE's extensive line of CovRguard™ shielded lamps include T8 with Starcoat™ for best color and most light over life; Ecolux® reduced mercury lamps; and XL types for long life. Many sizes and wattages available. CovRguard™ A-Line, PAR and R bulbs are also available in popular wattages.

FOR MAXIMUM ENERGY SAVINGS AND QUALITY LIGHT...GE T8 LAMPS AND GE ELECTRONIC BALLASTS

A unique synergy distinguishes the Total Performance System. We've brought together a dynamic collection of lamps and compatible ballasts to comprise a total system designed for superior results.

GE Electronic Ballasts

Energy efficiency and high performance make GE Electronic Ballasts and GE Fluorescent Lamps the perfect match for total performance.

- ***Energy efficient — GE has the most efficient system on the market — to dramatically reduce your cost of electricity***
- ***Broadest selection of electronic ballasts on the market***
- ***Outstanding quality***
- ***Industry-leading technical hotline provides specification and application support***

For your electromagnetic ballast needs, MagneTek magnetic ballasts are now also available from GE Lighting.

Selected Product Listings*

■ BEST COLOR ■ EXTRA LIFE°

PRODUCT CODE	DESCRIPTION	NOMINAL WATTS	MOL IN.	CRI/COLOR TEMPERATURE	LUMENS INITIAL	LUMENS MEAN†	LIFE 3 HRS/ START	LIFE 12 HRS/ START	CASE QTY.
STARCOAT™ T8									
22642	F17T8/SPX30	17	24	86 @ 3000K	1350	1280	20,000	24,000	24
22646	F17T8/SPX35	17	24	86 @ 3500K	1350	1280	20,000	24,000	24
22647	F17T8/SPX41	17	24	86 @ 4100K	1350	1280	20,000	24,000	24
17033	F17T8/SP30	17	24	78 @ 3000K	1325	1260	20,000	24,000	24
17035	F17T8/SP35	17	24	78 @ 3500K	1325	1260	20,000	24,000	24
17036	F17T8/SP41	17	24	78 @ 4100K	1325	1260	20,000	24,000	24
22648	F25T8/SPX30	25	36	86 @ 3000K	2150	2040	20,000	24,000	24
22650	F25T8/SPX35	25	36	86 @ 3500K	2150	2040	20,000	24,000	24
22651	F25T8/SPX41	25	36	86 @ 4100K	2150	2040	20,000	24,000	24
15943	F25T8/SP30	25	36	78 @ 3000K	2080	1970	20,000	24,000	24
15944	F25T8/SP35	25	36	78 @ 3500K	2080	1970	20,000	24,000	24
15945	F25T8/SP41	25	36	78 @ 4100K	2080	1970	20,000	24,000	24
22655	F32T8/SPX30	32	48	86 @ 3000K	2950	2800	20,000	24,000	36
22656	F32T8/SPX35	32	48	86 @ 3500K	2950	2800	20,000	24,000	36
22657	F32T8/SPX41	32	48	86 @ 4100K	2950	2800	20,000	24,000	36
23460	F32T8/SPX50	32	48	86 @ 5000K	2800	2660	20,000	24,000	36
15946	F32T8/SP30	32	48	78 @ 3000K	2850	2710	20,000	24,000	36
15947	F32T8/SP35	32	48	78 @ 3500K	2850	2710	20,000	24,000	36
15949	F32T8/SP41	32	48	78 @ 4100K	2850	2710	20,000	24,000	36
14613	F32T8/SP50	32	48	78 @ 5000K	2750	2610	20,000	24,000	36
12132	F32T8/SP65	32	48	78 @ 6500K	2700	2565	20,000	24,000	36
STARCOAT™ XL T8									
45485	F17T8/XL/SPX30	17	24	86 @ 3000K	1350	1280	24,000	30,000	24
45486	F17T8/XL/SPX35	17	24	86 @ 3500K	1350	1280	24,000	30,000	24
45487	F17T8/XL/SPX41	17	24	86 @ 4100K	1350	1280	24,000	30,000	24
45488	F17T8/XL/SP30	17	24	78 @ 3000K	1325	1260	24,000	30,000	24
45489	F17T8/XL/SP35	17	24	78 @ 3500K	1325	1260	24,000	30,000	24
45490	F17T8/XL/SP41	17	24	78 @ 4100K	1325	1260	24,000	30,000	24
45491	F25T8/XL/SPX30	25	36	86 @ 3000K	2150	2040	24,000	30,000	24
45492	F25T8/XL/SPX35	25	36	86 @ 3500K	2150	2040	24,000	30,000	24
45493	F25T8/XL/SPX41	25	36	86 @ 4100K	2150	2040	24,000	30,000	24
45494	F25T8/XL/SP30	25	36	78 @ 3000K	2080	1970	24,000	30,000	24
45495	F25T8/XL/SP35	25	36	78 @ 3500K	2080	1970	24,000	30,000	24
45496	F25T8/XL/SP41	25	36	78 @ 4100K	2080	1970	24,000	30,000	24
12582	F32T8/XL/SPX30	32	48	86 @ 3000K	2950	2800	24,000	30,000	36
12529	F32T8/XL/SPX35	32	48	86 @ 3500K	2950	2800	24,000	30,000	36
12530	F32T8/XL/SPX41	32	48	86 @ 4100K	2950	2800	24,000	30,000	36
12539	F32T8/XL/SPX50	32	48	86 @ 5000K	2850	2660	24,000	30,000	36
25359	F32T8/XL/SP30	32	48	78 @ 3000K	2850	2710	24,000	30,000	36
25360	F32T8/XL/SP35	32	48	78 @ 3500K	2850	2710	24,000	30,000	36
25363	F32T8/XL/SP41	32	48	78 @ 4100K	2850	2710	24,000	30,000	36

PRODUCT CODE	DESCRIPTION	NOMINAL WATTS	MOL IN.	CRI/COLOR TEMPERATURE	LUMENS INITIAL	LUMENS MEAN†	LIFE 3 HRS/ START	LIFE 12 HRS/ START	CASE QTY.
ECOLUX® T8 WITH STARCOAT™									
45742	F17T8/SPX30/ECO	17	24	86 @ 3000K	1350	1280	20,000	24,000	24
45747	F17T8/SPX35/ECO	17	24	86 @ 3500K	1350	1280	20,000	24,000	24
45749	F17T8/SPX41/ECO	17	24	86 @ 4100K	1350	1280	20,000	24,000	24
45741	F17T8/SP30/ECO	17	24	78 @ 3000K	1325	1260	20,000	24,000	24
45743	F17T8/SP35/ECO	17	24	78 @ 3500K	1325	1260	20,000	24,000	24
45748	F17T8/SP41/ECO	17	24	78 @ 4100K	1325	1260	20,000	24,000	24
45753	F25T8/SPX30/ECO	25	36	86 @ 3000K	2150	2040	20,000	24,000	24
45755	F25T8/SPX35/ECO	25	36	86 @ 3500K	2150	2040	20,000	24,000	24
45757	F25T8/SPX41/ECO	25	36	86 @ 4100K	2150	2040	20,000	24,000	24
45750	F25T8/SP30/ECO	25	36	78 @ 3000K	2080	1970	20,000	24,000	24
45754	F25T8/SP35/ECO	25	36	78 @ 3500K	2080	1970	20,000	24,000	24
45756	F25T8/SP41/ECO	25	36	78 @ 4100K	2080	1970	20,000	24,000	24
25611	F32T8/SPX30/ECO	32	48	86 @ 3000K	2950	2800	20,000	24,000	36
25612	F32T8/SPX35/ECO	32	48	86 @ 3500K	2950	2800	20,000	24,000	36
25613	F32T8/SPX41/ECO	32	48	86 @ 4100K	2950	2800	20,000	24,000	36
42064	F32T8/SPX50/ECO	32	48	86 @ 5000K	2950	2800	20,000	24,000	36
26666	F32T8/SP30/ECO	32	48	78 @ 3000K	2850	2710	20,000	24,000	36
26667	F32T8/SP35/ECO	32	48	78 @ 3500K	2850	2710	20,000	24,000	36
26668	F32T8/SP41/ECO	32	48	78 @ 4100K	2850	2710	20,000	24,000	36
ECOLUX® XL T8 WITH STARCOAT™									
27619	F32T8/XL/SPX30/ECO	32	48	86 @ 3000K	2950	2800	24,000	30,000	36
27620	F32T8/XL/SPX35/ECO	32	48	86 @ 3500K	2950	2800	24,000	30,000	36
27621	F32T8/XL/SPX41/ECO	32	48	86 @ 4100K	2950	2800	24,000	30,000	36
27616	F32T8/XL/SP30/ECO	32	48	78 @ 3000K	2850	2710	24,000	30,000	36
27617	F32T8/XL/SP35/ECO	32	48	78 @ 3500K	2850	2710	24,000	30,000	36
27618	F32T8/XL/SP41/ECO	32	48	78 @ 4100K	2850	2710	24,000	30,000	36
T8 MOD-U-LINE® WITH STARCOAT™									
10483	F32T8/SPX30/U/6	32	22.5	86 @ 3000K	2800	2630	20,000	24,000	12
10485	F32T8/SPX35/U/6	32	22.5	86 @ 3500K	2800	2630	20,000	24,000	12
10488	F32T8/SPX41/U/6	32	22.5	86 @ 4100K	2800	2630	20,000	24,000	12
10489	F32T8/SPX50/U/6	32	22.5	86 @ 5000K	2660	2510	20,000	24,000	12
10479	F32T8/SP30/U/6	32	22.5	78 @ 3000K	2700	2565	20,000	24,000	12
23585	F32T8/SP35/U/6	32	22.5	78 @ 3500K	2700	2565	20,000	24,000	12
10480	F32T8/SP41/U/6	32	22.5	78 @ 4100K	2700	2565	20,000	24,000	12
F96T8 8-FOOT HIGH OUTPUT WITH STARCOAT™									
12532	F96T8/SPX30/HO	86	96	86 @ 3000K	8200	7380	18,000	24,000	24
12533	F96T8/SPX35/HO	86	96	86 @ 3500K	8200	7380	18,000	24,000	24
12534	F96T8/SPX41/HO	86	96	86 @ 4100K	8200	7380	18,000	24,000	24
12535	F96T8/SPX50/HO	86	96	86 @ 5000K	8200	7380	18,000	24,000	24
12536	F96T8/SP30/HO	86	96	78 @ 3000K	8000	7200	18,000	24,000	24
12537	F96T8/SP35/HO	86	96	78 @ 3500K	8000	7200	18,000	24,000	24
12538	F96T8/SP41/HO	86	96	78 @ 4100K	8000	7200	18,000	24,000	24
F96T8 8-FOOT• WITH STARCOAT™									
23414	F96T8/SPX30	59	96	86 @ 3000K	5950	5440	15,000	20,000	24
23415	F96T8/SPX35	59	96	86 @ 3000K	5950	5440	15,000	20,000	24
23416	F96T8/SPX41	59	96	86 @ 3000K	5950	5440	15,000	20,000	24
23575	F96T8/SPX50	59	96	86 @ 3000K	5950	5308	15,000	20,000	24
23407	F96T8/SP30	59	96	78 @ 3000K	5800	5310	15,000	20,000	24
23411	F96T8/SP35	59	96	78 @ 3500K	5800	5310	15,000	20,000	24
23412	F96T8/SP41	59	96	78 @ 4100K	5800	5310	15,000	20,000	24
F25T12									
11439	F25T12/SP30	25	48	70 @ 3000K	2300	2140	20,000	24,000	30
11440	F25T12/SP35	25	48	73 @ 3500K	2300	2140	20,000	24,000	30
11442	F25T12/SP41	25	48	72 @ 4100K	2300	2140	20,000	24,000	30

