Bi-Level LED Parking Structure Demonstration Showcase

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Preface

PROJECT TEAM

This project is sponsored by San Diego Gas & Electric's (SDG&E®) Emerging Technologies Program (ETP), with Nate Taylor (NTaylor@semprautilities.com) as the project manager. Mark Eberling, Engineer, was the contact and project manager for National Oceanic and Atmospheric Administration (NOAA). Daryl DeJean (daryldejean@gmail.com) of Emerging Technologies Associates, Inc. (ETA) provided technical consulting, technical data analysis, coordination of all parties involved, and finalized the report.

DISCLAIMER

This report was prepared as an account of work sponsored by SDG&E® ETP. The SDG&E® 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."

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ACKNOWLEDGEMENTS

SDG&E® and ETA would like to acknowledge NOAA for their cooperation in the project. Without their participation, this project would not have been possible.

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Abbreviations and Acronyms

CALiPER Commercially Available LED Product Evaluation and Reporting

CLTC California Lighting Technology Center

DOE Department of Energy

ETA Emerging Technologies Associates, Inc.

ETP Emerging Technologies Program

GWh Gigawatt hours

HID High Intensity Discharge

HPS High Pressure Sodium

kW Kilowatt

kWh Kilowatt hours

LCC Life Cycle Cost

LED Light Emitting Diode

LEED Leadership in Energy and Environmental Design

MH Metal Halide

MWh Megawatt hours

NOAA National Oceanic and Atmospheric Administration

PG&E Pacific Gas & Electric

SDG&E San Diego Gas & Electric

SQFT Square Foot

SSL Solid State Lighting

SWFSC Southwest Fisheries Science Center

UC University of California

USGBC US Green Building Council

W Watts

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Executive Summary

San Diego Gas & Electric (SDG&E®) wanted to evaluate the potential of LED technology in parking structure applications. In late 2010, National Oceanic and Atmospheric Administration (NOAA) agreed to collaborate with SDG&E® to participate in an assessment to determine the viability of an LED lighting solution for their under building parking structure at their new facility. The goal of the project was to determine the energy savings potential provided by LED lighting as compared to the designed metal halide (MH) high intensity discharge (HID) base case.

SDG&E's goal with this assessment was to evaluate the economics of LED as compared to traditional HID light source. SDG&E® agreed to participate in this Savings by Design Project by working with NOAA in the parking structure lighting to substitute the planned MH fixtures with LED luminaires. Emerging Technologies Associates, Inc. (ETA) was retained by SDG&E® to manage the project, coordinate the participants and stakeholders, and conduct the analysis for the project.

The results of the project's technical assessment proved in favor of LED as a more efficient lighting solution for under building parking structure lighting applications. By substituting MH with LED luminaries, the electric energy and demand savings of 63% was achieved. The simple payback was calculated for both new construction and retrofit scenarios. The results of these are shown in Table 1, Table 2, and Table 3, respectively.

Table 1: Energy and Demand Savings

Lamp	System Wattage (W)	Annual Operating Hours	Number of Lamps	Energy (kWh)	Demand (kW)	Energy Savings (%)
Metal Halide *	185	8,760	167	270,640	30.90	-
LED PGL7	69	8,760	167	100,941	11.52	63

** Base Case*

Table 2: Simple Payback – New Construction

Lamp	Cost ($)	Total Incremental Cost ($)	Number of Lamps	Total Incremental Product Cost ($)	Energy (kWh)	Energy Cost/kWh ($)	Annual Energy Cost ($)	Annual Energy Cost Savings ($)	Simple Payback (years)
Metal Halide *	365	-	167	-	270,640	0.20	54,128	-	-
LED PGL7	600	235	167	39,245	100,941	0.20	20,188	33,940	1.2

** Base Case*

Table 3: Simple Payback – Retrofit

Lamp	Cost/lamp ($)	Number of Lamps	Total Product Cost ($)	Energy (kWh)	Energy Cost/kWh ($)	Annual Energy Cost ($)	Annual Energy Cost Savings ($)	Simple Payback (years)
Metal Halide *	30	167	5,010	270,640	0.20	54,128	-	-
LED PGL7	600	167	100,200	100,941	0.20	20,188	33,940	2.8

** Base Case*

This project will assist numerous facility managers and building owners across the country when considering LED technology as an option for lighting in parking structures and striving towards meeting their energy efficiency goals. Local site requirements, luminaire quality, as well as economic considerations may directly impact the outcome of similar assessment projects. Therefore, readers are advised that each installation is unique and due diligence is recommended in selecting the appropriate LED technology specific to their needs. The results of this project corroborate similar studies, specifically the one conducted by CLTC at UC Davis. [1]

