



Bi-Level LED Elevator Cab Lighting Demonstration Showcase

ET11SDGE0011

April 4, 2012

Prepared for:



Prepared by:



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. Allen Rutherford, Elevator Mechanic, was the contact and project manager for the University of California San Diego (UCSD). 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."

While this document is believed to contain correct information, SDG&E®, ETA, UCSD, or any employees and associates, make no warranty, expressed or implied, or assume any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represent that its use would not infringe privately owned rights. Any references herein to any specific commercial product, process or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by SDG&E®, ETA, UCSD, or their employees, associates, officers, and members. The ideas, views, opinions or findings of authors expressed herein do not necessarily state or reflect those of SDG&E®, ETA or UCSD. Such ideas, views, opinions or findings should not be construed as an endorsement to the exclusion of others that may be suitable. The contents, in whole or part, shall not be used for advertising or product endorsement purposes. Any reference to an external hyperlink does not constitute an endorsement. Although efforts have been made to provide complete and accurate information, the information should always be verified before it is used in any way.

ACKNOWLEDGEMENTS

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

Table of Contents

Executive Summary	5
Introduction.....	7
Project Objectives	8
Project Background	9
Technological Overview.....	9
Market Overview	9
Programs.....	10
Methodology	11
Host Site Information	11
Measurement Plan	11
Equipment	12
Project Results.....	13
Electrical Energy and Demand Savings	13
Economic Performance.....	14
Conclusion	17
Appendix A	18
Appendix B	19
Appendix C	21
Appendix D	22

Abbreviations and Acronyms

CALiPER Commercially Available LED Product Evaluation and Reporting

CFL Compact Fluorescent Lamp

DOE Department of Energy

DR Demand Response

EEBI Energy Efficiency Business Incentives

ESB Energy Savings Bid

ETA Emerging Technologies Associates, Inc.

ETP Emerging Technologies Program

GHG Greenhouse Gas

kW Kilowatt

kWh Kilowatt hours

LCCA Life Cycle Cost Analysis

LED Light Emitting Diode

MW Megawatt

MWh Megawatt hours

SDG&E® San Diego Gas & Electric

SSL Solid State Lighting

UC University of California

UCSD University of California San Diego

W Watts

List of Tables

Table 1: Energy and Demand Savings 5

Table 2: Simple Payback – Retrofit..... 6

Table 3: Energy and Demand Savings with Fan Off..... 6

Table 4: Energy and Demand Savings 13

Table 5: Energy and Demand Savings with Fan Off..... 13

Table 6: Energy Cost Savings Achieved 14

Table 7: Simple Payback – Retrofit..... 15

Table 8: Energy Cost Savings with Dimming 22

Table 9: Energy Cost Savings with Fan Off 22

Executive Summary

San Diego Gas & Electric (SDG&E®) was interested in a business incubation and scaled field placement project to demonstrate LED technology for elevator cab lighting. University of California San Diego (UCSD) agreed to participate in a demonstration to determine the viability of LED lighting solutions for their elevators. The goals of the project were to demonstrate the potential of LED as a viable replacement lighting technology and determine the energy savings potential provided by LED general illumination as compared to incandescent, fluorescent, and CFL base cases.

UCSD wanted to ensure the selected LED luminaire used in the elevator cab met the requirements of occupant safety, reduced ambient temperature, equivalent light quality and dimmability. UCSD has 171 elevators campus-wide with various fixtures and lamp types: 60 cabs with halogen MR16, 85 cabs with linear fluorescent and 26 cabs with CFL. This demonstration project allowed for an ideal substitution of the traditional base case incandescent, fluorescent and CFL with the LED solution.

