SMUD
SACRAMENTO MUNICIPAL UTILITY DISTRICT
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Energy Efficiency & Customer Research & Development

Technology Brief: LED Canopy Lighting

Executive Summary

During 2009, SMUD conducted several research projects to explore the potential benefits of LED lighting for a variety of applications including interior replacement lamps, street lighting, parking lots and gas station canopies. Objectives for these projects included assessing the lighting performance, energy and cost savings potential. The results were used in developing commercial rebate programs for LED lighting technologies for 2010.

The management team at 7-Eleven has made a decision to test LED lighting at several stores across the nation, including one store in Citrus Heights, California. Since this store was located within SMUD's service territory, SMUD agreed to provide a research grant and assist 7-Eleven with evaluating the performance of the LED lighting system. Results included:

- ✓ Higher initial illumination levels
- ✓ Less visual glare
- ✓ Less light pollution
- ✓ Energy savings of 63 to 80%

Without taking the SMUD grant into account, the simple financial payback was 9.2 years - somewhat long for this type of project. However, it is important to note that this calculation is based upon an average energy rate of $0.10 per kWh and many customers in California pay significantly higher rates. Also, since SMUD provided a research grant of $10,000 for this project, the estimated simple payback for 7-Eleven was 2.3 years.

Introduction

Has this ever happened to you? It's late at night and you are anxious to get home. That's when it happens: that annoying little light on the dashboard reminds you to stop for gas. With a heavy sigh you pull into a gas station and climb out of the car. You are greeted by the glare of what seems like a hundred lights. Alien abduction? Super nova? No – just the local gas station engaged in "lumen wars."

Many gas station owners use high illumination levels to attract customers – the brighter the better. Consequently, lighting power densities for fueling canopies can reach 3.5 Watts per square foot or higher. This is startling when you consider that current California Title 24 energy standards only allow less than one Watt per square foot for *office lighting!* Fortunately, recent advances in LED technology provide excellent opportunities to save energy and yet still satisfy the station owners' desire for higher illumination levels. This is good news since California and other states are currently working to tighten energy standards for exterior lighting applications.

Exterior Lighting 101

Before discussing the results of this project, it may be helpful to define a few key aspects of exterior lighting. A good lighting design should address:

- ✓ **Horizontal illumination:** the amount of light delivered to horizontal surfaces such as the ground or the top of a surface. In the United States, it is measured in units called foot-candles.
- ✓ **Vertical illumination:** the amount of light delivered to vertical surfaces such as walls or people. This is a critical element for safety since it helps drivers identify hazards. Vertical illumination is also measured in foot-candles.
- ✓ **Glare**: in simplified terms, glare is the light shining in your eyes that causes discomfort and impairs vision.
- ✓ **Color Rendering Index (CRI):** a measurement for how accurately a lighting source renders colors. CRI may be an important factor - especially in retail environments. CRI values range up to 100 with 100 considered to be excellent.
- ✓ **Correlated Color Temperature (CCT):** the appearance of a light source, units are in Kelvin. Exterior lighting sources range in appearance from orange to blue-white. CCT has a tremendous impact upon the appearance of the space being illuminated. For example: high pressure sodium lamps have a CCT of ~2100K and are very orange in appearance. Many exterior LED products are blue-white in appearance and tend to have ratings of 6200K (or even higher).
- ✓ **Lighting distribution:** the manner in which a fixture distributes the light produced by the source (e.g. lamps). The key is to select fixtures that deliver light where it is needed while minimizing glare and wasted light.
- ✓ **Efficacy (Lm/W):** the amount of light (measured in lumens) divided by the total power consumed (Watts). Analogous to miles per gallon for cars.
- ✓ **Cost of ownership:** every light source has advantages and disadvantages. When selecting fixtures, it is very important to look beyond first cost and consider maintenance requirements and energy costs.

Demonstration Project Overview

In 2009, 7-Eleven's management team chose a store in Citrus Heights, California as a test site for LED lighting. The original exterior lighting systems for this location included:

- ❑ Fueling canopy: ten 250-Watt, surface-mounted, metal halide fixtures (see Figure 1)
- ❑ Front parking lot: three 400-Watt, metal halide fixtures mounted on a 20 foot pole
- ❑ Canopy logo signs: two signs each with three 3-foot T12 HO fluorescent lamps

All of these exterior lights were controlled via a photocell and operated approximately 4,000 hours per year. Although the original illumination levels were adequate, the canopy fixtures produced a considerable amount of glare and had a rated average lamp life of only 10,000 hours. Furthermore, at 3.5 Watts per square foot, the original system was not very energy efficient.

