Hyatt Regency La Jolla

High Ceiling Lighting Options
Technology Assessment
Final Report

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Prepared for:

SDGE
A Sempra Energy utility™

Prepared by:

Emerging Technology Associates, Inc

PREFACE

PROJECT TEAM

This project is sponsored by San Diego Gas & Electric's (SDG&E®) Emerging Technologies Program (ETP) with Abdullah Ahmed (aahmed1@semprautilities.com) as the project manager. Cade Zimmerman, Engineer, was the contact and project manager for Hyatt Regency La Jolla. Daryl DeJean (daryl.eta@gmail.com) from Emerging Technologies Associates, Inc. provided technical consulting, data analysis, overall coordination of all parties involved, and finalized the report.

DISCLAIMER

ACKNOWLEDGEMENTS

We would like to acknowledge Hyatt Regency La Jolla and SDG&E® for their cooperation in the project. Without their participation, this assessment project would not have been possible.

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Abbreviations and Acronyms

CCT Correlated Color Temperature in degrees Kelvin

CFL Compact Fluorescent Lamp

DOE Department of Energy

ET Emerging Technologies

ETP Emerging Technologies Program

FC Footcandles

K Kelvin

kW Kilowatt

kWh Kilowatt hours

LCC Life Cycle Cost

LED Light Emitting Diode

MW Megawatt

MWh Megawatt hours

SDG&E San Diego Gas & Electric

SSL Solid State Lighting

W Watts

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EXECUTIVE SUMMARY

San Diego Gas &Electric (SDG&E®) was interested in evaluating CFL and LED technology in high ceiling applications, ceilings over 16 feet in height. Hyatt Regency La Jolla (Hyatt) agreed to participate in an assessment to determine the viability of CFL and LED lighting solutions for their grand foyer. The goal of the project was to determine the energy savings potential provided by CFL and LED general illumination as compared to the existing incandescent base cases.

Key elements of the scope of work were ensuring the selected CFL and LED luminaire were dimmable and compatible with the Hyatt's dimmer controls used in the grand foyer and meeting the requirements of maintaining the ambiance provided by the incandescent lamps.

Hyatt was selected as an ideal site for the project due to the height of the grand foyer ceiling. With one hundred recessed downlights in the grand foyer in organized groups of 4 fixtures, the site allowed for an ideal side by side comparison of the base case incandescent, dimming CFL and dimming LED solutions.

Quantitative light and electric power measurements were taken throughout the project. Electric energy and demand savings per lamp are shown in Table 1. Based upon the annual operating cost savings and installed cost of an each type of lamp, the simple payback period for a retrofit is shown below in Table 2.

Table 1: Energy and Demand Savings

Lamp	Power/lamp (watts)	Operating Hours	Total Lamps	Energy (kWh)	Demand (kW)	Savings (%)
Incandescent - Base Case (70W)	70.0	8760	100	61,320	7.0	-
CFL (26W)	28.0	8760	100	24,528	2.8	60%
LED (18W)	15.4	8760	100	13,490	1.5	78%
LED retrofit kit (36W)	35.0	8760	100	30,660	3.5	50%

Table 2: Simple Payback – Retrofit

Lamp	Cost/lamp ($)	Number of Lamps	Total Product Cost ($)	Energy (kWh)	Energy Cost (per kWh)	Annual Energy Cost ($)	Annual Energy Cost Savings ($)	Simple Payback (years)
Incandescent - Base Case (70W)	13	100	1,300	61,320	0.17	10424	-	-
CFL (26W)	136	100	13,600	24,528	0.17	4170	6255	2.2
LED (18W)	60	100	6,000	13,490	0.17	2293	8131	0.7
LED retrofit kit (36W)	175	100	17,500	30,660	0.17	5212	5212	3.4

This assessment project will assist numerous facility managers and building owners across the country when considering CFL and LED technology as an option for high ceiling general illumination applications meeting their energy efficiency goals while maintaining the desired ambiance which includes dimming. Individual hotel requirements, CFL or LED quality, as well as economic considerations may directly impact the outcome of similar assessment projects. **Therefore, readers are advised that each installation is unique. It is recommended the reader exercise due diligence in selecting the appropriate technology, CFL or LED, specific to their needs.**