Hobo loggers were used to measure the electric energy for the incandescent base case and the LED solution. It was observed the elevator cabs were usually unoccupied during nights for approximately 9 hours a day (3,285 hours per year). The lighting could be dimmed during this period to provide additional savings. Demand savings achieved per LED lamp as compared to the base cases are shown in Table 1. Based upon the annual operating cost savings and the installation cost of 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 (W)	Annual Operating Hours	Number of Lamps	Energy (kWh)	Demand (kW)	Energy Savings (%)
Incandescent *	58.3	8,760	9	4,596	0.52	-
LED	3.6	8,760	9	284	0.03	94
LED w/dimming function **		8,760	9	225	0.03	95
Fluorescent *	32.0 ***	8,760	4	1,121	0.13	-
LED	3.6	8,760	9	284	0.03	75
LED w/dimming function **		8,760	9	225	0.03	80
CFL *	13.0 ***	8,760	6	683	0.08	-
LED	3.6	8,760	9	284	0.03	58
LED w/dimming function **		8,760	9	225	0.03	67

* Base Case

** See Appendix D for detailed calculations

*** Stated Wattage

Table 2: 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)
Incandescent *	6	9	54	4,596	0.08	368	-	-
LED	270	9	2,430	284	0.08	23	345	6.9
LED w/dimming function **	335	9	3,015	225	0.08	18	350	8.5
Fluorescent *	5	4	20	1,121 ***	0.08	90	-	-
LED	270	9	2,430	284	0.08	23	67	36.0
LED w/dimming function **	335	9	3,015	225	0.08	18	72	41.8
CFL *	3	6	18	683 ***	0.08	55	-	-
LED	270	9	2,430	284	0.08	23	32	75.5
LED w/dimming function **	335	9	3,015	225	0.08	18	37	81.7

* Base Case

** See Appendix D for detailed calculations

*** Estimated

In addition to the energy and demand savings reflected in Table 1, the cab fan could also be turned off to provide additional savings. Assuming the elevator cabs are occupied for approximately 60% of the time, dimming the lighting and turning the fan off for the remaining 40% of the time, when the cabs are unoccupied, will save approximately 40%. The fan consumes 40 watts. The results are shown below in Table 3.

Table 3: Energy and Demand Savings with Fan Off

Fan Status	Power/fan (W)	Annual Operating Hours	Number of Fans	Energy (kWh)	Energy Cost/kWh (\$)	Annual Energy Cost (\$)	Annual Energy Cost Savings (\$)	Energy Savings (%)
On *	40.0	8,760	1	350	0.08	28	-	-
w/Off feature **		8,760	1	210	0.08	17	11	40

* Base Case

** See Appendix D for detailed calculations

This demonstration project will assist numerous facilities managers, owners and elevator manufacturers in considering LED technology as an option for elevator cab illumination applications meeting their energy efficiency and greenhouse gas (GHG) emission reduction goals. Furthermore, it will provide insight as to the value of additional capabilities of controlling the LED based upon occupancy. Individual facility requirements as well as economic considerations may directly impact the outcome of similar demonstration projects. Based upon the findings of this project, it is recommended that future projects consider evaluating the benefits and acceptability of direct replacement LED lamps.

Introduction

With the continued advancement of LED light sources and published claims that LEDs can be dimmed and have 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, including elevator cab lighting, in which dimming may provide greater energy efficiency.

University of California San Diego (UCSD) agreed to participate in a demonstration to determine the viability of LED lighting solutions for their elevators. UCSD has 171 elevators campus-wide with various fixtures and lamp types: 60 cabs with halogen MR 16, 85 cabs with linear fluorescent and 26 cabs with CFL. The objectives of this project were to examine the energy efficiency and economics of LED lighting technology in an elevator cab general illumination application as compared to the traditional light sources of incandescent, fluorescent, and CFL. Of particular interest was to use LEDs capable of dimming to determine additional energy efficiency gains. UCSD wanted to ensure the selected LED luminaire used in the elevator cab met the requirements of occupant safety, reduced ambient temperature, equivalent light quality and dimmability. It was observed the elevator cabs were usually unoccupied during nights for approximately 9 hours a day (3,285 hours per year). The lighting could be dimmed and the fan turned off during this period to provide additional savings.

This demonstration project allowed for an ideal substitution of the traditional base case incandescent, fluorescent and CFL with the LED solution. Based upon the findings of this project, it is recommended that future projects consider evaluating the benefits and acceptability of direct replacement LED lamps.

