Resource Conservation District of Greater San Diego County

LED Troffer and Downlight Interior General Illumination Lighting Assessment Final Report

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Prepared for:

SDGE
A Sempra Energy utility℠

Prepared by:

ETA
EMERGING TECHNOLOGIES ASSOCIATES, INC.

PREFACE

PROJECT TEAM

This project is sponsored by San Diego Gas & Electric's (SDG&E's) Emerging Technologies Program (ETP) with Jerine Ahmed as the project manager. Marty Leavitt, District Manager, was the contact and project manager for Resource Conservation District of Greater San Diego County (RCD). Emerging Technologies Associates (ETA), Inc provided technical consulting, data analyses and the overall coordination of all parties involved and finalizing the report.

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ACKNOWLEDGEMENTS

We would like to acknowledge the RCD for assisting in reviewing the products and installation of the LED fixtures. Without their participation, this assessment project would not have been possible.

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EXECUTIVE SUMMARY

In May 2009, the Resource Conservation District of Greater San Diego County and San Diego Gas & Electric's (SDG&E's) Emerging Technologies Program (ETP) agreed to conduct an assessment project to evaluate solid state lighting (SSL) light emitting diode (LED) technology. The goal of the project was to determine the energy savings potential provided by LED as the light source for general illumination lighting compared to the standard base case fluorescent in a small office setting.

In addition to the assessment project goals, the RCD's goals were: (1) to eliminate disposal concerns of fluorescent lighting and (2) to embrace the "greenest" lighting technology available.

The project was selected due to the RCD's willingness to allow for general illumination of their entire office space to be provided solely by LED light sources.

Quantitative and qualitative light and electric power measurements were taken. A 16% reduction in energy use and demand were recorded with LED luminaires over the minimum standard for general illumination interior lighting systems established by California's 2008 Title 24 standards. When compared with the less stringent 2005 Title 24 standards, which was prevailing standard when the lighting was installed the savings are 35%.

The tables 1 and 2 illustrate how the manufacturer's product data provided on its product data sheet compare to the project's measured data and the CALiPER testing data. CALiPER is Department of Energy's Commercially Available LED Product Evaluation and Reporting Program.

Table 1: CREE LR6 LED Downlight Performance Data

	Manufacturer	Measured	CALiPER 07-47
Power in watts	10.5	11.8	10.8
CCT in kelvin	3500	3377	3402
CRI	90	not measured	90.7
Power Factor	>0.90	0.98	0.97

Table 2: CREE LR24 LED Troffer Performance Data

	Manufacturer	Measured	CALiPER 09-41-01
Power in watts	44	46.7	41
CCT in kelvin	3500	3377	3250
CRI	90	not measured	89
Power Factor	0.9	0.98	0.97

This assessment project will assist not only other Greater San Diego County offices, but all offices across the country, to determine the applicability of LED light sources for general illumination lighting retrofits. Consideration of design, functionality and occupant behavior, acceptance and tolerance of a new "emerging" light source technology, luminaire quality, and economic considerations may directly impact the decision to select LEDs for the purpose of office general illumination. **Therefore, readers are advised that each situation is unique. It is recommended the reader exercise due diligence in determining the appropriateness of LEDs for general illumination, luminaire selection, lighting design and layout.** This project is unique in that it is the first to assess a complete office space with general illumination provided solely by LEDs.

Based upon the findings of this project, it is recommended that future projects conducted consider: 1) an actual situation where the base case fluorescent lighting system can be measured allowing for comparison of light characteristics and performance; 2) the use of dimming; 3) LED task lights; 4) task ambient lighting relationship by incorporating a lighting control system to determine the impact on energy savings; and 5) due to the relative newness of LED lighting, it is recommended research be conducted into how LED lighting affects the occupant's eyes, i.e. eye strain.

INTRODUCTION

In response to an overwhelming interest in LED general illumination lighting technology among customers in its service area, SDG&E's objective with this assessment was to:

– assess LED lighting technology, validating manufacturer claims regarding energy savings, light levels and light characteristics

– perform a comparison of LED technology against traditional light sources meeting CA Title 24 requirements

The RCD selected and arranged for the installation of new LED overhead general illumination for its office building.

In collaboration with the RCD and its contractors, SDG&E agreed tp assess the performance of the selected LED luminaires. Installation of the LED luminaires was completed mid year 2009. Quantitative and qualitative lighting and electrical power measurements were taken post installation. Pre installation data was based upon Title 24 requirements for office general illumination.