Based upon the findings of this project, it is recommended that future projects consider the following:

- evaluate the benefits and acceptability of bi-level or adaptive lighting, including dimming.
- the impact of an occupancy sensor based bi-level luminaire on demand and energy savings
- the impact of daylighting on energy efficiency for such high ceiling applications

INTRODUCTION

In response to an overwhelming interest in innovations in CFL and LED lighting technology for indoor lighting applications, San Diego Gas & Electric's Emerging Technologies Program conducted this assessment with the following objectives:

- **identify potential CFL and LED solutions for indoor lighting which are capable of dimming, specifically high ceiling applications**
- **assess CFL and LED lighting technologies, validating manufacturer's claims regarding energy savings, light levels and light characteristics**
- **perform a comparison of CFL and LED technologies against traditional incandescent technology in high ceiling applications to determine customer acceptance levels of CFL and LED technologies**

Hyatt Regency (Hyatt), located in La Jolla, California began considering options for their indoor general illumination needs. Due to the excitement surrounding solid state lighting (SSL) Hyatt had high hopes for a "perfect" light emitting diode (LED) solution for their indoor general illumination, specifically their high ceiling applications such as that in their grand foyer.

In collaboration with Hyatt, San Diego Gas & Electric selected and arranged for the installation of both CFL and LED lighting in the grand foyer to replace existing incandescent lamps.

A side by side comparison of CFL, LED and the base case incandescent technology was conducted with the selected product. **A lesson learned during this project was that an in situ sample demonstration of the selected product is a must before committing or gaining a customer's acceptance to allow for a larger scale installation for assessing the product.**

PROJECT BACKGROUND

Project Overview

The High Ceiling Lighting Options Technology Assessment project was conducted as part of the Emerging Technologies Program of San Diego Gas & Electric Company (SDG&E®). The Emerging Technologies Program (ETP) "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." Emerging Technologies Associates, Inc. was retained by SDG&E® to manage the High Ceiling Lighting Options Technology Assessment project, develop project methodology, coordinate the participants and stakeholders and conduct the data collection and analysis for the project.

The High Ceiling Lighting Options Technology Assessment project studied the applicability of compact fluorescent lamps (CFL) and light emitting diodes (LEDs) in a high ceiling general illumination application. At Hyatt, areas of the grand foyer were selected to replace the base case incandescent lamps with CFL, direct replacement lamp LED and a recessed LED downlight retrofit assembly allowing for a side by side comparison of the light sources. The applicability of the technology was determined by light output and power usage, economic factors and customer satisfaction.

Technological Overview

At the time of this assessment, CFL and LED lighting in indoor general illumination applications such as high ceilings was not recognized as achievable, especially when dimming was required. However, SDG&E's ETP recognized the advancement of both CFL and LED technology. Since the advent of high brightness LED's, SDG&E's ETP felt the LED technology may present some significant opportunities in high ceiling lighting applications. Combined with the emergence of newer CFL technology, SDG&E's ETP felt it would be in the best interest of their programs to assess both CFL and LED lighting technologies for high ceiling applications.

The most common light sources utilized to illuminate indoor areas, especially when provided from high ceilings in the hospitality market segment, are incandescent. The reason for utilizing incandescent lamps is the belief that only the incandescent lamp can provide the proper illumination and is compatible with dimming systems.

There are dimmable CFLs yet the end user is not very aware of this CFL solution. With the advent of LED light sources, the published claims that LEDs can be dimmed and a longer lamp life than both incandescent and CFL lamps, there is an interest in determining the validity of LEDs as a solution in numerous indoor lighting applications.

The performance of incandescent and CFL light sources is well documented with regard to lamp life and light characteristics. It is believed that a well-designed dimmable CFL and LED indoor lamp or luminaire can provide at least comparable light characteristics as incandescent light sources in an efficient manner for high ceiling applications.

The US Department of Energy (DOE) reports that LED technology is changing at a rapid pace. Overall, the performance of LED technology is quickly gaining efficiency but the 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 reaching requirements for indoor general illumination applications.