Figure 1: The original exterior lighting system for the fueling canopy area included ten surface-mounted, 250-Watt metal halide fixtures. Photo: Stephen Anselmino

The original lights were replaced with products made by LSI Industries, a company based in Cincinnati, Ohio. The new lighting fixtures included:

- ❑ Fueling canopy: ten 115-Watt, recessed LED fixtures (LSI Crossover)
- ❑ Front parking lot: three 137-Watt, LED fixtures (LSI XAM)
- ❑ Logo signs: two 30-Watt, LED retrofit kits

Figure 2: The new LED lighting system for the fueling canopy area included ten recessed, 115-Watt LSI Crossover fixtures. Photo: Stephen Anselmino

A comparison of the metal halide and LED fixtures used in the fueling canopy area is presented in the table below (Figure 3). Some observations:

- Since the 250-Watt metal halide fixtures use magnetic ballasts, they actually consume 295 Watts. The wattage for the LED fixtures, including the power supply, is only 115 Watts; a savings of nearly 63%.
- The metal halide lamps are rated for 10,000 hours. This is the point at which 50% of the lamps are predicted to fail.
- Based upon independent lab test data, the manufacturer predicts the useful life of the LEDs will be at least 50,000 hours. It is important to note that the "useful life" of an LED light source is the point at which the light output is expected to diminish by 30% - not when the LEDs fail.
- The CCT and the CRI for both the LED and the metal halide are comparable.

System	Fixture Watts	CCT	CRI	Rated lamp life (hours)
Metal halide[1]	295	4200K	65	10,000
LED[2]	115	5100K	69	50,000

Notes:

(1) Values for the metal-halide fixtures were taken from a lamp and ballast catalog

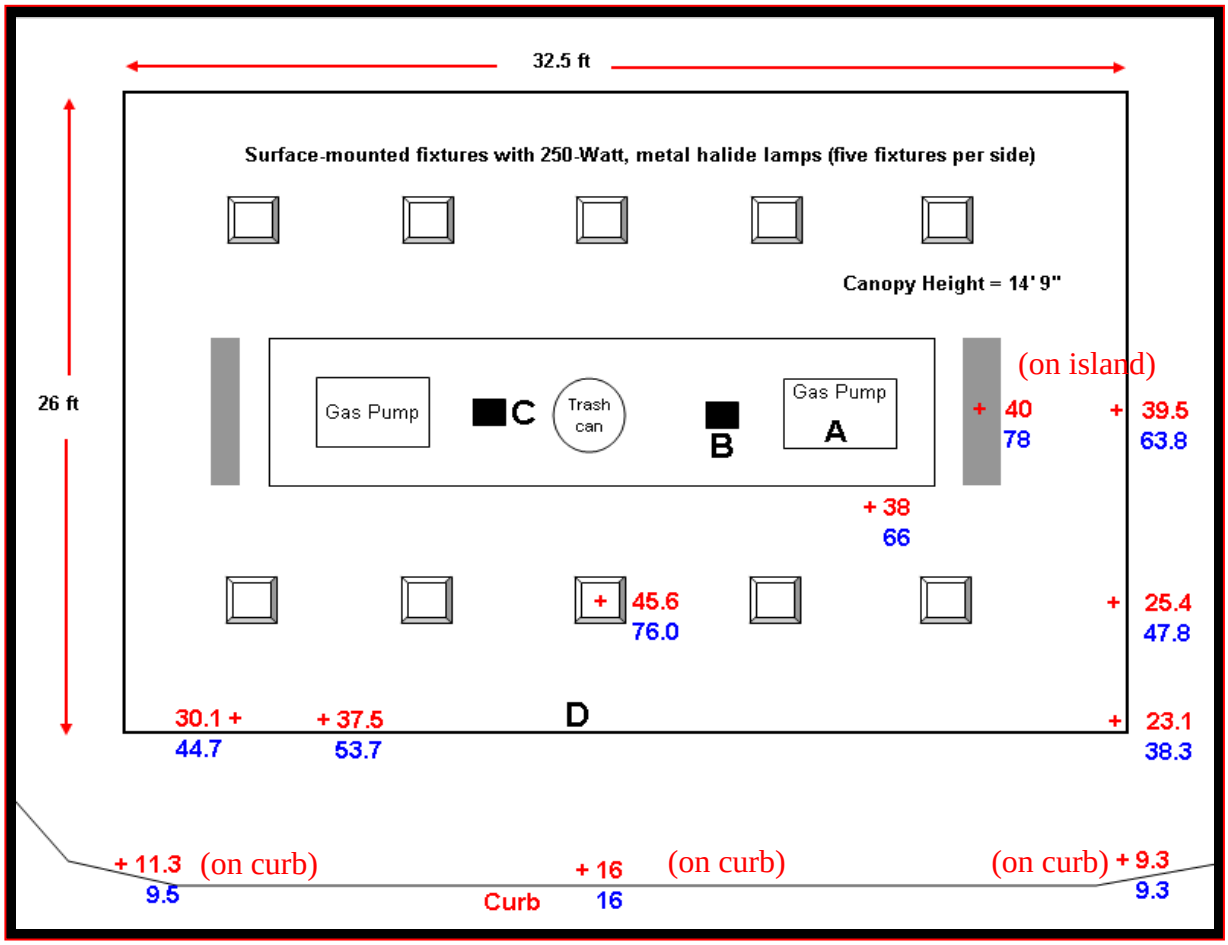
(2) Values for the LED fixtures were taken from independent lab tests (IESNA LM79-08)

Figure 3: Comparison of metal halide and LEDs

Project Results

Lighting Performance

The project team used a calibrated light meter to measure horizontal and vertical illumination levels before and after the retrofit. Overall, the new LED fixtures produced excellent results including higher initial illumination levels, less glare, and less light pollution. The illumination measurements for the fueling canopy area are shown below.