* All data is based on a reference ballast of 60Hz, except life, which is based on a high frequency electronic ballast.

° 20% extra life at 3 hours/start, 25% extra life at 12 hours/start.

† Mean lumens calculated at 40% of rated life.

• F96 lamp bases are single pin, all other bases are medium bipin.

For the most up-to-date, comprehensive product information, visit the GE Lighting Web site at

www.GELighting.com

GE Lighting

85067 (3/00)
Printed in USA

GE T5 Starcoat® Ecolux Lamps

All T5 Starcoat lamps are Ecolux
Full range of Color temperature
High Color Consistency and CRI - 85

Includes:
High Efficiency
High Output

31590	F14W/T5/830/ECO	46704	F28W/T5/830/ECO	46751	F49W/T5/830/ECO
46671	F14W/T5/835/ECO	46705	F28W/T5/835/ECO	46752	F49W/T5/835/ECO
46673	F14W/T5/841/ECO	46706	F28W/T5/841/ECO	46753	F49W/T5/841/ECO
46674	F14W/T5/850/ECO	46707	F28W/T5/850/ECO	46757	F49W/T5/850/ECO
46676	F14W/T5/865/ECO	46700	F28W/T5/865/ECO	46758	F49W/T5/865/ECO
46677	F21W/T5/830/ECO	46724	F35W/T5/830/ECO	46759	F54W/T5/830/ECO
46684	F21W/T5/835/ECO	46727	F35W/T5/835/ECO	46760	F54W/T5/835/ECO
46687	F21W/T5/841/ECO	46735	F35W/T5/841/ECO	46761	F54W/T5/841/ECO
46688	F21W/T5/850/ECO	46742	F35W/T5/850/ECO	46762	F54W/T5/850/ECO
46689	F21W/T5/865/ECO	46743	F35W/T5/865/ECO	46763	F54W/T5/865/ECO
46699	F24W/T5/830/ECO	46744	F39W/T5/830/ECO	46802	F80W/T5/830/ECO
46700	F24W/T5/835/ECO	46745	F39W/T5/835/ECO	46803	F80W/T5/835/ECO
46701	F24W/T5/841/ECO	46746	F39W/T5/841/ECO	46804	F80W/T5/841/ECO
46702	F24W/T5/850/ECO	46747	F39W/T5/850/ECO	46805	F80W/T5/850/ECO
46703	F24W/T5/865/ECO	46748	F39W/T5/865/ECO	46806	F80W/T5/865/ECO

GE CFL Ecolux Lamps

All 4-pin TBX and QBX are TCLP compliant
Full Life and Light output

26W DBX 2-Pin and 4-Pin are TCLP Compliant
All 4-Pin are dimmable

35250	F26DBXT4/SPX27	34405	F18TBX/SPX35/A/4P	46312	F42TBX/SPX27/A/4P/EOL
35237	F26DBXT4/SPX30	34385	F18TBX/SPX41/A/4P	46313	F42TBX/SPX30/A/4P/EOL
35251	F26DBXT4/SPX35	34393	F26TBX/SPX27/A/4P	46314	F42TBX/SPX35/A/4P/EOL
35252	F26DBXT4/SPX41	34397	F26TBX/SPX30/A/4P	46315	F42TBX/SPX41/A/4P/EOL
35247	F26DBXT4/SPX27/4P	34406	F26TBX/SPX35/A/4P	48861	F57QBX/827/A/4P/EOL
35235	F26DBXT4/SPX30/4P	34381	F26TBX/SPX41/A/4P	48862	F57QBX/830/A/4P/EOL
35248	F26DBXT4/SPX35/4P	39377	F32TBX/SPX27/A/4P	48863	F57QBX/835/A/4P/EOL
35236	F26DBXT4/SPX41/4P	39378	F32TBX/SPX30/A/4P	48864	F57QBX/841/A/4P/EOL
34391	F13TBX/SPX27/A/4	39379	F32TBX/SPX35/A/4P	93404	F57QBX/850/A/4P/EOL
34395	F13TBX/SPX30/A/4	39380	F32TBX/SPX41/A/4P	48865	F70QBX/827/A/4P/EOL
34400	F13TBX/SPX35/A/4	46290	F26DBX/E/827	48866	F70QBX/830/A/4P/EOL
34387	F13TBX/SPX41/A/4	46291	F26DBX/E/830	48867	F70QBX/835/A/4P/EOL
34392	F18TBX/SPX27/A/4P	46292	F26DBX/E/835	48868	F70QBX/841/A/4P/EOL
34396	F18TBX/SPX30/A/4P	46294	F26DBX/E/841	93406	F70QBX/850/A/4P/EOL

GE HPS Ecolux Lamps

Reduced Mercury for lower disposal costs
Passes TCLP test
Lead-Free base

Direct Replacement for existing HPS

Ecolux NC™ - Non-cycling makes end-of-life replacement quick and easy

45760	LU70/ECO	45763	LU200/ECO
14672	LU70/ECO/NC	45059	LU200/ECO/NC
45761	LU100/ECO	45764	LU250/ECO
14673	LU100/ECO/NC	14674	LU250/ECO/NC
45762	LU150/ECO	45765	LU400/ECO
40390	LU150/ECO/NC	14675	LU400/ECO/NC
		44058	LU1000/ECO

GE CMH Ecolux PAR 38 Lamps

Lead-Free Base
Passes TCLP Test

Excellent Color – 80+ CRI
High Efficiency – Up to 95LPW

45675	CMH70/PAR38/830SP15/ECO
45677	CMH70/PAR38/830FL25/ECO
45679	CMH70/PAR38/830WF/ECO
45680	CMH100/PAR38/830SP15/ECO
45681	CMH100/PAR38/830SPFL25/ECO
45682	CMH100/PAR38/830WF/ECO

Ecolux®

For additional product and application information, please consult GE's Website: www.gelighting.com

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GE Consumer & Industrial
Lighting

Ecolux®

TCLP Compliant Lamps that Feature Outstanding Performance and Reliability

imagination at work

Ecolux®

Ecolux® Advantages:

Economical
Excellent Lumen Maintenance
Available in Quality Color Options
Lower Disposal Costs

Featured Products

Ecolux Fluorescent Lamps

T12: All 2-foot
All 3-foot
All 4-foot
Ecolux 8-foot Watt-Miser®

T8: All 2-foot
All 3-foot
All 4-foot

T5: All Starcoat® T5 lamps are Ecolux

Ecolux CFL Lamps

26 Watt Double Biax® 2-Pin and 4-Pin
All Triple Biax®
All Quad Biax®

Ecolux High Intensity Discharge

Ecolux HPS -Low Mercury
Ecolux NC -Non-Cycling Low Mercury
Ecolux CMH PAR38

Ecolux® Passes TCLP Tests

All Ecolux® products pass the EPA Toxicity Characteristic Leaching Procedure (TCLP) test. This TCLP test characterizes fluorescent lamp waste as either hazardous or non-hazardous for the purpose of disposal.