Market Overview

The recessed downlight market provides tremendous opportunity for energy and demand savings. According to the Navigant Consulting, Inc. report entitled "Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications," the commercial market segment has a total of 394, 086,000 recessed downlights with 313,548,000 of those still being incandescent consuming on average 72 watts each.[1]

Figure 1: US Recessed Downlight Market

Sector	Incandescent Recessed Downlights	CFL Recessed Downlights	Total
Residential	370,765,000	64,103,000	434,868,000
Commercial	313,548,000	80,538,000	394,086,000
Total	**684,313,000**	**144,641,000**	**828,954,000**

Figure 2: Recessed Downlight Average Power

Reflector Lamp Type	Residential Average Wattage (W)	Equivalent Residential LED (W)	Commercial Average Wattage (W)	Equivalent Commercial LED (W)
Incandescent	72	14	72	14
CFL	11	7	16	11

Figure 3: Recessed Downlight Average Annual Operating Hours

Year	Residential Average Operating Hours (hrs)	Commercial Average Operating Hours (hrs)
2007	843	3347

California represents approximately **8.4%** of the total energy consumption in the US. (Source: http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=CA). Applying this 8.4% to the installed base of recessed downlight fixtures of 394 million units results in California having an estimated installed base of 33.1 million of such fixtures. Assuming SDG&E® service territory equates to approximately **7%** of California's total installed base (based upon statistics located at http://www.ecdms.energy.ca.gov/elecbyplan.aspx data found in Appendix A), it is estimated that SDG&E® has an installed base of 2.3 million recessed downlight fixtures in its service territory. 100% market adoption for all recessed downlights would result in a reduction of 461,886 MWh and 138 MW demand. Assuming that the high ceiling application comprises only 5% of the recessed downlight market, 100% market adoption for this application would only result in replacing 115,000 fixtures or lamps. **Assuming 0.5% market penetration each year would result in an electricity savings of approximately 115.5 MWh annually using the average operating hours shown above in Figure 3.** In SDG&E® service territory, **this translates into 34.5 kW of reduced demand.** Realistically, market penetration will most likely not ramp up until the high first cost barrier of LED luminaires is overcome and customers are made aware of the advances in CFL technology. Additionally, customers must be made aware of the results of this assessment project to fuel adoption.

[1] Energy Savings Estimates of Light Emitting Diodes, Navigant Consulting Inc. , 2008

PROJECT OBJECTIVES

The objectives of this project were to examine lighting performance and economics of CFL and LED lighting technology in an indoor high ceiling general illumination application as compared to the traditional light source of incandescent. The potential electrical demand and energy savings were calculated in terms of instantaneous system wattage. The grand foyer lighting operates 8760 hours (24 hours/day 365 days/year) annually.

Lighting performance was measured in terms of illuminance and correlated color temperature (CCT) measured in Kelvin (K). Finally, the economic performance was calculated using the simple-payback for substitution in new installation or retrofit scenarios without consideration for additional energy savings due to dimming.

METHODOLOGY

Host Site Information

Hyatt Regency is a full service hotel consisting of 419 rooms.

Hyatt's indoor lighting in high ceiling applications is incandescent. The grand foyer lighting is provided by 100 fixtures of 70 watt incandescent lamps. Even though daylight is available from the windows, the grand foyer lights remain on for 24 hours each day since the grand foyer is a common area which guest transit 24/7. The purpose of the lights operating 24/7 is to provide sufficient lighting for guests to feel safe when transiting the area. The fixtures are mounted at a height of 20 feet with spacing of 6 feet between fixtures. The lights operate 8760 hours annually. The customer's blended electric cost is $0.17 per kWh.

Measurement Plan

Pre and post installation field visits were conducted. The illuminance and correlated color temperature (CCT) were recorded directly below the luminaire. The light characteristic data for each application is in Table 4. Instantaneous electrical power data for each light source was collected utilizing a WattsUp Pro meter. The customer had several different departments review the "new" lighting to determine acceptance to ensure the design and ambiance of the hotel was maintained.