Project Objectives

The SDG&E® ETP conducted the Bi-level LED Elevator Cab Lighting Demonstration Showcase and business incubation project with the following objectives:

- identify potential LED solutions for elevator cab lighting which are capable of dimming
- substitution of the base cases with LED lighting technologies, validating manufacturer's claims regarding energy savings
- perform a comparison of LED technology against traditional incandescent, fluorescent and CFL technologies in elevator cab illumination applications and to determine additional energy savings achieved through dimming capability of the LED
- recommend the most cost effective product features which may enhance the cost effectiveness of the LED product offering

Project Background

TECHNOLOGICAL OVERVIEW

The most common light sources utilized to illuminate elevator cabs are fluorescent and incandescent. Older generations of elevator cabs utilized incandescent lamps while the subsequent generations utilized fluorescent. The new generation of elevator cab lighting is incorporating LED technology as the ideal cab light source.

The performance of incandescent and CFL light sources is well documented with regard to lamp life and light characteristics. However, it is known that a well-designed LED indoor lamp or luminaire can provide at least comparable light characteristics as incandescent and CFL light sources in a more efficient manner for general illumination applications.

At the time of this demonstration, LED lighting in indoor elevator cab illumination applications were recognized and being used in newly manufactured elevator cabs. The ability of an LED solution to incorporate control features such as dimming was becoming achievable. SDG&E's ETP recognized the advancements of LED technology and felt that it presented some significant opportunities. They believed it would be in the best interest of their programs to provide a full-scale demonstration of LED lighting technologies in elevator cab illumination applications. Additionally, SDG&E® ETP saw this project as an opportunity for business incubation. The goal was to provide the manufacturers feedback as to which features are required to provide a cost effective solution.

The US Department of Energy (DOE) reports that LED technology continues to change at a rapid pace. While the performance of LED technology is quickly gaining efficiency, it is the high initial price and the cost of retrofitting which remains a barrier to market adoption. However, it should be noted that if a life cycle cost analysis (LCCA) (assuming all aspects of utilizing the technology being considered) of implementing LED technology is considered, LED technology becomes more competitive for indoor general illumination applications. In the future, it is expected that LED solutions will have a more favorable payback due to reduced initial costs.

MARKET OVERVIEW

The number of elevators installed in the United States, based on reasonable data collected from jurisdictional and industry associations collected by the National Elevator Industry, Inc., is approximately 900,000. The retrofit or modernization opportunities for elevators are considered to be an appropriate application for improving lighting as well as other aspects of the elevator cab.¹

¹ http://www.elevatorbooks.com/Content/Site108/ProductContent/VerticalTranspo_00000008509.pdf

According to an article published by CBS on May 12, 2011, California accounts for approximately 92,000 elevators². Assuming SDG&E[®] service territory equates to approximately 7.5% of California's total energy³, it is estimated that SDG&E[®] has an installed base of 6,900 elevators in its service territory operating 8,760 hours annually. 100% market adoption for all elevator lighting would result in an estimated reduction from 29,757 MWh to 2,756 MWh and a demand of 3.4 MW to 0.3 MW, depending upon the base case lamp. Assuming 5% market penetration each year, this would result in an electricity savings of approximately from 1,488 MWh to 138 MWh annually. In SDG&E[®] service territory, this translates to a load reduction from 169.9 kW to 15.8 kW.

Realistically, market penetration will not ramp up until the high first cost barrier of LED luminaires is overcome.

PROGRAMS

SDG&E[®] offers various programs and services for businesses to promote market adoption, help lower their energy usage and manage costs. Some of their energy-savings programs include rebates, incentives, on-bill financing, and Demand Response (DR).

Rebates are the easiest way for businesses to earn money on energy-efficient purchases. With SDG&E's Energy Efficiency Business Rebates program, businesses can earn cash rebates with the purchase of new energy-efficient equipment such as lighting, refrigeration, ventilation, food service and more. Through its Energy Efficiency Business Incentives (EEBI) and Energy Savings Bid (ESB) programs, SDG&E[®] offers cash incentives for customers who replace existing equipment or install new high efficiency equipment. On-Bill Financing offers eligible businesses zero-percent financing for qualifying energy-efficient business improvements and works in conjunction with SDG&E's incentive and rebates programs. Moreover, with the DR programs, businesses that can lower their energy use during peak demand or shift their electricity use to off-peak hours are eligible to receive bill credits, payments or other incentives.

