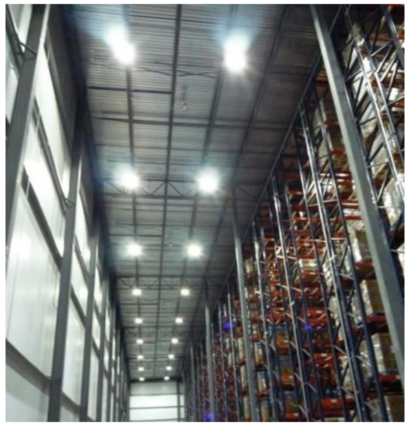

LED High Bay Lighting Assessment

ET09SDGE0004

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Prepared for:

SDGE
A Sempra Energy utility®

Prepared by:

Emerging Technologies Associates, Inc.

Preface

PROJECT TEAM

This project is sponsored by San Diego Gas & Electric's (SDG&E®) Emerging Technologies Program (ETP), with Abdullah Ahmed as the project manager. Phoebe Hamann-Jones, was the contact and project manager for Hamann Cold Storage ICE II (Hamann). Daryl DeJean (daryldejean@gmail.com) of Emerging Technologies Associates, Inc. (ETA) provided technical consulting, 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 (all actual measurements unless stated otherwise), 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 Hamann for their cooperation in the project. Without their participation, this demonstration project would not have been possible.

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Abbreviations and Acronyms

CEUS California End Use Survey

DOE Department of Energy

ETA Emerging Technologies Associates, Inc.

ETP Emerging Technologies Program

FC Foot Candle

FT Foot

GWh Gigawatt hours

HID High Intensity Discharge

ICE Ice Cold storage Enterprises, Inc.

IOU Investor-owned Utility

kW Kilowatt

kWh Kilowatt hours

L/W Lumens per Watt

LED Light Emitting Diode

MH Metal Halide

SDG&E® San Diego Gas & Electric

SQFT Square Foot

W Watts

List of Tables

Executive Summary

This report summarizes a refrigerated warehouse LED high bay lighting demonstration project conducted to study the applicability of LEDs as a replacement for traditional metal halide (MH) high intensity discharge (HID) lighting in the refrigerated warehouse and storage sectors. In lieu of the specified MH HID lighting LED high bay fixtures were installed throughout the entire refrigerated warehouse facility, Hamann Cold Storage ICE II in Otay Mesa, CA. The LED high bay technology was installed as a replacement for 400 W MH HID fixtures which were specified for use at this facility. SDG&E® Savings by Design program contacted the SDG&E® Emerging Technologies program to discuss collaborating on this effort. The suitability of the new technology was determined by technical data analysis regarding energy and power usage, lighting performance characteristics, qualitative satisfaction, and economic factors. In the warehouse and storage sector, lighting is used to provide adequate lighting for picking product, stocking product and to create a safely lit working environment.

This LED demonstration project involved the demonstration of 272 LED high bay fixtures from Beta LED that are controlled with occupancy sensors in the warehouse and dock area. For this application, the quantity of light fixtures was reduced by using the LED. Originally specifications called for 321 400 W MH HID fixtures. Due to the directional nature of LEDs and the optics available to create defined light distribution patterns, the Beta Edge LED high bay fixture provided calculated equivalent lighting with only 272 fixtures. This resulted in a 15% reduction in the number of fixtures required. The installed LED high bay fixtures have a stated draw of 321 W (42 units) and 86 W (230 units), which are 32% (148 watts) and 81% (383 W) lower, respectively, than the 400 W (nominal) MH HID fixture originally specified. Based upon warehouse usage with assumptions showing that occupancy sensor-controlled lighting is on only 15 to 20% of the time, the annual operating hours of the warehouse lighting used to calculate the energy savings are 1,752 hours (8,760 hours*0.20). To ensure a proper comparison, it was assumed that the MH HID lighting would have been operated utilizing occupancy sensors. Technical data comparison results from the study are tabulated in Table 1 below.