What is the TCLP Test and what does it measure?

TCLP is one of the Federal EPA test methods that are used to characterize waste as either hazardous or non-hazardous for the purpose of disposal. TCLP is an acronym for Toxicity Characteristic Leaching Procedure. It is performed by environmental testing labs. The TCLP test does not measure total mercury content; rather, it measures the potential for mercury to seep or "leach" into groundwater if a waste is landfill disposed.

In most states, there are no special disposal requirements for non-hazardous waste lamps.

How does the Ecolux® design differ from traditional designs?

Fluorescent

The mercury content of GE Ecolux® lamps has been reduced by over 80% versus older traditional fluorescent lamp designs. To assure long life, advanced coating technologies have been developed to minimize the absorption of mercury within the lamp.

Additionally, Ecolux® lamps use an exclusive material design that helps to prevent the small amount of mercury in the lamp from forming mercury compounds which may leach into groundwater after lamp disposal.

Compact Fluorescent

GE's family of TCLP compliant compact fluorescent lamps offer superior performance and long life. Offered in a large family of wattages and color temperature to fit your design needs.

HID

GE Ecolux HPS lamps reduce mercury content by 56% up to 93% versus standard HPS lamps and include a lead-free base. Also available in a Non-cycling version making end-of-life replacement quick and easy. Light color changes from yellow to blue-white near end of life, making lamps easy to spot and replace.

GE Ecolux CMH PAR 38 lamps use a lead-free base, and pass the TCLP test.

GE's innovative, patented design gives Ecolux users "the best of both worlds" for exceptional performance and environmental responsibility.

GE T12 Ecolux Lamps

All 2, 3, and 4-foot T12 lamps are Ecolux
F96T12 Watt-Miser® lamps
Same Life and Lumen Output

Includes:
Watt-Miser®
XL Versions
CovRguard®

80044	F20T12/C50/ECO	40805	F34CW/RS/WM/ECO/CVG	80187	F40SP41/ECO
80982	F20T12/C50ECOCVG	23163	F34SP30/RS/WM/ECO	80188	F40SP65/ECO
80045	F20T12/CW/ECO	23165	F34SP35/RS/WM/ECO	80990	F40SP65/ECO/CVG
80046	F20T12/CW/ECO6PK	80489	F34SP35WM/ECOCVG	80189	F40SPX30/ECO
80983	F20T12/CW/ECOCVG	23166	F34SP41/RS/WM/ECO	80493	F40SPX30/ECO/CVG
80047	F20T12/D/ECO	80490	F34SP41WMECOCVG	80190	F40SPX35/ECO
80048	F20T12/SP35/ECO	41563	F34SP65/RS/WM/ECO	80494	F40SPX35/ECO/CVG
80049	F20T12/SPX35/ECO	23157	F34SPX30/RS/WM/ECO	80191	F40SPX41/ECO
80050	F20T12/WW/ECO	41138	F34SPX30/RS/WM/ECO/CVG	80991	F40SPX41/ECO/CVG
80980	F20T12SP35ECOCVG	23158	F34SPX35/RS/WM/ECO	80199	F40SPX50/ECO
80981	F20T12SPX35ECOCV	41139	F34SPX35/RS/WM/ECO/CVG	80217	F40XL/SP30/ECO
80065	F25T12/CWRSWMECO	23159	F34SPX41/RS/WM/ECO	80224	F40XL/SP35/ECO
80077	F25T12/WWRSWMECO	80491	F34SPX41WMECOCVG	80227	F40XL/SP41/ECO
80080	F25T12SP30RSWMEC	80095	F34SPX50/RSWMECO	80230	F40XL/SPX30/ECO
80081	F25T12SP35RSWMEC	45065	F34WW/RS/WM/ECO	80248	F40XL/SPX35/ECO
80083	F30T12/C50/RSECO	80488	F34WWRSWMECOCVG	80249	F40XL/SPX41/ECO
80084	F30T12/CW/RS/ECO	15622	F35CW/U/6/WM/ECO	80250	F40XL/SPX50/ECO
80086	F30T12/D/RS/ECO	80496	F40/C50/ECO/CVG	80066	F25T12/SP30/ECO
80087	F30T12/SP35RSECO	80096	F40C50/ECO	80067	F25T12/SP35/ECO
80088	F30T12/SP41RSECO	80495	F40CW/ECO/CVG	80076	F25T12/SP41/ECO
80091	F30T12/WW/RS/ECO	80992	F40CW/ECO/CVG 6P	16495	F96T12/CW/HO/WM/ECO
80085	F30T12CWRSECO6PK	80993	F40D/ECO/CVG	27186	F96T12/CW/WM/ECO
80486	F30T12CWRSECOCVG	80097	F40DX/ECO	40807	F96T12/CW/WM/ECO/CVG
80986	F30T12SP35ECOCVG	80994	F40DX/ECO/CVG	16821	F96T12/CW/HO/WM/ECO/CVG
80987	F30T12SPX30ECOCV	80098	F40N/ECO	27232	F96T12/SP30/WM/ECO
80089	F30T12SPX30RSECO	80996	F40N/ECO/CVG	27233	F96T12/SP35/WM/ECO
80487	F30T12SPX35ECOCV	80099	F40SP30/ECO	27235	F96T12/SP41/WM/ECO
80090	F30T12SPX35RSECO	80988	F40SP30/ECO/CVG	40373	F96T12/SP65/WM/ECO
80092	F34/C50/RS/WMECO	80186	F40SP35/ECO	27237	F96T12/SPX30/WM/ECO
23010	F34CW/RS/WM/ECO	80989	F40SP35/ECO/CVG	27238	F96T12/SPX35/WM/ECO
				27239	F96T12/SPX41/WM/ECO

GE T8 Ecolux Lamps

All 2, 3, and 4-foot T12 lamps are TCLP compliant
Same long life and outstanding efficiency
Full range of color temperatures

Includes:
F28
F32T8 Watt-Miser &XL
F32T8 High Lumen
CovRguard

45741	F17T8/SP30/ECO	45753	F25T8/SPX30/ECO	26668	F32T8/SP41/ECO
45743	F17T8/SP35/ECO	45755	F25T8/SPX35/ECO	40812	F32T8/SP41/ECO/CVG
15974	F17T8/SP35/ECO/CVG	15990	F25T8/SPX35/ECO/CVG	48279	F32T8/SP41/IS/WM/ECO
45748	F17T8/SP41/ECO	45757	F25T8/SPX41/ECO	40309	F32T8/SP41ISWMECOCVG
15977	F17T8/SP41/ECO/CVG	15991	F25T8/SPX41/ECO/CVG	16090	F32T8/SP50/ECO
45742	F17T8/SPX30/ECO	16314	F25T8/XL/SPX65/ECO	16091	F32T8/SP65/ECO
45747	F17T8/SPX35/ECO	00255	F28T8/SP30/UMX/ECO	25611	F32T8/SPX30/ECO
15975	F17T8/SPX35/ECO/CVG	00256	F28T8/SP35/UMX/ECO	25612	F32T8/SPX35/ECO
45749	F17T8/SPX41/ECO	00257	F28T8/SP41/UMX/ECO	41126	F32T8/SPX35/ECO/CVG
15976	F17T8/SPX41/ECO/CVG	26666	F32T8/SP30/ECO	25613	F32T8/SPX41/ECO
16092	F17T8/XL/SPX65/ECO	40803	F32T8/SP30/ECO/CVG	41127	F32T8/SPX41/ECO/CVG
45750	F25T8/SP30/ECO	48277	F32T8/SP30/IS/WM/ECO	42064	F32T8/SPX50/ECO
45754	F25T8/SP35/ECO	40286	F32T8/SP30/IS/WM/ECO/CVG	49702	F32T8/SXL/SP30/ECO
15981	F25T8/SP35/ECO/CVG	26667	F32T8/SP35/ECO	49778	F32T8/SXL/SP35/ECO
45756	F25T8/SP41/ECO	40804	F32T8/SP35/ECO/CVG	49779	F32T8/SXL/SP41/ECO
15984	F25T8/SP41/ECO/CVG	48278	F32T8/SP35/IS/WM/ECO	27616	F32T8/XL/SP30/ECO
48522	F32T8/XL/SP35/WM/ECO	40299	F32T8/SP35/IS/WM/ECO/CVG	27617	F32T8/XL/SP35/ECO
40297	F32T8/XL/SP35/WM/ECO/CVG	48523	F32T8/XL/SP41/WM/ECO	10326	F32T8/XL/SPX35/HL/ECO
40310	F32T8/XL/SP4/1WM/ECO/CVG	27619	F32T8/XL/SPX30/ECO	27621	F32T8/XL/SPX41/ECO
27618	F32T8/XL/SP41/ECO	10327	F32T8/XL/SPX30/HL/ECO	10322	F32T8/XL/SPX41/HL/ECO
		27620	F32T8/XL/SPX35/ECO	16313	F32T8/XL/SPX50/ECO
				16089	F32T8/XL/SPX65/ECO

WORLDWIDE PARTNER

GE Lighting

Commercial Products & Solutions

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Where to Buy | FAQs | Contact Us | EliteNet

Products > F32T8-SP30-Eco > 26666

26666 – F32T8/SP30/ECO

GE Ecolux® Starcoat® T8

PRINT

• Passes TCLP, which can lower disposal costs.