Figure 1: CREE LR24 LED Troffer In Open Work Space

PROJECT BACKGROUND

Project Overview

The LED Troffer and Downlight Interior General Illumination Lighting Assessment project was conducted as part of SDG&E's Emerging Technologies Program. The Emerging Technologies program "is an information-only program that seeks to accelerate the introduction of innovative energy-efficient technologies, applications and analytical tools that are not widely adopted in California. The information includes verified energy savings and demand reductions, market potential and market barriers, incremental cost, and the technology's life expectancy. Project Management and Methodology was provided by ETA.

This project studied the applicability of overhead general illumination lighting consisting of light emitting diode (LED) luminaires in a small commercial office. This was a renovation of a vacant space in which the occupant selected LED technology in lieu of the traditional fluorescent lighting technology. The general lighting was designed in accordance with the 2005 version and less stringent Title 24 requirements. The applicability of the technology was determined by light output, energy and power usage, economic factors and qualitative satisfaction.

Technological Overview

At the time of this assessment, LED lighting in general illumination applications, i.e. downlights, were gaining momentum. Due the luminaire's ability to provide greater control of light dispersion, greater operating and maintenance savings and desire for higher quality light, RCD decided to pursue the use of LEDs for general illumination of their entire office space.

LED downlights were used in the office restrooms. LED troffers were used in this project for the general office and common area overhead general illumination light source. With the "newness" of the use of LEDs in this troffer application, the Department of Energy's Commercially Available LED Product Evaluation and Reporting Program (CALiPER) is evaluating product designed for this application.

Currently, lighting retrofits for general illumination in San Diego County, as well as across the country, are illuminated with T8 or T5 fluorescent and compact fluorescent lamps. Fluorescent technology is used primarily because of their long rated life and high efficiency relative to other conventional options. In California, Title 24 2008 which became effective January 2010, requires an office to have a lower lighting power density (LPD) of 0.85 W/sq ft for general illumination lighting than the previous version's LPD requirement of 1.1 W/sq ft. New lighting technologies like LEDs have the potential for even longer life, reduced maintenance, high color rendition, and reduced operating cost including lower energy usage as compared to fluorescent. Currently however, the initial cost of this technology is higher than conventional light sources such as fluorescent.

Since RCD used several downlights in their space and there is a wealth of published information on the potential of LED downlights, not LED troffers, for use in general illumination, the following information is provided for the readers. According to a Navigant Consulting, Inc report, "Energy Savings Estimates of Light Emitting Diodes in Niche Applications October 2008" prepared for Building Technologies Program, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, LED recessed downlights have the greatest energy savings potential of applications currently being considered for white light LEDs. The report states that "electricity is saved in white-light applications where LED sources are used to replace incandescent, halogen, and in some cases, CFL and some types of fluorescents."

Due to the directional nature of the light provided, recessed downlights have become the most common fixture used for general illumination ambient lighting in both residential and commercial buildings. Currently recessed troffer fixtures commonly used with linear fluorescent lamps are not included as part of the above mentioned Navigant report.

Below are the Navigant report details on the emergence of LEDs in the recessed downlight market.

"While some LED-based products have been offered as "substitutes" for incandescent reflector lamps for these applications, only in 2007 were products introduced to the market which offered a sufficiently bright lumen level and quality of light that they could be considered adequate substitutes for incandescent reflector lamps. In 2007, LED Lighting Fixtures Inc. (now CREE LED Lighting Solutions) won the grand prize in the *Lighting for Tomorrow* competition for an LED LR6 recessed downlight that could replace the common BR30 incandescent reflector, or CFL reflector lamps (Lighting for Tomorrow, 2008).

These LED recessed downlight products, as measured by the DOE's Commercially Available LED Product Evaluation and Reporting Program (CALiPER), can be more efficient *in situ* than both conventional incandescent reflector and compact fluorescent technologies (DOE, 2007b). In addition to being an efficient lighting technology, LED reflector lamps can also be designed for either directional or ambient lighting unlike reflector compact fluorescent lamps which are best suited for ambient lighting conditions."

The CREE LR6 downlight (Figure 2) and LR24 troffer luminaire (Figure 3) was used in this project. Appendix B contains the product data sheets for both products.