Equipment

The following equipment was used to collect the light and power characteristic data. The meters were calibrated as per manufacturer specifications.

Illuminance and Correlated Color Temperature Meter:
Konica Minolta Chroma Meter, Model CL-500
Accuracy: +- 2.0%

http://www.konicaminolta.com/sensingusa/products/Light-Measurement

Power reading: WattsUp Pro
Accuracy: +- 1.5%

https://www.wattsupmeters.com/secure/products.php?pn=0&wai=316&spec=4

PROJECT RESULTS AND DISCUSSION

Electrical Demand and Energy Savings

The grand foyer lighting consists of 100 recessed downlight fixtures. Even though daylight is available, the lights remain on 24 hours/day. Each incandescent lamp was measured and found to consume 70 W. The direct replacement LED lamp consumed 15.4 W, 78% less power. The retrofit LED recessed downlight kit consumed 35 W, 50% reduction in power. The CFL consumed 28 W, 60% reduction in power. The results are shown in Table 3.

Table 3: Project Electric Energy and Demand Savings

Lamp	Power/lamp (watts)	Operating Hours	Total Lamps	Energy (kWh)	Demand (kW)	Savings (%)
Incandescent - Base Case (70W)	70.0	8760	100	61,320	7.0	-
CFL (26W)	28.0	8760	100	24,528	2.8	60%
LED (18W)	15.4	8760	100	13,490	1.5	78%
LED retrofit kit (36W)	35.0	8760	100	30,660	3.5	50%

Lighting Performance

For the assessment area, illuminance and correlated color temperature (CCT) readings were taken. A side by side comparison of the base case incandescent, CFL, direct replacement lamp LED and the LED recessed downlight retrofit kit technology was conducted. The performance results are provided in Table 4.

Table 4: Performance Results

Lamp	Actual Power (watts)	Average CCT (Kelvin)	Average Illuminance (fc)
Incandescent - Base Case (70W)	70.0	2710	14
CFL (26W)	28.0	2800	10
LED (18W)	15.4	2780	12.5
LED retrofit kit (36W)	35.0	2830	13

Economic Performance

It is important to note that the cost and equipment assumptions made in this section apply only to Hyatt. Hyatt was assessing the replacement of incandescent light sources. Therefore readers should consider their specific variables such as maintenance, energy, luminaire/lamp costs and requirements for dimming before drawing any conclusions about the cost effectiveness of either CFL and LED lamps or luminaires. For LED lamps and luminaires, luminaire/lamp lifetime is a function of all 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.**

1. Energy Cost Estimates

The energy cost is based upon the Hyatt's blended rate of $0.17 per kWh. Hyatt's grand foyer lighting operates 8760 hours annually. Table 5 provides the energy cost and savings estimate assuming all the recessed downlights in the grand foyer were converted from the base case incandescent to CFL or LED lamps/luminaires.

Table 5: Project Energy Cost Savings Achieved

Lamp	Cost ($)	Number of Lamps	Total Product Cost ($)	Energy (kWh)	Energy Cost (per kWh)	Annual Energy Cost ($)	Annual Energy Cost Savings ($)	Percent Cost Savings
Incandescent - Base Case (70W)	13	100	1,300	61,320	0.17	10,424	-	-
CFL (26W)	136	100	13,600	24,528	0.17	4,170	6,254.64	60%
LED (18W)	60	100	6,000	13,490	0.17	2,293	8,131.03	78%
LED retrofit kit (36W)	175	100	17,500	30,660	0.17	5,212	5,212.20	50%

The simple payback calculations for a retrofit and new construction scenario considered the total investment cost and energy savings for the CFL and LED solutions. In this project, the simple paybacks are shown in tables 6 and 7.