High Color Rendering
Meets Federal Minimum Efficiency Standards

GENERAL CHARACTERISTICS

Lamp type	Linear Fluorescent - Straight Linear
Bulb	T8
Base	Medium Bi-Pin (G13)
Wattage	32
Voltage	137
Rated Life	20000 hrs
Rated Life (instant start) @ Time	20000 h @ 3 h 24000 h @ 12 h
Rated Life (rapid start) @ Time	24000 h @ 12 h
Bulb Material	Soda lime
Starting Temperature (MIN)	10 °C (50 °F)
Additional Info	TCLP compliant

PHOTOMETRIC CHARACTERISTICS

Initial Lumens	2800
Mean Lumens	2660
Nominal Initial Lumens per Watt	87
Color Temperature	3000 K
Color Rendering Index (CRI)	78
S/P Ratio (Scotopic/Photopic Ratio)	1.3

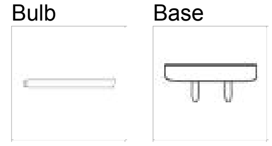
ELECTRICAL CHARACTERISTICS

Open Circuit Voltage (rapid start) Min @ Temperature	315 V @ 10 °C
Cathode Resistance Ratio - Rh/Rc (MIN)	4.25
Cathode Resistance Ratio - Rh/Rc (MAX)	6.5
Current Crest Factor (MAX)	1.7

DIMENSIONS

Maximum Overall Length (MOL)	47.7800 in (1213.6 mm)
Minimum Overall Length	47.6700 in (1210.8 mm)
Nominal Length	48.000 in (1219.2 mm)

Bulb Base



View Larger

ADDITIONAL RESOURCES

Catalogs

Testimonials

Brochures

Product Brochures

- Color
- Ecolux
- Ecolux (Environmental)
- Industrial Lighting
- Linear Fluorescent Lamps

Application/Segment Brochures

- Contractor Lighting
- Healthcare Lighting
- Office Lighting
- Retail Lighting

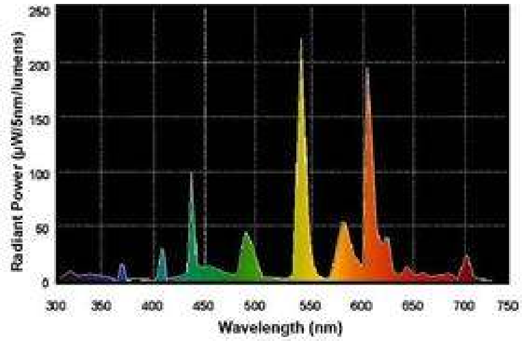
MSDS (Material Safety Data Sheets)

Disposal Policies & Recycling Information

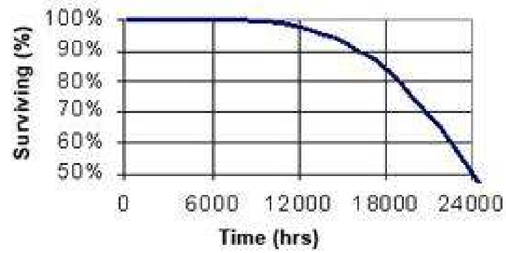
GRAPHS & CHARTS

Spectral Power Distribution

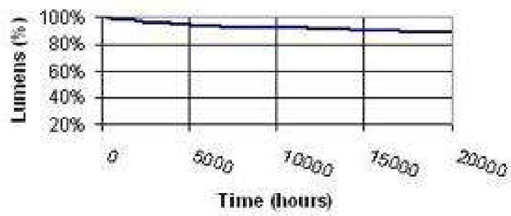
Bulb Diameter (DIA)	1.000 in (25.4 mm)
Bulb Diameter (DIA) (MIN)	0.940 in (23.8 mm)
Bulb Diameter (DIA) (MAX)	1.100 in (27.9 mm)
Max Base Face to Base Face (A)	47.220 in (1199.3 mm)
Face to End of Opposing Pin (B) (MIN)	47.400 in (1203.9 mm)
Face to End of Opposing Pin (B) (MAX)	47.500 in (1206.5 mm)
End of Base Pin to End of Opposite Pin End (C)	47.670 in (1210.8 mm)



Lamp Mortality



Lumen Maintenance



PRODUCT INFORMATION

Product Code	26666
Description	F32T8/SP30/ECO
ANSI Code	1005-2
Standard Package	Case
Standard Package GTIN	10043168266663
Standard Package Quantity	36
Sales Unit	Unit
No Of Items Per Sales Unit	1
No Of Items Per Standard Package	36
UPC	043168266666

COMPATIBLE GE BALLASTS

Product Code	Description	# of Bulbs	Power Factor	Ballast Factor
80353	B132R120V5	1	90.0	0.88
80355	B232SR120V5	2	90.0	0.88
80362	B232SR277S50	2	90.0	0.88
80356	B232SR277V5	2		0.88
80357	B332SR120V5	3	90.0	0.88
80358	B332SR277V5	3	90.0	0.88
23680	GE-132-120-N	1	99.0	0.87
24161	GE-132-120-N-84T	1	99.0	0.87
23681	GE-132-277-N	1	99.0	0.87
24162	GE-132-277-N-84T	1	99.0	0.87
72258	GE132MAX-L/ULTRA	1	99.0	0.77
49706	GE132MAX-L/ULTRA	1	99.0	0.77
72260	GE132MAX-N-DIY	1	99.0	0.87
49771	GE132MAX-N/ULTRA	1	99.0	0.88
72259	GE132MAX-N/ULTRA	1	99.0	0.87
72269	GE-132-MV-N	1	99.0	0.87
30189	GE-132-MV-N	1	99.0	0.87
30268	GE-132-MV-N-42T	1	99.0	0.87
72270	GE-132-MV-N-42T	1	99.0	0.87
23671	GE-232-120-N	1	99.0	0.94
24163	GE-232-120-N-84T	1	99.0	0.94
29621	GE-232-120-PS-N	1	99.0	1.03
29630	GE-232-120PS-N-T	1	99.0	1.03
97782	GE232-120-RES	1	48.0	0.99

YOU MIGHT ALSO BE INTERESTED IN...

For Energy

GE Ecolux® Watt-Miser® Starcoat® T8
Product code: 48277

• Passes TCLP, which can lower disposal costs.

• Saves energy compared to standard wattage lamps

COMPARE

GE Ecolux® Starcoat® T8
Product code: 72128

• Saves energy compared to standard wattage lamps

• Passes TCLP, which can lower disposal costs.

COMPARE

For Better Light

GE Ecolux® Starcoat® T8
Product code: 27619

• Passes TCLP, which can lower disposal costs.

• Provides significantly longer life than standard lamp helping to reduce maintenance costs

COMPARE

71037	GE232-120RES-DIY	1	48.0	0.99
23672	GE-232-277-N	2	99.0	0.94
24164	GE-232-277-N-84T	2	99.0	0.94
29622	GE-232-277-PS-N	1	95.0	1.03
29632	GE-232-277PS-N-T	1	95.0	1.03
47548	GE232MAX-H-42T	1	99.0	1.15
49775	GE232MAX-H/ULTRA	1	99.0	1.15
72263	GE232MAX-L-42T	1	99.0	0.77
49707	GE232MAX-L/ULTRA	1	99.0	0.77
72262	GE232MAX-L/ULTRA	1	99.0	0.77
71421	GE232MAX-N+	1	99.0	1.0
31052	GE232MAX-N-42T	1	99.0	0.87
72267	GE232MAX-N-42T	1	99.0	0.87
72264	GE232MAX-N/AMP	1	99.0	0.87
97656	GE232MAX-N/CTR	1	99.0	0.87
72265	GE232MAX-N/CTR	1	99.0	0.87
72268	GE232MAX-N-DIY	1	99.0	0.87
23940	GE232MAX-N-DIY	1	99.0	0.87
49772	GE232MAX-N/ULTRA	1	99.0	0.87
72266	GE232MAX-N/ULTRA	1	99.0	0.87
30198	GE-232-MV-H	1	99.0	1.34
30275	GE-232-MV-H-42T	1	99.0	1.34
72273	GE-232-MV-L	1	99.0	0.93
30247	GE-232-MV-L	1	99.0	0.93
72274	GE-232-MV-L-42T	1	99.0	0.93
30191	GE-232-MV-N	1	99.0	1.02
72275	GE-232-MV-N	1	99.0	1.08
72276	GE-232-MV-N-42T	1	99.0	1.08
30269	GE-232-MV-N-42T	1	99.0	1.02
97709	GE-232MV-N-DIY	1	99.0	1.02
72277	GE232MV-N-DIY	1	99.0	1.08
29675	GE-232-MVPS-H	2	94.0	1.37
96720	GE232-MVPS-L	1	98.0	0.81
96714	GE232-MVPS-N	1	98.0	1.05
96717	GE232-MVPS-N-42T	1	98.0	1.05
29671	GE-232-MVPS-XL	2	90.0	0.7
29665	GE-232-MVPS-XL-T	1	98.0	0.7
23673	GE-332-120-N	2	99.0	0.94
24165	GE-332-120-N-84T	2	99.0	0.94
29623	GE-332-120-PS-N	2	99.0	1.0
29633	GE-332-120PS-N-T	2	99.0	1.0
23674	GE-332-277-N	2	99.0	0.94
24166	GE-332-277-N-84T	2	99.0	0.94
29624	GE-332-277-PS-N	2	97.0	1.0
47549	GE332MAX-H-42T	2	99.0	1.15
71715	GE332MAX-H-42T	2	99.0	1.29
97713	GE332MAX-HSL84T	2	99.0	1.15
71714	GE332MAX-H/ULTRA	2	99.0	1.29
49776	GE332MAX-H/ULTRA	2	99.0	1.15
71718	GE332MAX-L-42T	2	99.0	0.89