SDG&E[®] also offers online tools to help businesses manage energy use. Some of its online tools include kWickview, Benchmarking, Energy Waves, and Energy Challenger. There are also seminars, training workshops, and on-site energy consultations available as well. For more information on SDG&E[®] energy efficiency programs, it is recommended visiting the SDG&E[®] energy efficiency website: <http://www.sdge.com/business/rebatesincentives/programs/allPrograms.shtml>.

² <http://losangeles.cbslocal.com/2011/05/12/thousands-of-elevators-found-running-with-expired-permits/>

³ Based upon statistics located at <http://www.ecdms.energy.ca.gov/elecbyplan.aspx> data found in Appendix A

Methodology

HOST SITE INFORMATION

UCSD, a well-known university located in San Diego, CA, is one of the ten campuses of the UC system and sits on 1,200 acres of land comprised of 759 buildings and a total of 171 elevators. UCSD is renowned for being a green campus and their Sustainability Team identified elevator cabs as a potential opportunity in reducing both energy consumption and GHG emissions. Thus, they became interested in assessing the viability of LED lighting in all their elevator cabs. Having noted the excellent performance of LEDs in their new elevator cabs, UCSD desired to determine the feasibility and cost effectiveness of retrofitting their existing elevator cabs throughout the campus completely with LEDs. In addition, the Facilities Team wished to determine the feasibility and cost effectiveness of control options such as dimming based upon occupancy.

The lighting for elevator cab general illumination was provided by incandescent, fluorescent, and CFL. There is no consistency of quantity, placement or spacing of the fixtures in the elevator cab throughout the campus. The wide variety of lighting technology, quantity and spacing is a result of additions of buildings over time and the lack of elevator cab lighting standard. The elevator cab lighting operates 8,760 hours (24 hours/day 365 days/year) annually. UCSD stated their blended electric cost is \$0.08 per kWh.

MEASUREMENT PLAN

SDG&E® retained Emerging Technologies Associates, Inc. to manage the Elevator Cab Lighting Demonstration Showcase project, coordinate the participants and stakeholders, and conduct the data collection and analysis for the project. In collaboration with UCSD Facilities Management, SDG&E® selected and arranged for the installation of LED lighting in an elevator cab as replacement for the incandescent, fluorescent, and CFL. The base case incandescent and fluorescent lamps in the elevator cabs were substituted with 3.6 watt LEDs.

Pre and post installation field visits were conducted. Instantaneous electrical power data for the incandescent base case and the LED solution was collected utilizing a Hobo CT and U12-0006 data logger. Stated wattages were used to determine demand savings for the fluorescent and CFL base cases. After meetings with UCSD were conducted to determine acceptability of the temperature and light levels, spot foot candle readings were taken to confirm that lighting levels met the required minimum as set forth in state code. Occupancy sensors were then installed to determine the savings from dimming the LED lamps and turning the fan off.

The acceptability of the technology was determined by the customer's acceptance of the light levels, power usage and economic factors. The LED illumination met both the visual and temperature comfort

resulting in the UCSD elevator mechanic expressing an overwhelming endorsement and acceptance of LED technology as a desirable lighting solution.

EQUIPMENT

The following equipment was used to collect the power characteristic data. The current transformer was connected above the elevator cab on the lighting and fan circuits. The meter was calibrated as per manufacturer specifications.

Power reading:



HOBO U12 DATA LOGGER

ACCURACY: $\pm 2 \text{ mV} \pm 2.5\%$ of absolute reading;
 $\pm 2 \text{ mV} \pm 1\%$ of reading for logger-powered sensors



HOBO CURRENT TRANSFORMER

ACCURACY: $\pm 1\%$

Project Results

ELECTRICAL ENERGY AND DEMAND SAVINGS

The base case elevator lighting consists of incandescent halogen MR 16 lamps, linear fluorescent tubes and CFL downlights. The measured demand for the base case incandescent is 58.3 watts and the stated demand for the fluorescent and CFL is 32 watts and 13 watts respectively. The retrofit LED kit measured demand is 3.6 watts, resulting in a reduction in energy of 94%, 75%, and 58% respectively. It was observed the elevator cabs were usually unoccupied during nights for approximately 9 hours a day (3,285 hours per year). The lighting could be dimmed during this period to provide additional savings. The results are shown in Table 4.