Figure 2: LR6 LED Downlight

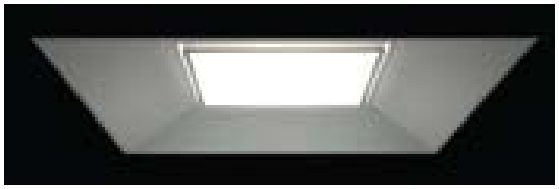


Figure 3: LR24 LED Troffer

According to the US Department of Energy, LED technology is changing at a rapid pace. The performance of LED technology is quickly gaining efficiency but the first cost remains a barrier to market entry. However, it should be noted that the costs for LED technology seems to be getting more competitive in the market place with each year that passes and technological advances are applied to general illumination ambient lighting luminaires. This is particularly true for the recessed downlight application.

The LED troffer application is so new that it may take some more time before costs began to become more competitive. Additionally, the proper lighting design considering the task ambient

lighting relationship may create a more compelling payback for using the LED troffer in lieu of fluorescent technology. In this project, the LED troffer provided the IESNA recommended illuminance at the task plane of 50 foot candles, which is the recommended illuminance level for private offices. Since the RCD is an open office plan, the IESNA recommended illuminance level is 30 foot candles at the task plane. Therefore, a lighting design to the IESNA recommended illuminance levels for open office general illumination lighting may have resulted in less LED fixtures being required in this space. This would have resulted in a much shorter simple payback period.

Market Overview

The anticipated escalation rate for electricity is an increasing concern. Both energy costs to operate traditional lighting technology and the environmental disposal issues of various light sources including fluorescent technology, will inevitably increase over time. The market for new energy efficient interior white light sources will continue to grow due to increasing demand for electricity and the cost to operate and maintain interior lighting. Increasing electricity rates and a growing awareness of energy efficiency will increase the economic feasibility of new general illumination ambient lighting technologies in future years to come.

Figures 4 and 5 provide the breakdown of both electric energy use by building type and the end use, i.e. interior lighting according to the California Commercial End-Use Survey (CEUS) conducted 2006 by Itron, Inc. As Figure 4 indicates, offices comprise 28.8% of the entire segments square footage. Figure 5 indicates the dominance of interior lighting, 28.4%, as the largest application for electric energy.

