Resource Conservation District
Greater San Diego County

Parking Lot LED Lighting 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 Jerine Ahmed as the project manager. Marty Leavitt, District Manager, was the contact and project manager for Resource Conservation District. 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.

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ACKNOWLEDGEMENTS

We would like to acknowledge Resource Conservation District 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

DOE Department of Energy

ETP Emerging Technologies Program

GWh Gigawatt Hour

HID High Intensity Discharge

HPS High Pressure Sodium

IESNA Illuminating Engineering Society of North America

kW Kilowatt

kWh Kilowatt Hour

LED Light Emitting Diode

MH Metal Halide

MWh Megawatt hour

SDG&E San Diego Gas & Electric

SSL Solid State Lighting

US United States

W Watt

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EXECUTIVE SUMMARY

San Diego Gas &Electric (SDG&E®) was interested in evaluating LED technology in parking lot applications. Resource Conservation District agreed to participate in an assessment to determine the viability of an LED lighting solution for their parking lot. The goal of the project was to determine the energy savings potential provided by LED lighting as compared to the traditional high intensity discharge metal halide light source.

Resource Conservation District was selected as an ideal site for the project due to the size of the parking lot. With only seven luminaires in the parking lot, the site allowed for a complete implementation of LED luminaires. Additionally, this was a new installation requiring the pole and luminaire, not just a retrofit of the luminaire.

Quantitative light and electric power measurements were taken for the project. Electric energy and demand savings per LED luminaire are shown in Table 1. Based upon the annual operating cost savings and installed cost of an LED luminaire, the simple payback period for this new construction project is shown below in Table 2.

Table 1: Demand and Energy Savings

Parking Lot (4165 Operating hours)	# of Units	Power (W)	Demand (kW)	Reduction (%)	Energy (kWh)	Reduction (%)
250 W MH	7	291	2.0	-	8,484	-
135 W LED	7	139	1.0	52	4,053	52

Table 2: Simple Payback New Construction

Parking Lot (4165 Operating hours)	# of Units	Product Cost ($)	Incremental Cost ($)	Annual Energy Cost Savings ($)	Simple Payback (years)
250 W MH	7	8,196	-	-	-
135 W LED	7	13,423	5,227	886	5.9

This assessment project will assist numerous facility managers and building owners across the country when considering LED luminaires as an option for new lighting installations in parking lots meeting their energy efficiency as well as safety and security needs. 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. It is recommended the reader exercise due diligence in selecting luminaires specific to their needs.** The results of this project corroborate similar studies, specifically those conducted by Pacific Gas & Electric (www.etcc-ca.com).

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

- evaluating the benefits and acceptability of bi-level or adaptive lighting
- determination of the impact of LED lighting on security cameras and their ability to clearly depict images in the parking lot

INTRODUCTION

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

- **identify potential LED solution for outdoor area lighting, specifically for parking lots**
- **assess LED lighting technologies, validating manufacturer's claims regarding energy savings, light levels and light characteristics**

During early 2009, Resource Conservation District, located in Lakeside, California began considering options for their outdoor area lighting needs. The build out of their new office space allowed for the opportunity to include new parking lot lighting. In lieu of replacing dysfunctional poles and fixtures with traditional metal halide fixtures, LEDs were the light source of choice. The construction was completed in July 2009.

PROJECT BACKGROUND

Project Overview

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

The Parking Lot LED Lighting Technology Assessment project studied the applicability of light emitting diodes (LEDs) in a parking lot application. At Resource Conservation District, the seven parking lot lights which were planned to be metal halide were replaced with an LED luminaire. The specification required a different pole and luminaire than originally planned. The applicability of the technology was determined by light output and power usage and economic factors.

Technological Overview

At the time of this assessment, LED lighting in outdoor area lighting applications such as parking lots 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 traditional light sources. The advancement of LED technology since the advent of white LED's presents some significant opportunities in outdoor area lighting which includes parking lots. "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 (*source: www.netl.doe.gov/ssl DOE SSL LED Application Series: Outdoor Area Lighting).*

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 outdoor area lighting applications.

Market Overview

The development of LEDs for the outdoor area lighting niche represents a major breakthrough in energy efficiency advancement. This parking lot application normally (66%) involves high wattage high intensity discharge (HID) fixtures. The HID installed base of 3.1 million parking lot/garage/structure luminaires nationally. Currently, the market penetration of LEDs in this sector is estimated at 0% because LED products for this application have only recently become available. Further market penetration is expected to increase, as lamp efficacy rises. [1]

[1] Navigant Consulting, Inc. (2008). "Savings Estimates of Light Emitting Diodes in Niche Lighting Applications."