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

- a methodology to determine the impact of LED lighting on security cameras and the ability to clearly depict images in the parking structure
- a survey of drivers may provide valuable insight as to the perception and receptiveness of LED technology in a parking structure
- measure the impact of an occupancy sensor based bi-level luminaire on demand and energy savings

[1] http://www.everlastlight.com/cltc_garage_fixture_study.html

Introduction

Facility managers and building owners are always looking for the best possible options for their outdoor area lighting needs. Outdoor area lighting includes parking structures, parking lots, and entrance roadways. By retrofitting or upgrading their outdoor area lighting, facility managers and building owners can enjoy energy savings while improving the quality of their lighting. Outdoor area lighting is usually provided by metal halide (MH) and high pressure sodium (HPS) lamps. MH and HPS are members of the HID family of lamps. It offers various advantages including a high light output in comparison to its size, making it a compact, powerful, and efficient light source.

SDG&E® was interested in evaluating the potential of converting the lighting in a parking structure entirely to LEDs. In response to the desire to understand the energy savings potential of solid-state lighting (SSL), NOAA agreed to replace the designed HID with a LED lighting "makeover" for their new under building parking structure. In general, LED products offer various advantages over conventional lighting products including energy savings, long operating life, reduced radiated heat, minimal light loss, dimmability and controllability, durability, enhanced performance at low temperatures, safety improvements, smaller package size, uniform illumination, mercury reduction, enhanced product appearance, improved color rendition, and lower lumen depreciation.[2] NOAA hoped that by opting for LEDs, in addition to energy cost savings, they could reduce their maintenance costs since LEDs are presumed to have a longer life than traditional light sources.

[2] Navigant Consulting, Inc. (2011). "Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications."

Project Objectives

The SDG&E® ETP conducted the Bi-Level LED Parking Structure Demonstration Showcase project with the following objective:

- determine the energy efficiency potential of LEDs for outdoor area lighting, specifically under building parking structures

Project Background

TECHNOLOGICAL OVERVIEW

At the time of this assessment, LED lighting in outdoor area lighting applications such as parking structures was gaining momentum because of the light source's ability to provide the required surface illuminance with improved uniformity and longer life using less energy than conventional lighting. The advancement of LED technology since the advent of white LED's presents some significant opportunities in outdoor area lighting which includes parking structures. "LED technology is rapidly becoming competitive with high-intensity discharge (HID) light sources for outdoor area lighting" (Source: www.netl.doe.gov/ssl DOE SSL LED Application Series: Outdoor Area Lighting).

The most common light sources utilized to illuminate outdoor areas including streets, roadways, parking lots, parking structures and pedestrian areas are metal halide (MH) and high pressure sodium (HPS). The performance of these light sources is well documented with regard to lamp life and light characteristics. It is believed that a well-designed LED outdoor luminaire can provide at least comparable light characteristics as the traditional high intensity discharge light sources in an efficient manner. LEDs are particularly advantageous in outdoor lighting applications because they offer extremely long lifetimes, are directional light sources that limits light pollution and light trespass, are highly efficacious, function well in cold temperatures, are greatly resilient to vibration, and are able to provide a high quality light. [3]

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 perceived 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 outdoor area lighting applications.

MARKET OVERVIEW

The development of LEDs for the outdoor area, especially parking lot/garage lighting niche represents a major breakthrough in energy efficiency advancement because this application normally involves high wattage HID fixtures. Parking garages and lots face unique challenges concerning their lighting. Public safety concerns demand that lamps produce a high quality light with a low probability of failure. LEDs are becoming a popular option in parking applications as their long lifetime helps facility managers reduce costly lamp replacements. Some facilities also view LEDs relatively high CRIs as welcome replacements for the poor quality of light that some incumbent technologies emit. [4]

[3] Navigant Consulting, Inc. (2011). "Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications."
[4] Navigant Consulting, Inc. (2011). "Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications."

The metal halide installed base consists of 5.6 million parking garage luminaires nationally (Table 4). Currently, the market penetration of LEDs in this sector is becoming more apparent with some garage lighting manufacturers noting LED sales of nearly 30%. Further market penetration is expected to increase, as lamp efficacy rises.[5] Additionally, cost and customer confidence in the quality and life expectancy will be barriers to market adoption.