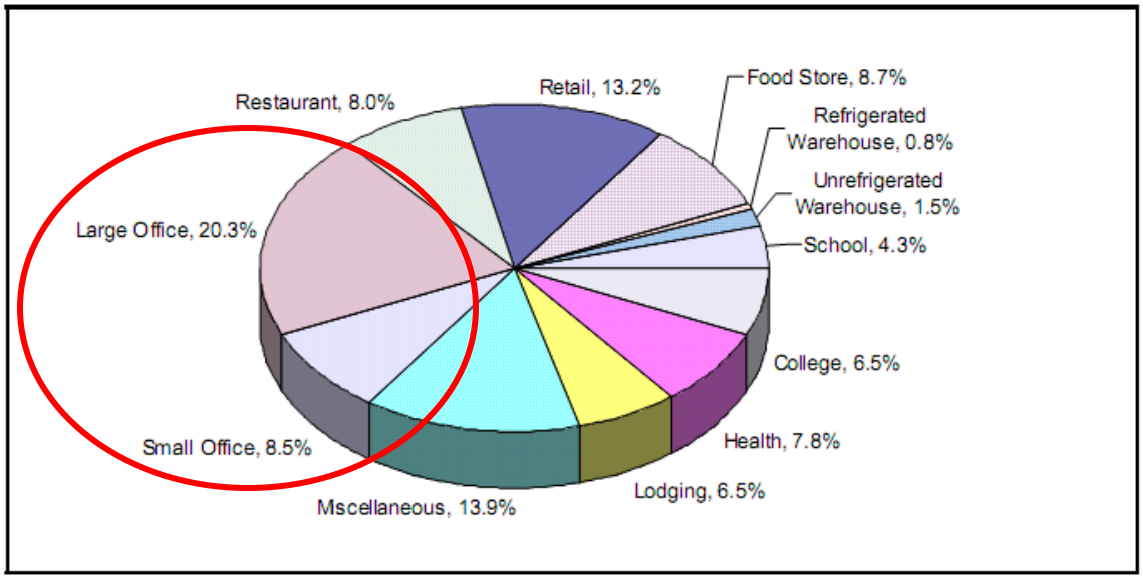


Figure 4: Electric Use by Building Type in SDG&E's Service Area

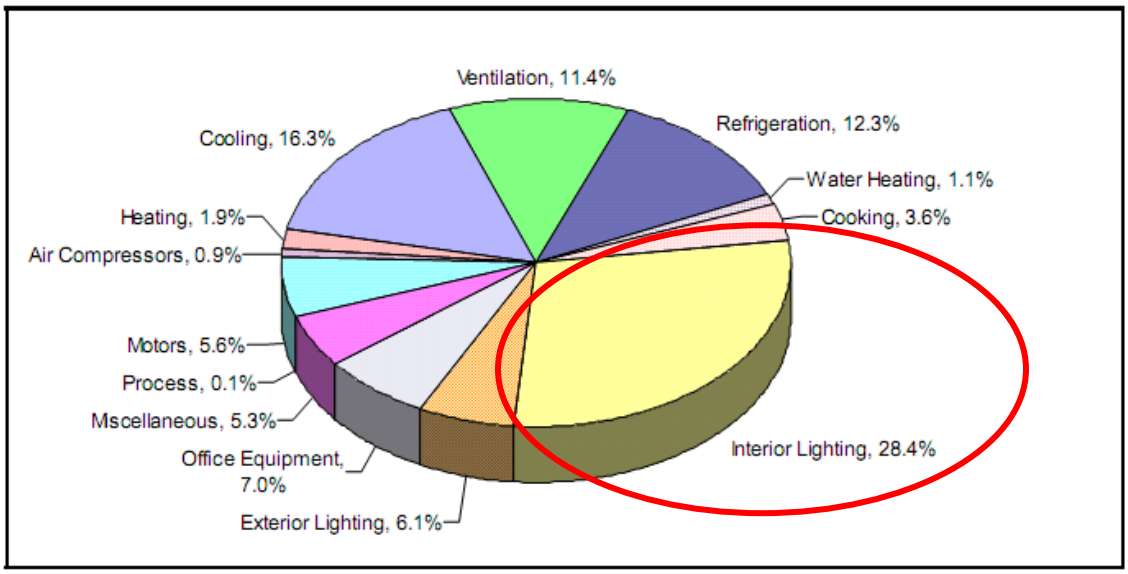


Figure 5: Electric Usage by End Use in SDG&E's Service Area

According to CEUS, in SDG&E's service area, the entire commercial segment utilizes 4.16 kWh/sq ft for interior lighting. The small and large commercial office space utilizes 3.94 kWh/sq ft and 4.45 kWh/sq ft, respectively.

The results of this project indicate the potential for small office to utilize only 2401 kWh for the entire 1566 square feet, or 1.53 kWh/sq ft electric energy intensity for the interior lighting. This is a significant reduction when compared to the above 3.94 kWh/sq ft referenced in the CEUS report. This is based upon operating approximately 8 hours/day 260 days per year.

PROJECT OBJECTIVES

The objectives of this project were to examine electrical, lighting, and economic performance of LED troffer and recessed downlight luminaires as compared to the requirements of Title 24. The potential electrical demand and energy savings were measured in terms of instantaneous system wattage and annual kWh usage was based on the RCD's annual operating hours. Lighting performance was measured in terms of illuminance in foot candles and correlated color temperature (CCT) measured in Kelvin. Finally, economic performance was calculated as simple-payback for the incremental cost of utilizing LEDs in lieu of traditional fluorescent fixtures in a new installation.

Figure 6: CREE LR24 LED Troffers In Open Office Area

METHODOLOGY

Host Site Information

The site selected for this assessment was the office located in Lakeside, CA. The project was considered a "new construction" project since it was a complete renovation of an entire space. As such, it had to meet the standards established by Title 24.

The office ceiling height was 7'9" throughout the 1566 square foot office space. In lieu of traditional fluorescent fixtures, twenty-two CREE LR24 LED troffer fixtures were used in the general office spaces and common areas, i.e. break room. Two restrooms had one CREE LR6 LED recessed can light installed in each. The annual operating hours of the office was 2142 hours. The customer pays $0.21/kWh.

Measurement Plan

The assessment project studied the suitability and performance of LED luminaires in a small office general illumination lighting application. In lieu of traditional fluorescent fixtures, LED luminaires were used throughout the entire office space. Quantitative and qualitative light and electrical power measurements were taken.