Additionally, decreasing cost and increasing customer confidence in the quality and life expectancy will further reduce barriers to market adoption.

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 parking lot/garage lighting fixtures of 3.1 million units results in California having an estimated installed base of 260,400 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 B), it is estimated that SDG&E® has an installed base of 18,228 parking lot/garage/structure fixtures in its service territory. 100% market penetration would equate to approximately 130 GWh reduction in electricity use. Realistically, market penetration will most likely not ramp up until the high first cost barrier of LED luminaires is overcome. **Assuming 0.5% market penetration each year would result in an electricity savings of approximately 650 MWh annually** in SDG&E® service territory. **This translates into 156.2 kW of reduced demand using 4165 annual operating hours** (assumed to be equal to hours stated in street light LS-2 Rate) for outdoor area lighting in SDG&E® service territory.

PROJECT OBJECTIVES

The objectives of this project were to examine electrical, lighting, and economics of LED lighting technology in an outdoor area application, specifically a parking lot, as compared to the traditional light source of metal halide (MH). The potential electrical demand and energy savings were measured in terms of instantaneous system wattage. The parking lot operates 4165 hours annually (based upon SDG&E's LS-2 Rate). Lighting performance was measured in terms of illuminance and Correlated Color Temperature (CCT) measured in Kelvin. Finally, since this was a new installation the economic performance was calculated using the simple-payback for a new construction project.

METHODOLOGY

Host Site Information

Resource Conservation District is a public service organization providing services throughout San Diego County. The location is the regional office providing office space for approximately 15 personnel.

Resource Conservation District's parking lot lighting was specified to be metal halide. The parking lot was to be lit by seven 250 W (nominal) metal halide (MH) fixtures. The parking lot is not a homogeneous area, meaning there is a small row of parking off the main entrance roadway, a small lot behind the front office building and another area near their warehouse building. The fixtures are mounted at a height of 18 - 24 feet with no real pattern of spacing between fixtures. The lights operate 4165 hours annually. The area does not have a surveillance camera. The customer's blended electric cost is $0.20 per kWh.

Measurement Plan

A measurement plan was developed to measure the lighting performance of each luminaire. Pre installation lighting characteristics, power and energy is based upon manufacturer data for a 250 watt metal halide system. A data point grid was used to collect the illuminance for each light source. The Correlated Color Temperature was recorded at each data point as well. Instantaneous electrical power data for each luminaire was collected utilizing a Fluke meter.

Equipment

The following equipment was used to collect the light and power characteristic data.

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:
Fluke 322 meter

http://www.fluke.com

PROJECT RESULTS AND DISCUSSION

Electrical Demand and Energy Savings

The parking lot lighting consisted of seven 250 W metal halide (MH) fixtures. Based upon industry technical data, each MH fixture, consisting of the lamp and ballast, consumes 291 W. The new LED luminaire was stated as 135 W. This results in the LED luminaire using 52% less demand than the MH fixtures. Taking into account all seven fixtures in the parking lot, the annual reduction of energy usage is 18,396 kWh or 52% less as shown in Table 3.

Table 3: Demand and Energy Savings

Parking Lot (4165 Operating hours)	# of Units	Power (W)	Demand (kW)	Reduction (%)	Energy (kWh)	Reduction (%)
250 W MH	7	291	2.0	-	8,484	-
135 W LED	7	139	1.0	52	4,053	52

Lighting Performance

For the assessment area, photopic illuminance and Correlated Color Temperature readings were taken. The focus of this section is on the parking area off the main entrance roadway. Photopic illuminance measurements were taken over a 175' X 40' area covering the one traffic lane and the parking stalls.

Illuminance levels were measured on a 10' X 10' grid. The maximum and minimum illuminance levels were determined from all measurements. The ratio of these two values is known as the uniformity ratio. The Illuminating Engineering Society of North America recommends a minimum light level of one foot-candle and a maximum uniformity ratio for parking lot of 10:1. Table 4 contains the photopic illuminance data and uniformity ratios. It is evident that neither light source meets IESNA requirements in terms of maximum uniformity ratio *or* minimum light level. While the LED setup appears worse than the MH setup by IESNA numbers, in reality the LED-lit parking lot "feels" a *lot* brighter than the MH setup, and appears perfectly fine in terms of light distribution and light quality. It was not in the scope of this study to determine from parking lot users or facility management whether they were satisfied with light levels and light quality.