Table 1: Energy and Demand Savings

Fixture	Number of Fixtures	Stated Average Power (W)	Demand (kW)	Annual Energy (kWh)
400 W MH (originally specified)	321	469	150.6	263,762
Beta Edge BLD-CAN-25-PD-034-LED-B-UL-SV-525	26	321	8.3	14,622
Beta Edge BLD-CAN-PS-PD-102-LED-B-UL-SV-700	16	321	5.1	8,998
Beta Edge BLD-PKG-15-PD-034-LED-B-UL-SV-525	230	86	19.8	34,655
Total LED	272		33.3	58,275
TOTAL Savings - Fixture, Demand & Energy	49		117.3	205,510
% Reduction in Fixtures, Demand & Energy Savings	15%		78%	78%

The desired minimum illuminance acceptable to the customer is 1 foot candle (fc). During preliminary LED product selection the LED luminaire BLD-PKG-15-PD-034-LED-B-UL-SV-525 produced on average 3.2 fc mounted at a 60' ceiling height with acceptable light distribution.

Due to the as yet undemonstrated useful life of these LED lamps, economic and reliability claims are based on the best available information from the manufacturer and Department of Energy (DOE) reports.

Due to the significant energy savings of the LED high bay fixture, simple payback was 4.95 years in this new construction scenario. The assessed fixtures were determined to be sufficient to replace the specified baseline fixtures in this demonstration, allowing for a reduction in the total number of fixtures required. This demonstration illustrates the potential for LED technology when a mixture of LED fixtures is considered to deliver the proper lighting for each aspect of the application being considered.

Table 2: Simple Payback Economics

Fixture Type & Cost	Incremental Fixture Cost ($)	Number of Fixtures	Total Incremental Cost ($)	Annual Energy Savings (kWh)	Annual Energy Savings ($)	Simple Payback (years)
MH HID 400 W	N/A	321	N/A			---
Beta Edge BLD-CAN-25-PD-034-LED-B-UL-SV-525	1,275	26	33,150	6,742	944	35.12
Beta Edge BLD-CAN-PS-PD-102-LED-B-UL-SV-700	1,275	16	20,400	4,149	581	35.12
Beta Edge BLD-PKG-15-PD-034-LED-B-UL-SV-525	439	230	100,970	154,334	21,607	4.67
Credit for less fixtures	249	(49)	(12,201)	40,263	5,637	
Total Incremental Cost, Savings and Simple Payback		272	142,319	205,595	28,768	4.95

Project Background

PROJECT OVERVIEW

The LED High Bay Lighting Assessment project studied the applicability of LED lamps replacing MH HID to provide adequate lighting for warehouse and storage facilities. MH HID fixtures were replaced with new LED high bay fixtures at the refrigerated warehouse facility, Hamann Cold Storage ICE II, located in Otay Mesa, CA. The applicability of the technology was determined by energy and power usage, qualitative satisfaction, lighting performance, and economic factors.

This demonstration project was conducted as part of the SDG&E's Emerging Technologies Program in collaboration with their Savings by Design Program. The Emerging Technologies Program is an information-only program that seeks to accelerate the introduction of innovative energy efficient technologies, applications. The information includes calculated energy savings and demand reductions, market potential and market barriers, incremental cost, and the technology's life expectancy.

TECHNOLOGICAL OVERVIEW

The LED High Bay Lighting Assessment project focused on providing adequate lighting for the safety and productivity of warehouse personnel.

At the time of this assessment, LEDs began to show promise in high bay lighting because of their potential for reduced energy consumption. Additional benefits for warehouse and storage lighting applications include long operating life, lower maintenance and life-cycle costs, reduced radiated heat, minimal light loss, and controllability, direction illumination, and adjustable color when compared to traditional sources.[1] At this time, however, the initial cost of LED fixtures in general was much higher than alternative light sources such as MH HID fixtures. The economic feasibility of energy efficiency measures utilizing LED sources is heavily dependent upon the operating hours of the application.

Information from the US Department of Energy suggests LED technology is changing at a rapid pace such that, "since 2002, commercial white LED device efficacies have increased from 30 L/W (DOE,2006a) to about 100 L/W in 2008."[2] Due to these rapid advances in this field, it is expected that even more robust LED products will be entering the market which may permit direct one-for-one replacement scenarios as well as meet a broader base of customer investment criteria.