A measurement plan was developed for this assessment. Due to this being a "new construction" project pre-installation measurements were calculated using Title 24 lighting power density (LPD) requirements. Since this project was completed prior to the effective date of the more stringent requirements established in Title 24, the required LPD was only 1.1 W/sq ft versus the current effective version's 0.85 W/sq ft for an office general illumination application.

The office area had a significant amount of natural daylight. Therefore, all light measurements were taken after dusk to obtain the actual lighting performance of the LED luminaires without any influence of natural daylight.

The luminaires were mounted flush to the ceiling at a height of 7'9" above the finished grade. The illuminance levels were taken at the task plane, specifically the occupants' work surface, in each work space and in the common areas.

Equipment

Consultant owned equipment was used for:

Correlated Color Temperature Meter

Konica Minolta Chrome Meter, Model CL-200, last calibrated 10/2007

Power Readings

Fluke Clamp Meter, Model 332

PROJECT RESULTS AND DISCUSSION

Electrical Demand and Energy Savings

The LED luminaires used less power than the lighting system required by Title 24 with an annual reduction of energy usage. Tables 3 and 4 show the demand and energy savings achieved with LED lighting technology.

Table 3: Project Demand Savings

Light Source	Stated Power	Measured Power	Power Savings	% Power Savings
Title 24 Project	1722			
Title 24 Current	1331			
LED v Title 24 Project	1061	1121	601	35%
LED v Current Title 24	1061	1121	210	16%

Table 4: Project Electric Energy Savings

Light Source	Annual Energy (kWh)	Annual Energy Savings (kWh)	% Energy Savings
Title 24 Project	3689		
Title 24 Current	2851		
LED v Title 24 Project	2401	1287	35%
LED v Current Title 24	2401	450	16%

Lighting Performance

Photopic illuminance measurements were taken at the task plane of each occupant's work surface as described in the above section, "Measurement Plan."

Correlated Color Temperature

Correlated color temperature (CCT) measurements were taken using a Konica Minolta Chromameter under the LED luminaires. The average color temperature under the LED luminaire was 3377 K.

Validation of Manufacturer Data

The below tables, 5 and 6, illustrate how the manufacturer's product data provided on its product data sheet compare to the project's measured data and the CALiPER testing data which can be found at http://www1.eere.energy.gov/buildings/ssl/caliper.html

Table 5: Performance Results of CREE LR6 LED Downlight

	Manufacturer	Measured	CALiPER 07-47
Power in watts	10.5	11.8	10.8
CCT in kelvin	3500	3377	3402
CRI	90	not measured	90.7
Power Factor	>0.90	0.98	0.97

Table 6: Performance Results of CREE LR24 LED Troffer

	Manufacturer	Measured	CALiPER 09-41-01
Power in watts	44	46.7	41
CCT in kelvin	3500	3377	3250
CRI	90	not measured	89
Power Factor	0.9	0.98	0.97

Figure 7: CREE LR24 LED Troffer in Kitchen Area

Economic Performance

It is important to note that the cost and equipment assumptions made in this section apply only to the RCD. Readers should consider their specific variables such as maintenance, energy, luminaire efficacy, luminaire costs and type of distribution before drawing any conclusions about the cost effectiveness of LED luminaires. LED luminaire lifetime is a function of all the manufacturer's components of the luminaire (LEDs, driver, housing, coatings, etc.), electrical and thermal properties. Therefore, manufacturer claims, with regard to the aforementioned factors, are highly variable. The cost and savings estimates for this section is based upon the RCD's situation to evaluate economic performance of the base case Title 24 requirements and the LED luminaires assessed in this project.

1. Energy Cost Estimates

The energy cost is based upon the RCD's electric rate of $0.21/kWh. The annual operating hours of 2,142 hours was provided by RCD. This project focused on the substitution of LED luminaires in lieu of fluorescent fixtures in a "new" construction scenario. Table 7 provides the energy and energy cost savings results of this project.

Table 7: Project Energy Savings Achieved

Light Source	Annual Energy (kWh)	Annual Energy Savings (kWh)	% Energy Savings	Annual Energy Cost	Annual Energy Cost Savings	% Energy Cost Savings
Title 24 Project	3689			$775		
Title 24 Current	2851			$599		
LED v Title 24 Project	2401	1287	35%	$504	$270	35%
LED v Title 24 Current	2401	450	16%	$504	$94	16%

Simple payback calculations were calculated for a new construction scenario only. Due to the fact that the results of this project reflected a payback that far exceeded the lifetime of the lumianres, no calculations for maintenance or retrofit scenarios were calculated. Table 8 provided the simple payback for this project.