Table 4: Energy and Demand Savings

Lamp	Power/lamp (W)	Annual Operating Hours	Number of Lamps	Energy (kWh)	Demand (kW)	Energy Savings (%)
Incandescent *	58.3	8,760	9	4,596	0.52	-
LED	3.6	8,760	9	284	0.03	94
LED w/dimming function **		8,760	9	225	0.03	95
Fluorescent *	32.0 ***	8,760	4	1,121	0.13	-
LED	3.6	8,760	9	284	0.03	75
LED w/dimming function **		8,760	9	225	0.03	80
CFL *	13.0 ***	8,760	6	683	0.08	-
LED	3.6	8,760	9	284	0.03	58
LED w/dimming function **		8,760	9	225	0.03	67

* Base Case

** See Appendix D for detailed calculations

*** Stated Wattage

To provide deeper savings, the cab fan could also be turned off to provide additional savings. Assuming the elevator cabs are occupied for approximately 60% of the time, dimming the lighting and turning the fan off for the remaining 40% of the time, when the cabs are unoccupied, will save approximately 40%. The fan consumes 40 watts. The results are shown below in Table 5.

Table 5: Energy and Demand Savings with Fan Off

Fan Status	Power/fan (W)	Annual Operating Hours	Number of Fans	Energy (kWh)	Energy Cost/kWh (\$)	Annual Energy Cost (\$)	Annual Energy Cost Savings (%)	Energy Savings (%)
On *	40.0	8,760	1	350	0.08	28	-	-
w/Off feature **		8,760	1	210	0.08	17	11	40

* Base Case

** See Appendix D for detailed calculations

ECONOMIC PERFORMANCE

It is important to note that the cost and fixture assumptions made in this section apply only to UCSD. UCSD was demonstrating the substitution of incandescent lamps. 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 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 UCSD's blended rate of \$0.08 per kWh. UCSD elevator lighting operates 8,760 hours annually. Table 6 provides the energy cost and savings estimates assuming all elevator cab lighting was converted from the base case incandescent, fluorescent and CFL to LED lamps/luminaires.

Table 6: Energy Cost Savings Achieved

Lamp	Number of Lamps	Energy (kWh)	Energy Cost/kWh (\$)	Annual Energy Cost (\$)	Annual Energy Cost Savings (\$)	Energy Savings (%)
Incandescent *	9	4,596	0.08	368	-	-
LED	9	284	0.08	23	345	94
LED w/dimming function **	9	225	0.08	18	350	95
Fluorescent *	4	1,121 ***	0.08	90	-	-
LED	9	284	0.08	23	67	75
LED w/dimming function **	9	225	0.08	18	72	80
CFL *	6	683 ***	0.08	55	-	-
LED	9	284	0.08	23	32	58
LED w/dimming function **	9	225	0.08	18	37	67

* Base Case

** See Appendix D for detailed calculations

*** Estimated

The simple payback calculations for retrofit scenarios considered the total investment cost and energy savings for the LED solution. The results are shown in Table 7.

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)
Incandescent *	6	9	54	4,596	0.08	368	-	-
LED	270	9	2,430	284	0.08	23	345	6.9
LED w/dimming function **	335	9	3,015	225	0.08	18	350	8.5
Fluorescent *	5	4	20	1,121 ***	0.08	90	-	-
LED	270	9	2,430	284	0.08	23	67	36.0
LED w/dimming function **	335	9	3,015	225	0.08	18	72	41.8
CFL *	3	6	18	683 ***	0.08	55	-	-
LED	270	9	2,430	284	0.08	23	32	75.5
LED w/dimming function **	335	9	3,015	225	0.08	18	37	81.7

* Base Case

** See Appendix D for detailed calculations

*** Estimated

2. Luminaires and Lamp Life

This report uses the following lamp life in hours: LED direct replacement lamp – 50,000, recessed downlight LED retrofit kit – 50,000, and LED linear lamp – 50,000. The report uses 50,000 hours as the LED life expectancy, per the DOE website.⁴ 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 is evolving 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 that has not undergone proper testing.

⁴ http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/lifetime_white_leds.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. The pricing of the products may be reduced as a result of the rapid advancements in LED technology. Recently, prices have increased for precious minerals used in the manufacture of lighting technologies. Readers are encouraged to obtain current price quotes for fluorescent, 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.