RED Font = Metal Halide (pre-retrofit)

BLUE Font = LED (post-retrofit)

Figure 4: Illuminance measurements. Note that the LEDs provided higher illumination levels (horizontal and vertical) than the metal halide fixtures in the fueling canopy area. Horizontal measurements were taken on the ground unless otherwise noted.

Vertical Illumination Levels

Point	Location	Metal Halide	Initial LED
A	On face of cash machine / pump	29.0 fc	39.9 fc
B	On post beneath sign	42.6 fc	50.9 fc
C	Face of towel station	41.0 fc	51.7 fc
D	Along side of person's face	56.9 fc	47.0 fc

Energy Savings

The estimated energy savings for this project are very impressive – especially considering the fact that the LEDs provide higher illumination levels. Assuming the exterior lights operate 4,000 hours per year, the estimated annual energy savings are as follows:

Location	Number of fixtures	Original fixtures		LED fixtures		Estimated Savings	
		Watts	kWh	Watts	kWh	Annual kWh	%
Canopy	10	295	11,800	110	4,400	7,400	63%
Parking Lot	3	458	5,496	137	1,644	3,852	70%
Logo signs	2	150	1,200	30	240	960	80%
					Total	12,212	66%

Using an average energy rate of $0.10 per kWh, the estimated annual utility bill savings for this project would be $1,212. Since the lights are operated only during the off peak periods, this project did not yield any demand savings.

Maintenance Savings (assuming 50,000 hours / 12.5 years)

Since the LEDs are expected to last five times longer than the metal halide fixtures, lighting maintenance costs should be considerably lower. To protect customer privacy, hypothetical labor rates were used in the calculations shown below.

Fueling canopy fixtures:
5 lamp replacements / fixture x ($30 + $12 per fixture) x 10 fixtures = $2,100

Parking lot fixtures:
2.5 lamp replacements / fixture x ($30 + $12 per fixture) x 3 fixtures = $315

Logo signs:
5.5 lamp replacements / sign x ($30 + $15 per sign) x 2 signs = $494

Total maintenance savings: $2,909

Average annual maintenance savings = $2,909 ÷ 12.5 years = **$233 per year**

Assumptions

- ✓ Life of LED fixtures (based on IESNA LM80-08): 50,000 hours or 12.5 years (4,000 hours / year)
- ✓ 250 Watt metal halide fixtures: 10,000 hours of life; material cost of $12 per lamp
- ✓ 400 Watt metal halide fixtures: 20,000 hours of life; material cost of $12 per lamp
- ✓ Logo sign: 9,000 hours of life; material cost of $5 per lamp
- ✓ Assumed labor cost: $60 per hour, 30 minutes per lamp replacement ($30 per lamp)

Total Cost Savings

Utility Bill Reduction:	$1,212 per year
Annual maintenance savings:	$233 per year
Total cost savings =	$1,445 per year

Simple payback: $13,350 ÷ $1,445 per year = 9.2 years

Since SMUD provided a research grant of $10,000 for this project, the estimated simple payback for 7-Eleven was actually 2.3 years.

Final Thoughts

Demonstration projects such as this one provide valuable insights for deploying emerging technologies. Lessons learned from this project include:

- Before the retrofit, the horizontal illumination levels in the fueling canopy area were quite high (30 to 45 footcandles). The LED system produced even more light (40 to 78 footcandles). Since the Illumination Engineering Society of North America (IESNA) recommends only 3 to 5 foot-candles for pump islands,[1] much greater savings were possible for this project. Selecting fixtures with fewer LEDs would have reduced first costs, provided more savings and improved the financial payback.

- Although laboratory testing suggests the useful life of these LED fixtures should reach 50,000 hours or more, the jury is still out. Currently, IESNA is reluctant to extrapolate beyond 35,000 hours. SMUD intends to revisit this site next year to track the illumination levels.

- Although LED technology is steadily improving, there is an awful lot of junk out there! Fortunately, Pacific Gas and Electric (PG&E) and Energy Star have developed quality specifications for exterior LED lighting products. PG&E's list has been developed to guide customers until the Energy Star program is fully implemented. Customers are encouraged to purchase fixtures that are on PG&E's qualified product list or have been approved by Energy Star. Some helpful links:

    - PG&E http://www.pge.com/led/
    - DOE Solid State Lighting program / Energy Star: http://www.netl.doe.gov/redirect/

- SMUD will offer energy efficiency incentives for qualified LED exterior fixtures beginning in February of 2010. Although the details are still under development, the program should be up and running in February 2010. Please call SMUD Commercial Services, 1-877-622-7683 or visit www.smud.org in January for details.

[1] The IESNA Lighting Handbook, Ninth Edition