*Click on product for more specification details

49708	GE332MAX-L/ULTRA	2	99.0	0.77
71717	GE332MAX-L/ULTRA	2	99.0	0.89
71422	GE332MAX-N+	2	99.0	1.0
71721	GE332MAX-N-42T	2	99.0	0.97
31053	GE332MAX-N-42T	2	99.0	0.87
97657	GE332MAX-N/CTR	2	99.0	0.87
71720	GE332MAX-N/CTR	2	99.0	0.97
23941	GE332MAX-N-DIY	2	99.0	0.87
71722	GE332MAX-N-DIY	2	99.0	0.97
71719	GE332MAX-N/ULTRA	2	99.0	0.97
49773	GE332MAX-N/ULTRA	2	99.0	0.87
30199	GE-332-MV-H	2	99.0	1.27
30296	GE-332-MV-H-42T	2	99.0	1.27
30255	GE-332-MV-L	2	99.0	0.87
30309	GE-332-MV-L-42T	2	99.0	0.87
30192	GE-332-MV-N	2	99.0	0.96
30270	GE-332-MV-N-42T	2	99.0	0.96
97710	GE-332MV-N-DIY	2	99.0	0.96
29676	GE-332-MVPS-H	2	98.0	1.28
29656	GE-332-MV-PS-H-T	2	98.0	1.28
96721	GE332-MVPS-L	2	98.0	0.77
96715	GE332-MVPS-N	2	98.0	0.98
29672	GE-332-MVPS-XL	2	98.0	0.64
23675	GE-432-120-N	3	0.94	0.94
24167	GE-432-120-N-84T	3	99.0	0.94
29625	GE-432-120-PS-N	3	99.0	0.96
29635	GE-432-120PS-N-T	3	99.0	0.96
97783	GE432-120-RES	3	5.0	0.88
71038	GE432-120RES-DIY	3	5.0	0.88
24168	GE-432-277-N-84T	3	99.0	0.94
47550	GE432MAX-H-42T	3	99.0	1.15
71724	GE432MAX-H-42T	3	99.0	1.28
49777	GE432MAX-H/ULTRA	3	99.0	1.15
71723	GE432MAX-H/ULTRA	3	99.0	1.28
71726	GE432MAX-L-42T	3	99.0	0.88
49709	GE432MAX-L/ULTRA	3	99.0	0.77
71725	GE432MAX-L/ULTRA	3	99.0	0.88
71423	GE432MAX-N+	3	99.0	1.15
71728	GE432MAX-N/CTR	3	99.0	0.94
97658	GE432MAX-N/CTR	3	99.0	0.87
71730	GE432MAX-N-DIY	3	99.0	0.94
23942	GE432MAX-N-DIY	3	99.0	0.87
71727	GE432MAX-N/ULTRA	3	99.0	0.94
49774	GE432MAX-N/ULTRA	3	99.0	0.87
30219	GE-432-MV-H	3	99.0	1.24
30303	GE-432-MV-H-42T	3	99.0	1.24
30262	GE-432-MV-L	3	99.0	0.87
30310	GE-432-MV-L-42T	3	99.0	0.87
30193	GE-432-MV-N	3	99.0	0.93
30271	GE-432-MV-N-42T	3	99.0	0.93

97711	GE-432MV-N-DIY	3	99.0	0.93
29678	GE-432-MVPS-H	3	98.0	1.26
71832	GE432-MVPS-L	3	0.98	0.71
96716	GE432-MVPS-N	3	98.0	0.96
87125	GEM232T8RS120	2	98.0	0.94
87130	GEM232T8RS277	2	98.0	0.98

CAUTIONS & WARNINGS

See list of cautions & warnings.

Return To Top

WORLDWIDE PARTNER

GE Lighting

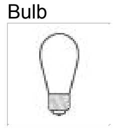
Commercial Products & Solutions

12575 – 11S14

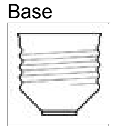
GE S14 - Sign

PRINT

Bulb



Base



Filament

View Larger

GENERAL CHARACTERISTICS

Lamp type	Incandescent - Appliance & Indicators
Bulb	S14
Base	Medium Screw (E26)
Filament	C-9
Bulb Finish	Clear
Wattage	11
Voltage	130
Rated Life	3000 hrs
Bulb Material	Soft glass
Primary Application	Sign

PHOTOMETRIC CHARACTERISTICS

Initial Lumens	76
Nominal Initial Lumens per Watt	6

DIMENSIONS

Maximum Overall Length (MOL)	3.5000 in (88.9 mm)
Bulb Diameter (DIA)	1.750 in (44.4 mm)
Light Center Length (LCL)	2.500 in (63.5 mm)

PRODUCT INFORMATION

Product Code	12575
Description	11S14
Standard Package	Case
Standard Package GTIN	10043168125755
Standard Package Quantity	120
Sales Unit	Unit
No Of Items Per Sales Unit	1
No Of Items Per Standard Package	120
UPC	043168125758

ADDITIONAL RESOURCES

Catalogs
MSDS (Material Safety Data Sheets)
Disposal Policies & Recycling Information

Return To Top

Return to search | Print Page

Product Number:	58327
Order Abbreviation:	50MR16/FL35/C(EXN) 12V
General Description:	Tungsten Halogen Tru-Aim MR16 STANDARD Axial Filament Dichroic Reflector Cover Glass GU5.3 Bi-Pin Base 50Watt 12Volt Flood Beam

Product Information

Abbrev. With Packaging Info.	50MR16FL35CEXN 12V 20/CS 1/SKU
ANSI Code	EXN
Average Rated Life (hr)	2000
Base	GU5.3 Bipin
Bulb	MR16
Centerbeam Candlepower (cp)	1450
Class	C (gas)
Color Rendering Index (CRI)	100
Color Temperature/CCT (K)	3000
Diameter (in)	2
Diameter (mm)	50.8
Ecologic	YES
Family Brand Name	TRU-AIM Standard
Filament	AXIAL
Horizontal Beam Angle (deg)	35
Maximum Overall Length - MOL (in)	1.750
Maximum Overall Length - MOL (mm)	45.0
Nominal Voltage (V)	12.00
Nominal Wattage (W)	50.00
Vertical Beam Angle (deg)	35

Additional Product Information

Product Documents, Graphs, and Images

Packaging Information

ECOLOGIC TM

Footnotes

- UV Filter capsul with axial filament in covered dichroic reflector.
- Max. seal temperature 370 C (662F)
- Max pin temperature 250 C.
- Max temperature at lens reflector joint 240 C.
- Suitable for use in unshielded fixtures. Consult most recent luminaire standards for your area to determine luminaire requirements.

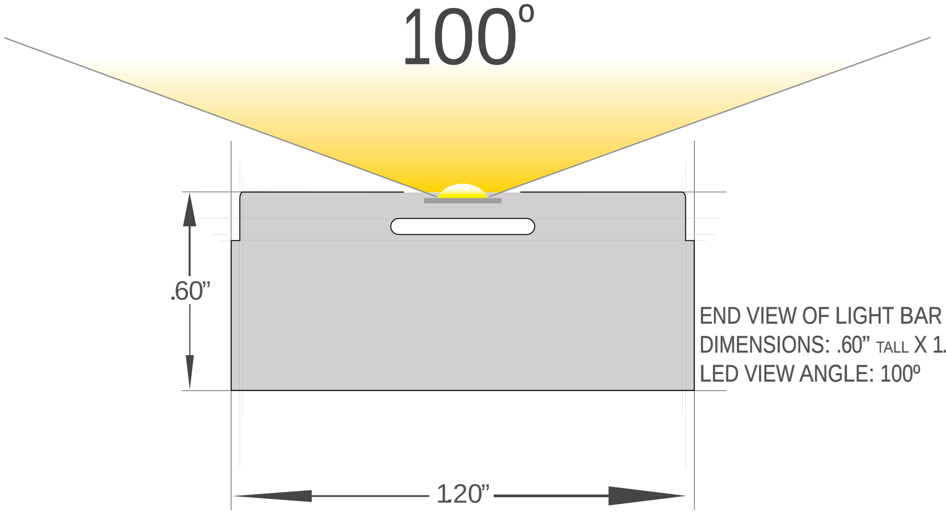
PIRANHA 36 LED LIGHT BAR WHITE

HOW TO READ AN LED POWER PART NUMBER:

LB 36 1-WWW P-100-24

LB IS SIMPLY TO IDENTIFY THE PART NUMBER INTO THE LIGHT BAR CATEGORY.
THESE TWO NUMBERS ARE HOW MANY LED LIGHTS PER FOOT ARE IN THE LIGHT BAR.
THIS NUMBER INDICATES THE LENGTH OF THE LIGHT BAR IN FEET. IT WILL EITHER BE 6",1, 2, 3, OR 4.
THESE THREE LETTERS REPRESENT THE COLOR OF THE LED LIGHTS IN THE LIGHT BAR.
THIS LETTER STANDS FOR THE TYPE OF LED USED. P = PIRANHA STYLE SUPER FLUX LED. 5 = 5 INCH LED. O = OVAL 100º/40º LED.
THIS NUMBER REPRESENTS THE VIEW ANGLE OF LIGHT EMITTED FROM THE LED.
12 VDC or 24 VDC

100°

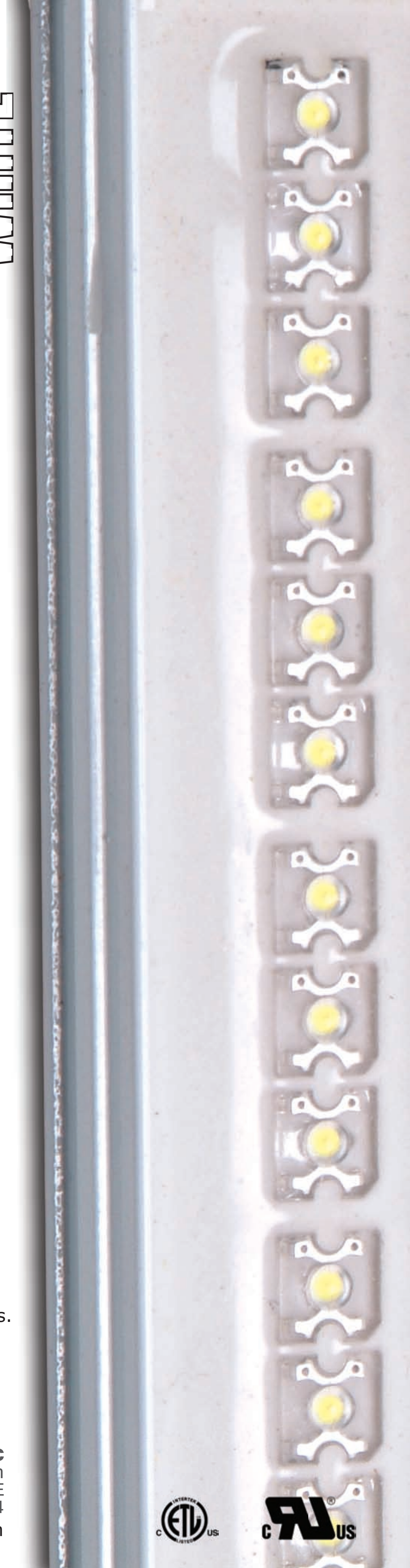


END VIEW OF LIGHT BAR
DIMENSIONS: .60" TALL X 1.20" WIDE
LED VIEW ANGLE: 100º

- This product is ETL Listed and confirms to UL Standard 1598.
- Certified to CAN/CSA Standard 22.2 No. 250.0-04.
- High-Quality LED based Light Bars are available in an array of colors and lengths.
- Choose from 6 inch to 4 foot long lengths with your choice of LED.
- Low-Wattage, Low-Voltage and very Low-Heat with 12VDC or 24VDC Operation.
- White Color Kelvin Temperatures from 2800°K, 3500°K, 5000°K & 8000°K.
- Mono Colors available in Red, Amber, Blue & Green.
- RGB with DMX compatible controllers also available for your color changing projects.
- Light Bars have LED view angles that are customizable from 20° to 120°.
- Ridged Aluminum Light Bars come fully silicone potted for added durability.
- User friendly, easy installation with quality end-to-end connections and brackets.
- Suitable for damp locations.

LED Power, Inc
17875 Sky Park North
Suite E
Irvine, CA 92614

949 679 0031 PHONE **949 679 0037** FAX info@ledpower.com www.ledpower.com



WHITE

LIGHT BAR ELECTRICAL SPECIFICATIONS

PART NUMBER	DESIGN VOLTAGE		TYPICAL CURRENT 12V	TYPICAL CURRENT 24V	TYPICAL WATTS	MAX (LOAD) AMPS PER RUN	MAX (LOAD) WATTS PER RUN 12V	MAX (LOAD) WATTS PER RUN 24V
LB361-XXXP-100-XX	12 VDC	24 VDC	0.33A	0.17A	4W	5 Amps	60W	120W
LB362-XXXP-100-XX			0.66A	0.33A	8W			
LB363-XXXP-100-XX			0.99A	0.50A	12W			
LB364-XXXP-100-XX			1.33A	0.67A	16W			

LIGHT BAR DIMENSIONS

PART NUMBER	LEDS PER FOOT	LEDs	LIGHT BAR LENGTH	ALUMINUM EXTRUSION
LB361-XXXP-100-XX	36	36	L = 12.5 INCH	1.20” Wide 0.60” High
LB362-XXXP-100-XX		72	L = 24.5 INCH	
LB363-XXXP-100-XX		108	L = 36.5 INCH	
LB364-XXXP-100-XX		144	L = 48.5 INCH	

LED SPECIFICATIONS

PART NUMBER	LED COLOR	TYPICAL KELVIN	VIEW ANGLE	TYPICAL LUMENS PER FOOT
LB36X-WASP-100-XX	Super Warm White	2800ºK	100º	130 lm
LB36X-WARP-100-XX	Warm White	3500ºK	100º	144 lm
LB36X-WCOP-100-XX	Cool White	5000ºK	100º	159 lm
LB36X-WBTP-100-XX	Bright White	8000ºK	100º	172 lm

LED Power, Inc
17875 Sky Park North
Suite E
Irvine, CA 92614

949 679 0031 PHONE **949 679 0037** FAX info@ledpower.com www.ledpower.com

Solid State LED 3W MR16 Lamp

Features:

Super Bright 3 Watt LED Lamp
DLR – Direct Lamp Replacement
Low Heat - Excellent Heat Sink Performance
No UV or IR Light Radiation

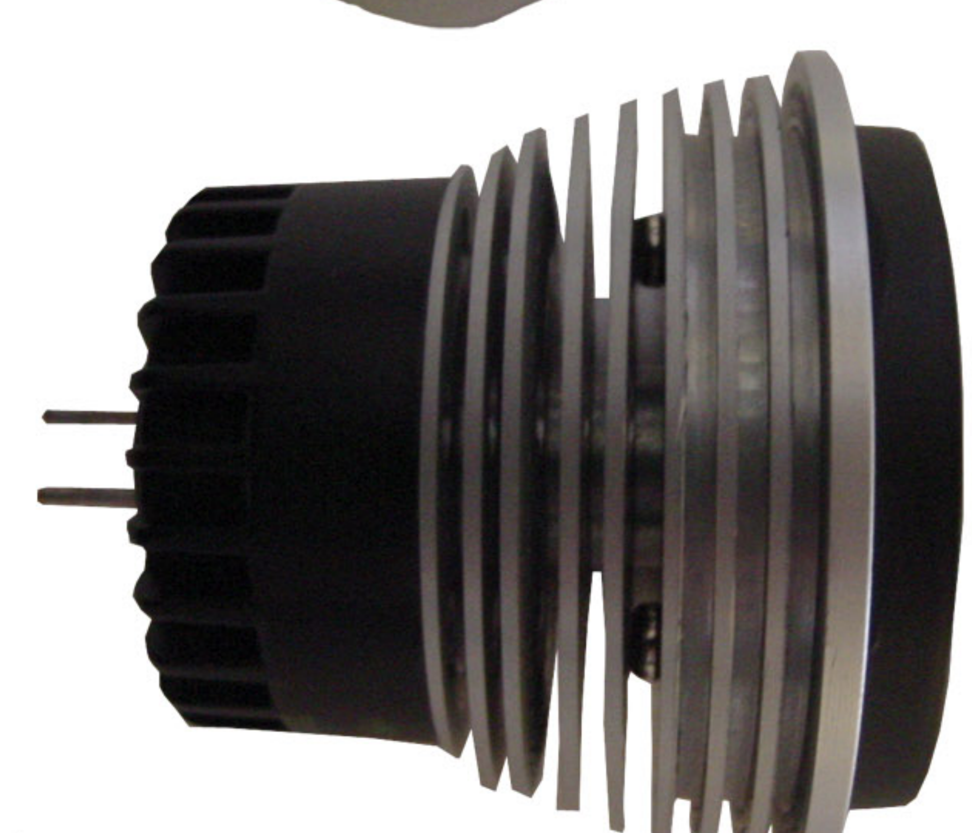
2.00 inches

Applications:

Office and Commercial Buildings
Replaces Standard Track Lighting
Entertainment Lighting
Architectural Lighting
Retail Store Lighting
Art Gallery and Museums

Specifications:

Voltage Requirement: 12 Volt
Power Consumption: 3 Watts
Beam Angle: 15°
2800°K Super Warm (130 lumens typical)
3500°K Warm White (150 lumens typical)
5000°K Cool White (190 lumens typical)
Standard Bi Pin Base
3 Year Warranty



2.00 inches

Part Numbers:

AL-MR163-SW-15 (2800°K)
AL-MR163-WW-15 (3500°K)
AL-MR163-CW-15 (5000°K)

LED Power, Inc.
17875 Sky Park North, Suite E Irvine, CA 92614
Tel: 949-679-0031 Fax: 949-679-0037
www.ledpower.com

Save 80% energy

Long life: 70,000 hours

Environmentally safe: no Mercury or Lead

The world's brightest LED MR16 lamp

Clear benefits

- Replace existing halogen MR16 lamps and save 80% energy.
- Produces 80% less heat: reduce high air conditioning costs.
- Emits no harmful ultraviolet (UV) or infrared (IR) light.
- Available in following beam angles: Spot (12˚), Narrow Flood (24˚), Flood (34˚) and Wide Flood (50˚).
- Available in Warm White, Natural White and Cool White in all beam angles. See product brochure.
- For AC and DC circuits. Fully dimmable. 12V 50/60Hz 4.7W
- RoHS compliant

Safer than CFL lamps - IMS LED MR16 lamps don't shatter upon impact, and contain no harmful Mercury (Hg).