Table 4: Parking Light Installed Base

Application	Lamp Type	Percentage	Number of Lights (000's)
Garage Lighting	Incandescent	1.6%	600
	Halogen	2.2%	800
	Fluorescent	45.9%	16,600
	Induction	7.4%	2,700
	Mercury Vapor	0.1%	44
	High Pressure Sodium	23.2%	8,500
	Metal Halide	15.3%	5,600
	LED	4.1%	1,500
	Total	**100%**	**36,400**
Lot Lighting	Incandescent	2.6%	400
	Halogen	0.1%	16
	Mercury Vapor	2.4%	400
	High Pressure Sodium	36.0%	5,700
	Metal Halide	54.2%	8,600
	LED	4.6%	700
	Total	**100%**	**15,800**

California represents approximately 6.9% of the total electric energy consumption in the US. [6] Applying this 6.9% to the installed base of parking garage lighting fixtures of 5.6 million units results in California having an estimated installed base of 386,400 of such fixtures. Assuming SDG&E® service territory equates to approximately 7.3% 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 28,207 parking garage fixtures in its service territory. 100% market penetration would equate to approximately 4,787 GWh reduction in electricity use and 546 GW in demand. Market penetration is ramping up due to the realization that the high first cost barrier of LED luminaires is a misperception. Assuming 0.5% market penetration each year would result in an electricity savings of approximately 239 GWh annually in SDG&E® service territory. This translates into 27 MW of reduced demand using 8760 annual operating hours.

[5] Navigant Consulting, Inc. (2011). "Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications."
[6] http://apps1.eere.energy.gov/states/electricity.cfm/state=CA#total

Methodology

HOST SITE INFORMATION

The National Oceanic and Atmospheric Administration (NOAA) is constructing the new Southwest Fisheries Science Center (SWFSC) laboratory in La Jolla, CA to replace the predecessor that was threatened by continuing bluff erosion. The design of the new building incorporates sustainable strategies and NOAA is pursuing certification for this award winning building under the USGBC LEED Green Building Rating System. The new 214,000 sqft facility includes 90,000 sqft under building parking which can accommodate over 200 vehicles.

The planned lighting for the parking structure at SWFSC was metal halide. The lighting was to be provided by 167 fixtures of MH lamps. The parking structure lights operates for 24 hours each day (8,760 hours annually) since the parking structure is a common area for people to enter/exit their the building. NOAA's blended electric cost is $0.20 per kWh.

Courtesy of Gould Evans

MEASUREMENT PLAN

SDG&E® retained Emerging Technologies Associates, Inc. to manage the Bi-Level LED Parking Structure Demonstration Showcase project, coordinate the participants and stakeholders, and conduct the analysis for the project. SDG&E® ETP agreed to participate in this Savings by Design Project by working with NOAA in the parking structure lighting to substitute the planned MH fixtures with LED luminaires. With a total of 167 MH fixtures planned to be installed in the parking structure, this technology assessment project allowed for a stated technical data comparison of the base case MH with the LED solution.

Project Results

ELECTRICAL ENERGY AND DEMAND SAVINGS

The parking structure lighting design called for 167 MH lamps. The lights operate 8760 hours annually (24 hours per day). The designed MH lamp is stated to draw a total of 185 watts (165 nominal watts). The LED luminaire's stated wattage is 69 watts resulting in 63% less power. The results are shown in Table 5.

Table 5: Energy and Demand Savings

Lamp	System Wattage (W)	Annual Operating Hours	Number of Lamps	Energy (kWh)	Demand (kW)	Energy Savings (%)
Metal Halide *	185	8,760	167	270,640	30.90	-
LED PGL7	69	8,760	167	100,941	11.52	63

** Base Case*

ECONOMIC PERFORMANCE

It is important to note that the cost and fixture assumptions made in this section apply only to NOAA. NOAA was demonstrating the use of LEDs as a substitute for a MH light source. Therefore, readers should consider their specific variables such as maintenance, energy, luminaire costs and requirements for dimming before drawing any conclusions about the cost effectiveness of LED luminaires. For LED 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 NOAA's blended rate of $0.20 per kWh. The NOAA SWFSC parking structure lighting is designed to operate 8760 hours annually. This project focused on the replacement of the designed MH lighting in parking structure with LED lighting technology. Table 6 provides the energy, energy cost and the cost savings for the designed base case MH and the new LED lamps installed at the NOAA SWFSC parking structure.