4. Program Potential

With approximately 900,000 elevators in the US and 92,000 in CA, it would be beneficial for SDG&E® and other utilities to offer a rebate or incentive program for elevator LED lighting. In the SDG&E® service territory, a 100% market adoption and an assumed 8,760 annual operating hours for all elevator lighting would result in an electricity savings of from 29,757 MWh to 2,756 MWh annually.

Conclusion

This demonstration project validated that properly designed LED luminaires can provide energy savings from 58% to 94% depending upon the lamp being replaced without significantly compromising the lighting performance required for elevator cab general illumination applications. The results showed the efficiency savings achieved by the dimming of already highly efficient LEDs to be 59 kWh or 21%. The additional cost savings realized was insignificant, approximately \$5, and does not justify the dimming feature. Turning the fan off during periods of no occupancy provided \$11 savings.

While the results of this demonstration indicate significant energy savings potential when LED lighting is used instead of incandescent, fluorescent, or CFL lighting, readers are encouraged to complete a full life cycle cost analysis to gain the complete economic picture of a technological change out.

For the elevator cab general illumination applications, LED solutions proved to be viable options. In this project due to the total elevator cab ceiling replacement, the paybacks were too long to make this a practical solution. In addition, these LED solutions are applicable to many other indoor 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. Although more favorable simple payback periods were achieved for the incandescent, the payback periods are sensitive to annual operating hours, product costs, and the installation specific maintenance, and electrical costs.

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 ENERGY STAR website: www.energystar.gov and the Lighting Facts website: www.lightingfacts.com.

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	2009	2,293
Dept. of Water Resources	2009	5,748
Imperial Irrigation District	2009	3,319
Los Angeles Department of Water	2009	25,087
Other	2009	1,744
Pacific Gas and Electric	2009	108,504
Sacramento Municipal Utility District	2009	10,616
San Diego Gas & Electric	2009	20,928
Southern California Edison	2009	100,579
TOTAL		278,819

*Total Usage express in Millions of kWh

SDG&E®

7.5 %

Appendix B

OVERVIEW OF THE INDUSTRY

by Robert S. Caporale, MSc

People in the vertical transportation industry, as well as those who are simply intrigued about elevators and escalators, have an abundant curiosity about how many there are in operation and where they are located. What is the elevator industry? How large is it? What components and other elements comprise the industry? Who are the participants? How many elevators and escalators exist in the U.S.? Worldwide? How many people does the industry employ? Additionally, elevator industry members and those who may be thinking of entering the elevator industry need to know what type of market to prepare for and how best to serve that market. This report strives to provide some of the answers to the most frequently asked questions regarding the size and state of the elevator industry in most parts of the world.

Imagine taking a census of the units installed and in place. How would that be done? Could we enlist every mechanic and sales representative, as well as any other possible participant, to count and record all the elevators in every building throughout the country? Even once the exact count had been determined, individuals would still have to coordinate and ensure that some units weren't counted twice or being demolished while others were sold and installed. Not only would we be trying to hit a moving target, but successfully doing so would be a nearly impossible task. Now, imagine repeating the process for another key segment of this industry – escalators.

The best alternative is to poll the various jurisdictional and industry associations and ask them to provide an estimate based on their known records, a knowledge of units that have been installed, based on reasonable recorded data. That was the method used to obtain the data estimates indicating that more than 900,000 elevators and 50,000 escalators operate in the U.S. An estimated 10% of that number operates in Canada. This is believed to be a reasonable number representative of the changing nature of the new installation market as estimated by the National Elevator Industry, Inc. (NEII [www.NEII.org]).

We wish we could know how many elevators have been modernized and how many are ripe for modernization. A little research has revealed many 20-to 30-yearold (or older) units are still in operation, and these are prime targets for upgrades -such as new controllers, improved leveling, replacement of door operators and fixtures – as well as the usual repairs. Knowing the total number of units is important for other aspects of our industry. From a total marketing aspect, the amount gives the dimension of the marketplace. From an elevator-safety aspect, it can be used as the basis for the number of accidents related to the total elevator ridership.