IMS LED MR16 lamps save up to 80% energy and unlike common halogen MR16s qualify as a High Efficacy Lamp per California Title 24.

IMS Lighting has succeeded where others have failed. By utilizing highly efficient, patented Hybrid optics the IMS LED MR16 lamp provides an energy efficient replacement to halogen MR16s.

US Patent No. 6,986,593; worldwide patent pending, including Europe, China and Japan.

Call our sales department for pricing and more information: 949.567.1930 x228

sales@imslighting.com

IMS Lighting

18242 McDurmott West, Suite J
Irvine, CA 92614, USA
www.imslighting.com

Patented optics make the difference

The IMS LED MR16 Lamp is the **world's brightest** LED MR16 lamp thanks to its **superior, patented optics**. The optics achieve maximum collection and distribution efficiency.

US Patent No. 6,986,593; worldwide patent pending, including Europe, China and Japan.

Reliable construction

The construction of the IMS LED MR16 Lamp is a careful synthesis of electronic components, adequate heat sink and superior optics. Our electronic components are designed to last at least 70,000* hrs, our large heat sink is designed to keep the LED lamp at a constant low temperature. Compare to common LED MR16 lamps where limited life of the electronic components and inadequate heat sinks can lead to **early catastrophic failure**.

High energy savings

The IMS LED MR16 Lamp provides up to **80% energy savings**.

First LED MR16 to qualify as a **High Efficacy Lamp per California Title 24**. This would require a modification to our lamp base. This modification is pending.

80% less power consumption results in **80% less heat production**; heat that normally raises the ambient temperature in commercial environments. This excessive and unnecessary heat produced by halogen MR16s is commonly neutralized by running costly air conditioning. Switching to IMS LED MR16 Lamps **reduces high air conditioning costs**.

Excellent return on investment

ROI is reached after 17 months of use. Calculations are based on 12 hours of use per day, electricity cost of $0.12/KWh, and $2 in labor towards bulb replacement. We used an average life span of 3,000 hrs for a halogen MR16, and 70,000* hrs projected life span for the IMS LED MR16 Lamp.

By utilizing the highly efficient, patented Hybrid optics the IMS LED MR16 Lamp provides an energy efficient replacement to halogen MR16s. While driven at a mere 4.7 Watts it offers comparable light output at **80% lower operating cost**.

Operating cost are just 1/8 of a cent per hour, compare to 6/10 of a cent per hour for an average 50W halogen MR16.

Our projected lamp life is 70,000* hrs. An average halogen MR16 has a life span of merely 3,000 hrs. The IMS MR16 LED Lamp offers a **23x longer projected life span**, radically reducing maintenance costs and increasing system reliability.

Reducing the total power consumption of a light system by 80% the use of IMS LED MR16 Lamps also **reduces high transformer costs by about 80%**.

Best light quality

The IMS LED MR16 Lamp produces the **best light pattern of any existing MR16**, halogen or LED. The light pattern is smooth and does not suffer from overlap issues - common to LED lamps with multiple LEDs.

Environmentally safe

Unlike CFL lamps IMS LED MR16 Lamps contain no Mercury (Hg) or Lead (Pb). It is an **environmentally safe product**. A CFL is a good product but contains Mercury (Hg), which can pose a health hazard and impacts our environment when disposed of in landfills.

The solder used in our circuitry is lead-free and fulfills strict European standards: **RoHS compliant**.

The IMS LED MR16 Lamp contains no glass, or other components that could shatter upon impact.

The IMS LED MR16 Lamp produces **no harmful Infrared (IR) and Ultraviolet (UV) radiation**.

Broad application

The IMS LED MR16 Lamp is designed to fit in most standard luminaires, but may not fit all. Please check specifications.

The IMS LED MR16 Lamp is fully dimmable.

The unit works best with regulated 12 Volt DC power supply. Also compatible with AC magnetic transformers. Not compatible with AC track lighting with integral electronic transformers due to the unit's low power consumption. Do not exceed 12.5 Volts. The unit works for both 50 and 60 Hz AC.

Projected life span

Based on 70% lumens maintenance, preferred new standard for LED lighting:

DC power in a free air flow fixture	70,000 hours
DC power in a can light	40,000 hours
AC power in a free air flow fixture	42,000 hours
AC power in a can light	25,000 hours

Projected life span based on 50% lumens maintenance, the current standard for halogen lighting:

DC power in a free air flow fixture	130,000 hours
DC power in a can light	75,000 hours
AC power in a free air flow fixture	77,000 hours
AC power in a can light	50,000 hours

* Projected life based on 70% lumens maintenance, DC power in a free air flow fixture (track light).

IMS Lighting

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F 949.567.1940

www.imslighting.com

The world's brightest
LED MR16 Lamp

80% energy savings

Only 4.7 Watts

Superior, patented Hybrid optics

Environmentally safe: contains no Mercury (Hg), no Lead (Pb). RoHS compliant

Long Life: 70,000 hours

IMS Lighting has succeeded where others have failed. By utilizing highly efficient, patented Hybrid optics the IMS LED MR16 lamp provides an energy efficient replacement to halogen MR16s.

At 70,000* hours its projected life is 23x the life span of an average halogen MR16, radically reducing maintenance costs and increasing system reliability.

High energy efficiency and long operating life result in 80% lower operating costs.**

The IMS LED MR16 emits no harmful ultraviolet (UV) or infrared (IR) light. The unit is constructively safe - there is no glass to break upon impact and it doesn't run as hot as halogen MR16s.

Fits in most standard luminaires, but may not fit all.

Fully dimmable.

First LED MR16 to qualify as a High Efficacy Lamp per **California Title 24**. This would require a modification to our lamp base. This modification is pending.

US Patent No. 6,986,593; worldwide patents pending, including Europe, China and Japan.

* Projected life based on 70% lumens maintenance, DC power in a free air flow fixture (track light).

** Based on 12 hours of use per day, electricity cost of $0.12/KWh, and $2 in labor towards bulb replacement, 3,000 hour halogen MR16.

IMS Lighting

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LED MR16 Lamp

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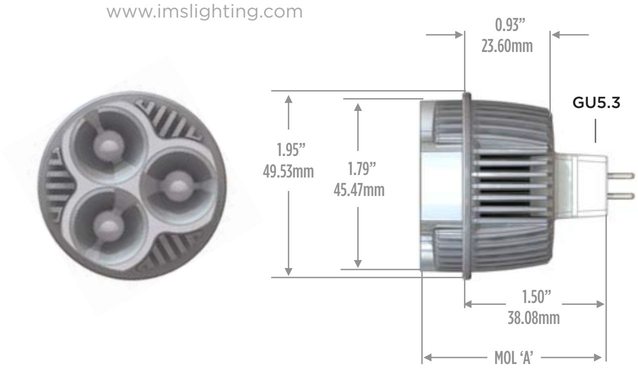

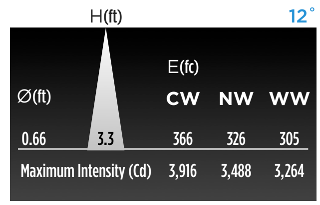

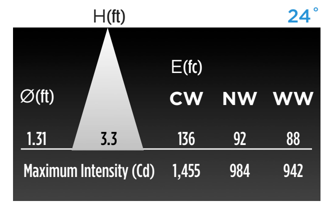

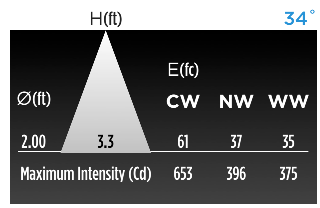

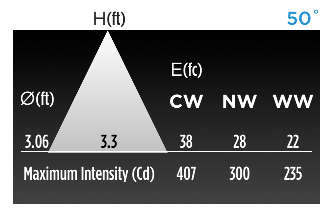

Specs: 12V, 4.7W, AC and DC, 50-60Hz.

Fully dimmable.

Works best with regulated 12V DC systems. Also compatible with AC track lighting with magnetic transformers. Not compatible with AC track lighting with integral electronic transformers due to the unit’s low power consumption of less than 5W.

Environmentally safe: contains no Mercury (Hg), no Lead (Pb). RoHS compliant.