Table 6: Energy Cost Savings Achieved

Lamp	Number of Lamps	Energy (kWh)	Energy Cost/kWh ($)	Annual Energy Cost ($)	Annual Energy Cost Savings ($)	Energy Savings (%)
Metal Halide *	167	270,640	0.20	54,128	-	-
LED PGL7	167	100,941	0.20	20,188	33,940	63

** Base Case*

The simple payback calculations for both a retrofit and new construction scenario considered the total investment cost and energy savings for the LED solution. The results are shown in Table 7 and 8, respectively.

Table 7: Simple Payback – Retrofit

Lamp	Cost/lamp ($)	Number of Lamps	Total Product Cost ($)	Energy (kWh)	Energy Cost/kWh ($)	Annual Energy Cost ($)	Annual Energy Cost Savings ($)	Simple Payback (years)
Metal Halide *	30	167	5,010	270,640	0.20	54,128	-	-
LED PGL7	600	167	100,200	100,941	0.20	20,188	33,940	2.8

** Base Case*

Table 8: Simple Payback – New Construction

Lamp	Cost ($)	Total Incremental Cost ($)	Number of Lamps	Total Incremental Product Cost ($)	Energy (kWh)	Energy Cost/kWh ($)	Annual Energy Cost ($)	Annual Energy Cost Savings ($)	Simple Payback (years)
Metal Halide *	365	-	167	-	270,640	0.20	54,128	-	-
LED PGL7	600	235	167	39,245	100,941	0.20	20,188	33,940	1.2

** Base Case*

2. Luminaires and Lamp Life

This report uses the manufacturer's stated 50,000 hours as the LED life expectancy. This is supported, 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."

In this project, the LED life is approximately 6 years. The payback period for retrofit and new construction, 2.8 and 1.2 years respectively, does not include maintenance in the economic analysis. When a complete life cycle cost analysis is conducted the paybacks would improve to new construction being less than a year and the retrofit remaining slightly over 2 years. This indicates that the LED luminaire will provide the appropriate payback to justify as a solution.

Actual performance data documenting the life of LED luminaires does not yet exist due to the relative infancy of LED technology for general illumination applications such as parking structure lighting. While LED technology appears to be a viable option for parking structure 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). The DOE LED Application Series: Outdoor Area Lighting Fact Sheet contains Design and Specifications Considerations: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/outdoor_area_lighting.pdf

3. Life Cycle Cost Analysis

Even though life cycle cost analysis (LCCA) was not part of the scope of this project, a full LCCA is recommended. There are many variables and considerations that 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 induction, HID, and LED luminaires. Furthermore, each project's economic analysis will yield its unique set of results depending upon the project sponsors and site requirements.

Conclusion

This data sheet technical assessment and demonstration project suggests that LED lighting may be a viable solution for lighting requirements in the outdoor area lighting applications, specifically under building parking structures. For the NOAA SWFSC parking structure lighting application, the LED solution appears to be a viable option. In addition, this LED solution is applicable to many other outdoor lighting applications. However, 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.

This demonstration project was conducted because technically it appears that properly designed LED luminaires can provide energy savings up to 63%. It is believed these savings can be achieved without significantly compromising the lighting performance required for under building parking structure applications. A future assessment is recommended to record actual light measurement data to validate this belief. Readers are encouraged to complete a life cycle cost analysis to gain the complete economic picture of a technological change out. It is important to note that each situation is different. Prior to committing to a technology, readers should conduct their own pilot or mini demonstration of the available options to determine the economic feasibility of their particular project.

For general information and programs on LED technology, it is recommended visiting the DOE SSL website: www1.eere.energy.gov/buildings/ssl. A recommended resource to assist in selecting LED solutions that have been mystery shopped to validate manufacturer claims is the DOE SSL Commercial Available LED Product Evaluation and Reporting (CALiPER) website: www1.eere.energy.gov/buildings/ssl/caliper.html. Other resources include the ENRGY STAR website: www.energystar.gov and the Lighting Facts website: www.lightingfacts.com.

Appendix

SDG&E® Market Potential Calculations Reference

California Electricity Statistics & Data

ECDMS Energy Consumption Data Management System
The California ENERGY COMMISSION

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

Electricity Consumption by Planning Area

Planning Area Description	Year	Total Usage *
Burbank, Glendale, and Pasadena	2005	3,394
Dept. of Water Resources	2005	8,283
Imperial Irrigation District	2005	3,232
Los Angeles Department of Water	2005	24,638
Other	2005	1,748
Pacific Gas and Electric	2005	101,460
Sacramento Municipal Utility District	2005	10,523
San Diego Gas & Electric	**2005**	**19,910**
Southern California Edison	2005	99,261
TOTAL		272,449

*All Usage Expressed in Millions of kWh

SDG&E® **7.3 %**