Estimating the number of elevators in a particular area can also be a frustrating task. New York City boasts some 75,000 to 80,000 units, though this is likewise an estimate, as precise records are not readily available. Some states have kept reasonable records, whereas others have not. Local elevator companies likely have a good idea of how many units are in their area. (At least, they should, since that is a major statistic for them to have in developing business plans.) Stated otherwise, we would be amazed if any company could claim 100% coverage in its area, and we would be delighted to feature them in ELEVATOR WORLD as “phenomenal.”

States or cities with good records, good estimates of the number of units in a city or an appraisal of the current, local “state of the art” are appreciated. From these raw data, intelligence is created, and future reports on the number of units, market potential, dimension of the industry plus many other significant factors can be developed. Also of benefit are records of transit agencies. Other Reporting Agencies

Annual reports issued by the major elevator companies can provide some insight as to U.S. business volume, and other newspaper and magazine articles have attempted to analyze the market. With many of the major companies being multinational firms, extracting the domestic sales volume from their reports often proves impossible. Even the U.S. Department of Commerce cannot define the elevator market, since elevators and escalators are lumped with building equipment, electrical equipment or other categories depending upon the source. The National Association of Elevator Contractors (NAEC) does not gather statistical reports from its membership. EW strives to gather statistics from its correspondents and industry contacts in an effort to determine the world market. The information is recorded in a database that, while not complete, is presented as a view of the world market.

Market Dimensions

Company annual business reports represent the elevator reporting activity of a previous year. Elevator companies are identified by the government-established Standard Industry Classifications (SIC), however, even this classification is deceptive. Many companies making lifting devices, such as “cherry pickers,” elevating platforms and automobile lifts for garages, will report using that classification. Any report must be analyzed to extract the “elevator market” as we know it. Nevertheless, while it has proven to be valuable, these reports do have some notable absences.

There may be other companies unknown to EW. Absent from our statistics are hundreds of medium-sized and small companies offering complete systems or specializing in installations such as handicap lifts, mine elevators, specialized industrial lifts, inclines, shipboard elevators and others. Included are companies that primarily supply products included in a completely new or modernized installation. A review of the Elevator World Source© indicates that these represent only a fraction of the dozens of suppliers, the equipment of which would be included in another company’s sales. The list would also include multinational companies with sales in the millions and billions of U.S. dollars.

Prospects for new construction have dimmed a bit in recent years. Hence, the real-estate market increased pressure on existing properties to modernize. This is the business that continues to hold a bright prospect for expanded activity.

Investors and customers dealing with the industry are concerned with the dimensions, stability, resources and integrity of the industry. As with any field, the elevator industry is constantly changing relative to its participants, the economy, the marketplace – any facet that can affect the current picture or influence the future.

The past few years have seen many changes in the vertical-transportation industry. When I first entered the industry in 1964, it was dominated by U.S. companies. Today, of the major multinational elevator companies that do business throughout most of the world, only Otis Elevator Co. is based in the U.S. Although all of the multinational companies have national and regional operations on all continents, the locations of each of their headquarters are as follows:

- Otis – U.S.
- Schindler – Switzerland
- KONE – Finland/Brussels
- ThyssenKrupp – Germany
- Fujitec Elevator Co., Mitsubishi Elevator Co., Toshiba and Hitachi – Japan
- Hyundai – Korea

Throughout the world, numerous independent elevator companies install and service elevators and escalators, and while the independent segment of the industry remains quite large, the trend of major companies buying out smaller independent companies continues.

Introduced in 1996 by KONE, the rage of machineroom-less (MRL) elevators has grown throughout the world, with all of the major companies now providing this equipment. The past decade has seen a number of changes to the elevator market -both in the U.S. and internationally, as well as to the codes and standards that regulate this market.

This report also contains other sections that indicate the organizations that support and regulate the vertical transportation industry. Installation and modernization contractors provide the “hardware” and, along with subcontractors, provide the “software,” to make up a complete elevator or elevator operating system, with each depending upon the other. Both public and occupational safety are major concerns, and since elevators and escalators are one of the major transportation means throughout the world, an extensive discussion of their safety is presented.