Graphs **CW** = cool white, **NW** = natural white, **WW** = warm white

Daylight White **5,600K** LEDs available on special order. Please call for information and minimum order quantities

Thermal decline and color shift
Data published in this file is measured at turn-on. The nature of a solid-state lighting device is that rising temperature cause a slight decrease in brightness and a color shift on the Kelvin scale. For all inclusive data we refer to our file IMS_MR16_thermal.pdf which can be found on www.imslighting.com

Watts (W)	Could replace (W)	SKU	Voltage (V)	LED color	Color temperature* (K)	Beam angle	Beam spread	Luminous flux** (L)	MOL ‘A’ (inches)	MOL ‘A’ (mm)	Projected life (h)
4.7	25	MR16-12-C-S	12	cool white	6,500	12˚	spot	213	1.94”	49.28	70,000
4.7	25	MR16-24-C-S	12	cool white	6,500	24˚	narrow flood	213	1.89”	48.00	70,000
4.7	25	MR16-34-C-S	12	cool white	6,500	34˚	flood	213	1.90”	48.26	70,000
4.7	25	MR16-50-C-S	12	cool white	6,500	50˚	wide flood	213	1.82”	46.23	70,000
4.7	20	MR16-12-N-S	12	natural white	4,300	12˚	spot	160	1.94”	49.28	70,000
4.7	20	MR16-24-N-S	12	natural white	4,300	24˚	narrow flood	160	1.89”	48.00	70,000
4.7	20	MR16-34-N-S	12	natural white	4,300	34˚	flood	160	1.90”	48.26	70,000
4.7	20	MR16-50-N-S	12	natural white	4,300	50˚	wide flood	160	1.82”	46.23	70,000
4.7	20	MR16-12-W-S	12	warm white	3,200	12˚	spot	139	1.94”	49.28	70,000
4.7	20	MR16-24-W-S	12	warm white	3,200	24˚	narrow flood	139	1.89”	48.00	70,000
4.7	20	MR16-34-W-S	12	warm white	3,200	34˚	flood	139	1.90”	48.26	70,000
4.7	20	MR16-50-W-S	12	warm white	3,200	50˚	wide flood	139	1.82”	46.23	70,000

*Color temperature may vary per LED. **Average luminous flux. **Exit lumens** as measured exiting the optics, not input lumens as measured at the LED. Luminous flux may vary per LED.
Specifications on this sheet may be subject to change for design and specification improvement without prior notice.

Call our sales department for more information and pricing: 949.567.1930 x228
sales@imslighting.com

EMCOR Energy Services

Appendix E

Retailer Feedback Survey

CUSTOMER FEEDBACK SURVEY – LED LIGHTING TEST: DOUBLETREE

DEPARTMENT/POSITION SPRIGS DATE ____________

NAME (Optional) EDDY

A change was recently made to some of the lighting in the bar area, the restaurant and in the lobby entrance at the San Jose location. Please fill out a separate survey form for each lighting system for which you are providing feedback. Please indicate the lighting system that you are currently evaluating by marking an "X" next to the corresponding Test Area:

___ TEST AREA 1: Bar	X TEST AREA 2: Restaurant	___ TEST AREA 3: Lobby Entrance

For the questions below, circle the response that most closely matches your answer. Ratings are from 1 to 10; 1 being the LOWEST score and 10 being the HIGHEST score. Comments are encouraged.

1. Did you notice the lighting change before this survey made you aware of it?

Did Not Notice — Noticed

1 2 3 4 5 ~~6~~ 7 8 9 10

2. Have you overheard or otherwise received any direct feedback from guests about the lighting change?

Yes / ~~No~~ Feedback: Negative / Neutral / Positive

3. In general, does the replacement lighting system improve the visual aesthetics or ambiance in the surrounding environment compared with the previous lighting system?

Worsens Ambiance — Improves Ambiance

1 2 3 4 5 6 7 8 ~~9~~ 10

4. In general, does the replacement lighting system seem to provide more light, the same amount of light, or less light than was provided by the previous lighting system?

Provides Less Light — Same Amount — Provides More Light

1 2 3 4 ~~5~~ 6 7 8 9 10

5. In general, how satisfied are you with the replacement lighting system?

Not Satisfied — Very Satisfied

1 2 3 4 5 ~~6~~ 7 8 9 10

6. Would you recommend that the replacement lighting system be considered for use in additional display areas at this facility?

Would not recommend it — Would recommend it

1 2 3 4 5 6 7 ~~8~~ 9 10

Comments: Cool Look

CUSTOMER FEEDBACK SURVEY – LED LIGHTING TEST: DOUBLETREE

DEPARTMENT/POSITION Events / ESM DATE 5/31/08

NAME (Optional) Lori Johnson

A change was recently made to some of the lighting in the bar area, the restaurant and in the lobby entrance at the San Jose location. Please fill out a separate survey form for each lighting system for which you are providing feedback. Please indicate the lighting system that you are currently evaluating by marking an "X" next to the corresponding Test Area:

___ TEST AREA 1: Bar	___ TEST AREA 2: Restaurant	X TEST AREA 3: Lobby Entrance

For the questions below, circle the response that most closely matches your answer. Ratings are from 1 to 10; 1 being the LOWEST score and 10 being the HIGHEST score. Comments are encouraged.

1. Did you notice the lighting change before this survey made you aware of it?

Did Not Notice — Noticed

1 2 3 4 5 6 7 8 9 10

2. Have you overheard or otherwise received any direct feedback from guests about the lighting change?

Yes / No — Feedback: Negative / Neutral / Positive

3. In general, does the replacement lighting system improve the visual aesthetics or ambiance in the surrounding environment compared with the previous lighting system?

Worsens Ambiance — Improves Ambiance

1 2 3 4 5 6 7 8 9 10

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Provides Less Light — Same Amount — Provides More Light

1 2 3 4 5 6 7 8 9 10

5. In general, how satisfied are you with the replacement lighting system?

Not Satisfied — Very Satisfied

1 2 3 4 5 6 7 8 9 10

6. Would you recommend that the replacement lighting system be considered for use in additional display areas at this facility?

Would not recommend it — Would recommend it

1 2 3 4 5 6 7 8 9 10

Comments: Nice completion of the remodeling

CUSTOMER FEEDBACK SURVEY – LED LIGHTING TEST: DOUBLETREE

DEPARTMENT/POSITION Bell Desk / CAAC. DATE ____________

NAME (Optional) Don S

A change was recently made to some of the lighting in the bar area, the restaurant and in the lobby entrance at the San Jose location. Please fill out a separate survey form for each lighting system for which you are providing feedback. Please indicate the lighting system that you are currently evaluating by marking an "X" next to the corresponding Test Area:

___ TEST AREA 1: Bar	___ TEST AREA 2: Restaurant	___ TEST AREA 3: Lobby Entrance

For the questions below, circle the response that most closely matches your answer. Ratings are from 1 to 10; 1 being the LOWEST score and 10 being the HIGHEST score. Comments are encouraged.

1. Did you notice the lighting change before this survey made you aware of it?

Did Not Notice — Noticed

1 2 3 4 5 6 7 8 9 10

2. Have you overheard or otherwise received any direct feedback from guests about the lighting change?

Yes / No

Feedback: Negative / Neutral / Positive

3. In general, does the replacement lighting system improve the visual aesthetics or ambiance in the surrounding environment compared with the previous lighting system?

Worsens Ambiance — Improves Ambiance

1 2 3 4 5 6 7 8 9 10

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5. In general, how satisfied are you with the replacement lighting system?

Not Satisfied — Very Satisfied

1 2 3 4 5 6 7 8 9 10

6. Would you recommend that the replacement lighting system be considered for use in additional display areas at this facility?

Would not recommend it — Would recommend it

1 2 3 4 5 6 7 8 9 10

Comments: Very cool Lights

CUSTOMER FEEDBACK SURVEY – LED LIGHTING TEST: DOUBLETREE

DEPARTMENT/POSITION Events / ESM DATE 5/30/08

NAME (Optional) Lori Johnson

A change was recently made to some of the lighting in the bar area, the restaurant and in the lobby entrance at the San Jose location. Please fill out a separate survey form for each lighting system for which you are providing feedback. Please indicate the lighting system that you are currently evaluating by marking an "X" next to the corresponding Test Area:

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Provides Less Light — Same Amount — Provides More Light

1 2 3 4 5 6 7 8 9 10

5. In general, how satisfied are you with the replacement lighting system?

Not Satisfied — Very Satisfied

1 2 3 4 5 6 7 8 9 10

6. Would you recommend that the replacement lighting system be considered for use in additional display areas at this facility?

Would not recommend it — Would recommend it

1 2 3 4 5 6 7 8 9 10

Comments: Not aware of any change in restaurant. Coffee Garden has so many negative things to look at you don't bother to look up at lighting system

CUSTOMER FEEDBACK SURVEY – LED LIGHTING TEST: DOUBLETREE

DEPARTMENT/POSITION Events / ESM DATE 5/30/08

NAME (Optional) Lori Johnson

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For the questions below, circle the response that most closely matches your answer. Ratings are from 1 to 10; 1 being the LOWEST score and 10 being the HIGHEST score. Comments are encouraged.

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Yes / No

Feedback: Negative / Neutral / Positive

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5. In general, how satisfied are you with the replacement lighting system?

Not Satisfied — Very Satisfied

1 2 3 4 5 6 7 8 9 10

6. Would you recommend that the replacement lighting system be considered for use in additional display areas at this facility?

Would not recommend it — Would recommend it

1 2 3 4 5 6 7 8 9 10

Comments: The fan system is beautiful and looks really nice.