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

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

MARKET OVERVIEW

Warehouse and storage facilities are traditionally lit by high wattage fixtures. As a result, this market sector represents an important application for new lighting technologies because of the large potential for energy savings due to the high fixture wattages. Currently, the market penetration of LEDs in the warehouse and storage facility sector is estimated at 0% because LED high bay products have only recently become available. This is expected to increase, as technology develops and fixture efficacy increases. [3]

A report by Navigant Consulting in 2002 estimates that lighting makes up approximately 22% of IOU kWh sales on a national scale. Using kWh sales figures from a 2006 study, the total consumption in SDG&E's service territory for lighting is calculated to be on the order of 4,093 GWh in 2002.[4] This study also provides values for kWh lighting figures within SDG&E®'s commercial sector only. A California Commercial End Use Survey (CEUS) study conducted in 2006 by ITRON, found that of the total interior lighting in California attributed to warehouses is 1,485 GWh. Based upon estimates that 20% of the state energy load is within SDG&E® service territory, the savings potential of interior warehouse lighting of around 297 GWh.[5] Although these figures are not exclusively for high bay interior warehouses lighting using HID light sources the figures do give an idea of the significant potential that exists for savings.

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

[4] Itron Inc., et al (2006). "California Energy Efficiency Potential Study".

[5] Ibid.

Project Objectives

The objectives of this demonstration project were to examine and compare the technical data regarding electrical, lighting, and economic performance of LED high bay fixtures as compared to MH HID fixtures. The potential electrical demand and energy savings were compared in terms of average wattage and estimated annual kWh usage. Lighting power density was also calculated. Finally, economic performance was calculated as a simple-payback for substitution of LED fixtures in the new installation.

Methodology

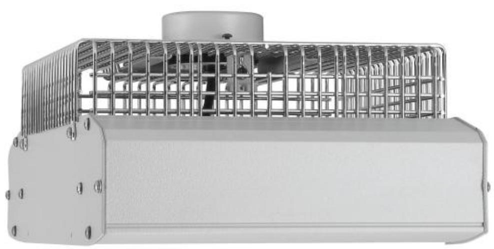
HOST SITE INFORMATION

The facility selected for this demonstration was a refrigerated warehouse facility, Hamann ICE II in Otay Mesa. It is approximately 132,000 sqft with 60 ft high roof deck. The facility accommodates 114,300 sqft freezer floor space and 13,200 sqft dock. This project focused on providing LED high bay replacement lighting for specified high bay MH HID fixtures.

The originally specified lighting system in the warehouse areas consisted of 321 units of the MH HID 400 W fixture to provide the ambient lighting.

LIGHTING TECHNOLOGY

This project involved the demonstration of Beta LED High Bay fixtures.



Beta Edge BLD-PKG-15-PD-034-LED-B-UL-SV-525

Beta Edge BLD-CAN-25-PD-034-LED-B-UL-SV-525

Project Results

ELECTRICAL ENERGY AND DEMAND SAVINGS

The LED high bay fixtures, as compared to the originally specified MH HID fixtures, were assessed utilizing manufacturer provided technical data to determine power consumption of each fixture to be used in Haman's new refrigerated warehouse facility.

At Hamann Cold Storage ICE II, Otay Mesa, the warehouse lighting is estimated to operate 24 hours per day 365 days, resulting in 8,760 operating hours per year. The stated power demand and estimated yearly energy consumption are summarized in Table 3. Table 4 displays the potential demand and energy savings of using the LED high bay fixtures as compared to the baseline 400 W MH HID fixture. Since the LED case utilized occupancy sensors, it was assumed the MH HID base case would have used occupancy sensors.

Table 3: Calculated Electric Demand and Estimated Energy Usage

Fixture	Number of Fixtures	Stated Average Power (W)	Demand (kW)	Annual Energy (kWh) (1,752 hours of operation)
400 W MH	321	469	150.6	263,762
Beta Edge BLD-CAN-25-PD-034-LED-B-UL-SV-525	26	321	8.3	14,622
Beta Edge BLD-CAN-PS-PD-102-LED-B-UL-SV-700	16	321	5.1	8,998
Beta Edge BLD-PKG-15-PD-034-LED-B-UL-SV-525	230	86	19.8	34,655
Total for LED Fixtures			33.3	58,275

Table 4: Potential Electric Demand, Energy Savings and Reduced Fixtures

Fixture	Number of Fixtures	Stated Average Power (W)	Demand (kW)	Annual Energy (kWh) (1,752 hours of operation)
400 W MH (Original Specified)	321	469	150.6	263,762
LED Beta Edge	272	321 and 86	33.3	58,275
Total Fixture, Demand & Energy Savings	(49)		117.3	205,595
% Reduction in Fixtures, Demand & Energy Savings	15%		78%	78%

LIGHTING POWER DENSITY

The lighting power density (LPD) was calculated according to the following equation:

The installed watts included the wattage of the 400 W MH lighting fixtures. There were 321 fixtures specified for the warehouse lighting system.