While much of this report focuses on the U.S. elevator industry, a nation-by-nation equipment and industry census is also presented. Although far from complete, this global study offers some insight into the international vertical transportation industry marketplace. This report is a compilation of the work of numerous individuals, trade associations and companies. The EW staff has spent countless hours in libraries and on the telephone creating, compiling, e-mailing and faxing survey forms to accumulate the data presented. We are extremely grateful for the assistance provided by the individuals and companies that responded to our surveys and were willing to share statistical information with the entire “elevator world.”

We trust readers will find this information useful. EW looks forward to receiving comments, so we may continue refining the processes by which we accumulate data.

Appendix C

This information is provided free of charge by the Department of Industrial Relations from its web site at www.dir.ca.gov. These regulations are for the convenience of the user and no representation or warranty is made that the information is current or accurate. See full disclaimer at http://www.dir.ca.gov/od_pub/disclaimer.html.

Subchapter 6. Elevator Safety Orders

Article 8. Machinery and Equipment for Power Cable-Driven Passenger and Freight Elevators

§3034. Cab Enclosures and Cab Doors and Gates.

(g) Illumination of Cabs.

(1) Cabs shall be provided with an electric light or lights. Not less than two lamps shall be provided.

(2) The minimum illumination measured at the landing edge of the cab platform when the cab and landing doors are open shall be not less than:

(A) For passenger elevators--5 foot-candles.

(B) For freight elevators--2 1/2 foot-candles.

(3) Passenger elevator cabs shall be provided with emergency lighting in accordance with Article E700, Part 3, Title 24, CAC, and conforming to the following:

(A) The emergency system shall provide some general illumination for the cab. The intensity of illumination 4 feet above the cab floor and approximately 1 foot in front of a cab station shall be no less than .2 of a foot-candle. Lights shall be automatically turned on in all elevators in service not more than 10 seconds after normal lighting power fails. The emergency power supply system shall be capable of maintaining the above light intensity for a period of not less than 4 hours.

(B) Not less than two lamps of approximately equal wattage shall be provided to obtain the required illumination.

(4) Light control switches are required and shall:

(A) Be located within the elevator enclosure.

(B) Be located in or adjacent to the operating device in the cab or in the space above the light diffusing ceiling where such ceilings are provided.

(C) In passenger elevators having automatic operation, be key operated or in a fixture with a locked cover if located below the light diffusing ceiling.

(5) The panels used for light diffusing shall not come in contact with the lamps or lampholders and shall be of a material that will not support combustion in air.

(6) Light bulbs or tubes in passenger elevators shall be installed behind a protecting cover.

EXCEPTION: Light bulbs mounted in a recess approximately the diameter of the bulb and recessed behind the parent surface a distance not less than the diameter of the bulb.

(7) Lamps in freight elevators shall be installed behind a protective guard to prevent breakage.

Appendix D

Energy and demand savings were realized by dimming the LEDs in the elevator cabs when the cabs were unoccupied, approximately 9 hours a day (3,285 hours per year). The additional cost savings achieved by dimming the LEDs proved to be only \$5. The results are shown below in Table 8.

Table 8: Energy Cost Savings with Dimming

Lamp	Power/lamp (W)	Annual Operating Hours	Number of Lamps	Energy (kWh)	Energy Cost/kWh (\$)	Annual Energy Cost (\$)	Additional Cost Savings with Dimming (\$)
LED *	3.6	8,760	9	284	0.08	23	-
LED	3.6	5,475	9	177	0.08	14	-
LED (dimmed)	1.6	3,285	9	47	0.08	4	-
LED w/dimming function		8,760	9	225	0.08	18	5

* Without dimming

Additional energy and demand savings may be realized by turning off the fan in the elevator cabs. The fan consumes 40 watts. Assuming the elevator cabs are occupied for approximately 60% of the time, dimming the lights and turning the fans off for 40% of the time, when the cabs are unoccupied, will save approximately 40% or \$11. The results are shown below in Table 9.

Table 9: Energy Cost Savings with Fan Off

Fan Status	Power/fan (W)	Operating Hours	Number of Fans	Energy (kWh)	Energy Cost/kWh (\$)	Annual Energy Cost (\$)	Additional Cost Savings w/Fan Off (\$)
On *	40.0	8,760	1	350	0.08	28	-
On	40.0	5,256	1	210	0.08	17	-
Off	0.0	3,504	1	0	0.08	0	
w/Off feature		8,760	1	210	0.08	17	11

* Base Case