Table 4: Photopic Illuminance Results

Luminaire	Grid Points Illuminated (%)	Average Illuminance (fc)	Max Illuminance (fc)	Min Illuminance (fc)	Average-to-Minimum Uniformity	Maximum-to-Minimum Uniformity	CCT
MH	100	1.08	5.04	0.05	22:1	101:1	3,860
LED	100	5.52	21.15	0.13	31:1	163:1	6,280

Economic Performance

It is important to note that the cost and equipment assumptions made in this section apply only to Resource Conservation District. **Resource Conservation District was assessing their selection of LED luminaires in lieu of high wattage high intensity discharge (HID) metal halide (MH) light sources. Therefore r**eaders should consider their specific variables such as maintenance, energy, luminaire/lamp costs and type of light distribution 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.** Although the manufacturer data states 60,000 hours, t*he **assumptions for LED life expectancy in this project is based upon 50,000 hours as per the United States Department of Energy website*** (*source:* http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/lifetime_white_leds.pdf).

1. Energy Cost Estimates

The energy cost is based upon the Resource Conservation District's blended rate of $0.20 per kWh. Resource Conservation District's parking lot lights operate 4165 hours annually. Table 5 provides the energy cost and savings estimate assuming all seven fixtures in the parking were converted from the base case metal halide to the new LED luminaires.

Table 5: Energy Cost Savings with LEDs

Parking Lot (4165 Operating hours)	# of Units	Power (W)	Energy (kWh)	Annual Energy Cost ($)	Annual Energy Cost Savings ($)	Reduction (%)
250 W MH	7	291	8,484	1,697	-	-
135 W LED	7	139	4,053	811	886	52

2. Payback Analysis

The simple payback calculations for the new construction scenario considered the total investment cost and energy savings for the LED. In this project, the LED simple paybacks are shown in tables 7. Table 8 provides the maintenance savings derived based upon the costs provided by Resource Conservation District.

Table 6: New Construction Simple Payback Based Upon Energy Savings

Parking Lot (4165 Operating hours)	# of Units	Product Cost ($)	Incremental Cost ($)	Annual Energy Cost Savings ($)	Simple Payback (years)
250 W MH	7	8,196	-	-	-
135 W LED	7	13,423	5,227	886	5.9

Table 7: New Construction Simple Payback Based Upon Energy and Annual Maintenance Savings with LEDs

Parking Lot (4165 Operating hours)	# of Units	Incremental Cost ($)	Annual Maintenance Cost ($)	Annual Maintenance Cost Savings ($)	Annual Energy Cost Savings ($)	Total Annual Savings ($)	Payback (years)
250 W MH	7	-	8,484	1,697	-	-	-
135 W LED	7	5,227	4,053	4,431	886	5,317	1.0

The disposal fees were obtained from City of San Diego Environmental Services Department. To derive annual maintenance cost savings, the total maintenance cost was divided by the life expectancy of the light source.

3. Luminaires and Lamp Life

This 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). The manufacturer of the LED luminaires assessed in this project claim life expectancies greater than 50,000 hours. 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 12 years. This results in the payback being achieved at approximately one half of the LED life, making this scenario an attractive alternative. ***This is an optimistic statement due to the unproven life of LED products and does not indicate that LEDs are necessarily a viable option for all similar situations.***

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 lot 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

4. Life Cycle Cost Analysis

Even though life cycle cost 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 LED luminaires as the LED market is in a state of flux. 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 LED luminaires can provide energy savings up to 52% without compromising light characteristics required for parking lot 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 LED luminaires replace high intensity discharge (HID) metal halide (MH) lighting, readers are encouraged to complete a life cycle cost analysis to gain the complete economic picture of a technological change out.

While the results of this project attest to the leaps in technological enhancements of LED lighting technology, the high first cost required to **retrofit** outdoor lighting applications including parking lots with LEDs will be the main barrier to significant market adoption. When using 50,000 hours as the expected life of the LED luminaire, the significant energy savings and reduced maintenance costs do not adequately offset this high initial first cost in a retrofit application. However, as illustrated by this project, LEDs may be a viable option in a new construction application. Performance of LEDs combined with growing market acceptance of their higher performance versus traditional outdoor area light sources may provide early adopters the impetus to invest in the emerging technology.

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

- evaluating the benefits and acceptability of bi-level or adaptive lighting
- determination of the impact of LED lighting on security cameras and their ability to clearly depict images in the parking lot

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**