Table 8: Project Simple Payback

Light Source	Total Installed Cost	Incremental Cost	Energy Cost Savings	Simple Payback
Title 24 Project	$6,500			
Current Title 24	$6,500			
LED v Title 24 Project	$17,471	$10,971	$270	65
LED v Title 24 Current	$17,471	$10,971	$94	116

2. Luminaires and Lamp Life

For the purposes of this project, the end of useful life for each lumianire is 50,000 hours.

LEDs require a properly designed fixture, meaning electrically and thermally, to achieve the life expectancy. If the fixture has poor electrical or thermal design the LED life is adversely affected resulting in a much shorter life.

James Brodrick, Lighting Program Manager, U.S. Department of Energy, Building Technologies Program, in a recent article entitled "Lifetime Concerns", when discussing how best to define the longevity of LED luminaires stated: "That's not a simple matter, because it doesn't just involve the LED themselves, but rather encompasses the entire system-including the power supply or driver, the electrical components, various optical components and the fixture housing."

The manufacturer of the LED luminaires assessed in this project claim life expectancies of up to 50,000 hours (approximately 23 years at 2142 operating hours per year). ***This report uses 50,000 hours, or 23 years in this situation, as the LED life expectancy.*** The Title 24 base case fluorescent system has an expected life of 20,000 to 30,000 hours (approximately 9 to 14 years based upon the 2142 annual operating hours).

3. Life Cycle Cost Analysis

As stated in the previous section no economic analysis taking into consideration maintenance savings and other savings was conducted due to the extremely long simple payback. However, to properly assess technology a full life cycle cost analysis is recommended. There are many variables and considerations which are specific to each reader's situation. It is recommended that variables such as labor, cost of materials, maintenance practices, cost of financing, inflation, energy rates, material cost, etc be determined for the specific project under evaluation. Due to the uncertainty as to future labor, product and other costs, especially for LED technology, readers are recommended to use their judgment regarding the future costs.

CONCLUSION

This assessment demonstrated that LED general illumination ambient lighting technologies deliver lighting power densities which meet or exceed Title 24 requirements. LEDs exhibited potential for energy savings and the potential for better operation and maintenance savings.

The lessons learned from this assessment are as follows:

- √ LED technology is a viable alternative for general illumination ambient lighting.
- √ Further studies are required to determine exactly how LEDs compare to fluorescent lighting systems.
- √ The manufacturer of the LEDs used in this project did exercise due diligence in their marketing materials providing accurate information. However, do not rely on marketing brochures and technical data sheets. A full assessment is recommended.

The results of this project attest to the leaps in technological enhancements of LED luminaires. However, the high incremental first cost required in new construction with LEDs as the light source providing general illumination ambient lighting will be the main barrier to significant market adoption. The energy savings and potential reduce maintenance costs do not adequately offset this high initial first cost. Performance of the LED luminaires combined with growing industry desire for more eco-friendly lighting products may provide early adopters the impetus to invest in the emerging technology.

Due to the as yet proven long life of LEDs, economic and reliability claims are based on the best available information from the manufacturer and DOE reports. James Brodrick, Lighting Program Manager, U.S. Department of Energy, Building Technologies Program, wrote an article in which he states, *"The question of LED luminaire and reliability is a complex one, fraught with nuance and ramification."*

Although the results of this assessment indicate an extremely long payback period for LED, one in which the LED will never pay for itself, other performance attributes such as environmental disposal issues combined with operating cost savings may be such that longer than typically acceptable commercial payback periods are acceptable. As LEDs gain acceptance as a viable alternative to existing general illumination technology and LED technologies continue advancing at such a fast rate, expectations are that these luminaires will be more economical in the near future. Utility incentives could also help in the short-term to make the luminaires cost-effective for customers fueling earlier adoption of the new technologies.

Based upon the findings of this project and others, it is important to note that each situation is different. It is highly recommended that prior to committing to a technology readers conduct their own pilot or mini assessment of the available options to determine the economic feasibility of their particular project.