As seen in Table 5 and Table 6 below, through the use of LED high bay lamps, the lighting power density for the warehouse was reduced by 78% over the specified MH lamps.

Table 5: Lighting Power Density Warehouse

Fixture	Power – Warehouse Lighting (W)	Area (ft^2)	Lighting Power Density (W/ft^2)
Specified Baseline - MH HID (400 W)	150,549	127,500	1.18
Beta Edge BLD-CAN-25-PD-034-LED-B-UL-SV-525	8,346		
Beta Edge BLD-CAN-PS-PD-102-LED-B-UL-SV-700	5,136		
Beta Edge BLD-PKG-15-PD-034-LED-B-UL-SV-525	19,780		
Beta Edge TOTAL	33,262	127,500	0.26

ECONOMIC PERFORMANCE

Economic performance was evaluated primarily by simple payback of the LED high bay fixture versus the MH HID fixture in new construction.

To estimate energy cost, the rate of $0.14 per kWh was assumed. The cost of a MH HID fixture was estimated to be $249.

Table 6: Simple Payback Economics

Fixture Type & Cost	Incremental Fixture Cost ($)	Number of Fixtures	Total Incremental Cost ($)	Annual Energy Savings (kWh)	Annual Energy Savings ($)	Simple Payback (years)
MH HID 400 W	N/A	321	N/A			---
Beta Edge BLD-CAN-25-PD-034-LED-B-UL-SV-525	1275	26	33,150	6,742	944	35.12
Beta Edge BLD-CAN-PS-PD-102-LED-B-UL-SV-700	1275	16	20,400	4,149	581	35.12
Beta Edge BLD-PKG-15-PD-034-LED-B-UL-SV-525	439	230	100,970	154,334	21,607	4.67
Credit for less fixtures	249	(49)	(12,201)	40,263	5,637	
Total Incremental Cost, Savings and Simple Payback		272	142,319	205,595	28,768	4.95

The fact that this project was new construction, and not a retrofit opportunity reduced the incremental cost of the high bay LED resulting in an acceptable payback of 4.95 years.

Discussion

LED luminaires have the potential for great energy savings in warehouse lighting applications. These energy savings are possible because of the high wattage and relative inefficiency of high intensity discharge lamps. The inherently directional nature of lighting output from LEDs, as well as their potentially small size, also gives LEDs an advantage over other efficient lighting technologies. In fact, for warehouse applications, the LED optics may allow for the light to be disbursed in the aisles where it is needed in lieu of the omnipresent distribution of light which traditional highbay luminaires utilize.

While LED technology is approaching the efficacy of HID lamps, LED chips still convert more of the total power input into light output as compared to other light sources. The rest of the power input is lost as heat, which must be dissipated away from the lamp at the junction. This is one of the primary factors affecting LED lamp performance; as LED chips become hot, they become less efficient and the chip degrades leading to shorter chip lifetimes. In this particular application, a refrigerated warehouse facility, the life of the LED may in fact be extended due to the cold temperatures resulting in a lower junction temperature. However, chip life times are of greatest concern when a warehouse is located in a very hot region and is in non-conditioned space. In high ambient temperature applications, the life expectancy of LED luminaires decreases, resulting in more frequent maintenance.

The demonstration carried out at Otay Mesa, CA resulted in a simple payback of 4.95 years. This short payback period is due to the significant energy savings associated with the LED luminaires and the reduction in the number fixtures.

SDG&E® uses this and other Emerging Technologies assessments to support development of potential incentives for emerging energy efficient solutions. Because the performance and quality of the LED fixtures are critical to the long-term delivery of energy savings, it is important that incentive programs include quality control mechanisms. Incentive programs should include performance standards for qualifying products that include minimum criteria for warranty, efficacy, light distribution, and other important criteria.

Conclusion

LED lighting has great potential for energy savings in warehouse and storage facility applications. This demonstration provided an example of this potential in warehouse lighting. Due to the ability to control the optics of the LED, the replacement scheme in this demonstration was favored the LED since it allowed for a 15% reduction in the number of fixtures. Additionally, if consideration is given to selecting various types and wattages of LED fixtures to match each aspect of the application, LED technology will prove to be an attractive solution.

As the technology increases in performance, utility or government incentive programs can help to tip the scale towards greater adoption of LED lamps by reducing the initial investment required. These utility incentive programs should require minimum performance standards for qualifying products in order to ensure long-term energy savings.