Table 6: Project Simple Payback – Retrofit

Lamp	Cost/lamp ($)	Number of Lamps	Total Product Cost ($)	Energy (kWh)	Energy Cost (per kWh)	Annual Energy Cost ($)	Annual Energy Cost Savings ($)	Simple Payback (years)
Incandescent - Base Case (70W)	13	100	1,300	61,320	0.17	10424	-	-
CFL (26W)	136	100	13,600	24,528	0.17	4170	6255	2.2
LED (18W)	60	100	6,000	13,490	0.17	2293	8131	0.7
LED retrofit kit (36W)	175	100	17,500	30,660	0.17	5212	5212	3.4

Table 7: Project Simple Payback – New Construction

Lamp	Cost ($)	Total Incremental Cost ($)	Number of Lamps	Total Incremental Product Cost ($)	Energy (kWh)	Energy Cost (per kWh)	Annual Energy Cost ($)	Annual Energy Cost Savings ($)	Simple Payback (years)
Incandescent - Base Case (70W)	125	-	100	-	61,320	0.17	10,424	-	-
CFL (26W)	185	60	100	6,000	24,528	0.17	4,170	6255	1.0
LED (18W)	135	10	100	1,000	13,490	0.17	2,293	8131	0.1
LED retrofit kit (36W)	250	125	100	12,500	30,660	0.17	5,212	5212	2.4

2. Luminaires and Lamp Life

This report uses the following lamp life in hours: CFL – 16,000; LED direct replacement lamp – 50,000 and recessed downlight LED retrofit kit – 50,000. The report uses 50,000 hours as the LED life expectancy, per the DOE website (source: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/lifetime_white_leds.pdf). 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."

Regarding LEDs, actual performance data documenting the life of LED luminaires/lamps does not yet exist due to the relative infancy of LED technology for indoor general illumination. While LED technology appears to be a viable option for indoor common area general illumination lighting, LED product quality can vary significantly among manufacturers. **Therefore, it is recommended that readers exercise due diligence when selecting LED technology for any application. Readers should also be aware that LED life and lighting performance are dependent upon proper thermal and electrical design.** Without the latter, premature failure may occur. Readers must properly assess the potential risk associated with LED technology which has not undergone proper testing (i.e. LM 79, LM 80).

3. Life Cycle Cost Analysis

Even though life cycle cost (LCC) analysis was not part of the scope of this project, 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, product life, 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 and do their own due diligence regarding the future costs. Due to the rapid advancements in LED technology, the pricing of the products may be reduced. **Readers are encouraged to obtain current price quotes for both CFL and LED lamps. Furthermore, each project's economic analysis will yield its unique set of results depending upon the project sponsors and site requirements.**

CONCLUSION

This assessment project demonstrated that properly designed CFL and LED luminaires can provide energy savings from 50% to 78%, respectively, without significantly compromising light characteristics required for indoor high ceiling general illumination applications.

A lesson learned during this assessment project is that there are many factors that may be unique and require careful consideration. Each reader should consider their capital budgeting needs, maintenance and installation, as well as any internal lighting standards. While the results of this assessment indicate significant energy savings potential when CFL and LED lamps replace incandescent lighting, readers are encouraged to complete a life cycle cost analysis to gain the complete economic picture of a technological change out.

Due to the unproven long life of LEDs, economic and reliability claims are based on the best available information from the manufacturer and DOE reports. For the high ceiling applications, both the CFL and LED solutions are viable options. Although in this project favorable payback periods were achieved, the payback periods are sensitive to annual operating hours, product costs and the installation specific maintenance and electrical costs. In addition, these CFL and LED solutions are applicable to many other indoor lighting applications.

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 should conduct their own pilot or mini assessment of the available options to determine the economic feasibility of their particular project.

APPENDIX A

SDG&E® Market Potential Calculations Reference

California Electricity Statistics & Data

http://www.ecdms.energy.ca.gov/elecbyplan.aspx

Electricity Consumption by Planning Area

Planning Area Description	Year	Total Usage
Burbank, Glendale, and Pasadena	2007	4155.237028
Dept. of Water Resources	2007	9956.406553
Imperial Irrigation District	2007	3563.224165
Los Angeles Department of Water	2007	25258.28371
Other	2007	1709.525015
Pacific Gas and Electric	2007	107987.2289
Sacramento Municipal Utility District	2007	10917.07883
San Diego Gas & Electric	2007	20492.55364
Southern California Edison	2007	100470.2711
	TOTAL	**284509.8089**
	SDG&E %	**7.202758216**