Appendix A

Data Collection Sheets

Desk		Illluminance	CCT
	1	35.6	3339
		69.09	3464
	2	20.56	3294
		25.83	3393
	3	63.47	3426
		14.29	3221
	4	64.73	3401
		34.8	3328
	5	68.51	3476
		35.8	3366
	6	53.21	3482
		28.71	3305
	7	62.57	3357
		41.21	3380
Office		68.5	3471
		91.3	3400
		63.9	3338
		74.01	3362
		43.8	3377
File cabinet 1		34.4	3352
File cabinet 2		38.6	3302
Bookcase		44.1	3370
Credenza		59.24	3349
Print Area		58.08	3375
		70.02	3395
		35.9	3348
		60.05	3413
Xerox		72.16	3442
		46.41	3455
Kitchen		43.48	3359
		38.21	3357
AVERAGE		**50**	**3377**

Task Lights 1566 sq ft

Dimensions
55.3' X 30.2'

Wattage

22.1
23.5
23
22.8
22.9
23.1
22.9
23.7
22.9
206.9 Total

Height of Ceiling
7'9"

Task light LPD
0.13 watts/sq ft

Overhead

Wattage 1106.7

Overhead Light LPD
0.71 watts/sq ft

LR 24 Sample Wattage

	46.4		
	46.4		
	47.2		
Average	**46.67**	**22**	**1026.667**

LR Wattage

Average	**11.8**	**2**	**23.6**

Fluorescent

35	**2**	**70**

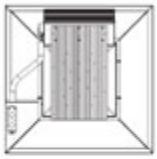
Total **1120.267**

Total LPD 0.84 watts/sq ft

power factor
98%

Appendix B
Product Data Sheets

CREE LR24 – Architectural luminaire designed for offices, schools, hospitals, and retail environments.



World-Changing Technology

The LR24 combines numerous technical innovations, including breakthroughs in optical design, electronics design, mechanical design, and thermal management. The core innovation is a new way to generate white light with LEDs.

A Better Way to Generate White Light

The technology is elegantly simple, yet incredibly effective. It delivers high efficacy light with beautiful, warm color characteristics by mixing the light from yellow and red LEDs. This approach enables active color management to maintain tight color consistency over the life of the product.

A Fresh Solution Not Possible with Fluorescent Technology

The design of traditional lay-in fixtures is limited by the use of fluorescent technology. Lighting requirements dictate the use of multiple large sources that are challenging to accommodate, restricting aesthetic possibilities. LED technology does not have these constraints, enabling products like the LR24 that break the norms of lay-in fixture design and create fresh and contemporary solutions.

Create a Quiet Ceiling

Many fluorescent luminaires are very bright when viewed from a distance. This creates a busy appearance with scores of bright squares scattered across the ceiling. The LR24 lens is recessed into the lower reflector to provide mechanical shielding and a soft, low brightness appearance when viewed at a distance — blending into the ceiling plane.

Resources:

LR24 Product Overview
LR24 Product Info Sheet
LR24HC High Ceiling Product Info Sheet
LR24 Installation Instructions
Find a Distributor

Save Energy

48 to 58 Watts
3200 and 3800 lumens
0.5 to 0.75 W/ft² with high ambient light levels

Sacrifice Nothing

92 CRI
3500K
Dimmable to 5% (0-10V DC Control)

Reduce Maintenance Costs

Designed to last 50,000 hours
8 to 12 years with commercial use
Waste no time changing lamps

Protect the Environment

Long life, energy savings, no toxic mercury
Enable multiple LEED points

CREE LR6 – The first viable LED downlight for commercial and residential applications.

World-Changing Technology

The LR6 is an amazing combination of technical innovations, including breakthroughs in optical design, electronics design, mechanical design, and thermal management. The core of the innovation is a new way to generate white light with LEDs.

A Better Way to Generate White Light

The technology is elegantly simple, yet incredibly effective. It delivers high efficacy light with beautiful, warm color characteristics by mixing the light from yellow and red LEDs. This approach enables active color management that maintains tight color consistency over the life of the product.

Effective Thermal Management

Ensuring the long life of an LED product depends on effectively controlling the operating temperature of the LEDs. The LR6 was designed to utilize all components to effectively transfer heat and keep the maximum LED temperature at or below acceptable levels- even its worst-case environment.

Resources:

LR6 Product Info Sheet

Photometry (IES)

Find a Distributor

Save Energy

12 Watt Input Power
with output of 65W Incandescent

Sacrifice Nothing

92 CRI
2700K or 3500K
Dimmable to 20%

Reduce Maintenance Costs

Designed to last 50,000 hours

Protect the Environment

Long life, energy savings

No mercury