Better Buildings®
U.S. DEPARTMENT OF ENERGY

Looking Inside for Better Lighting Solutions

Tuesday, May 10 2016
2:00 - 3:15

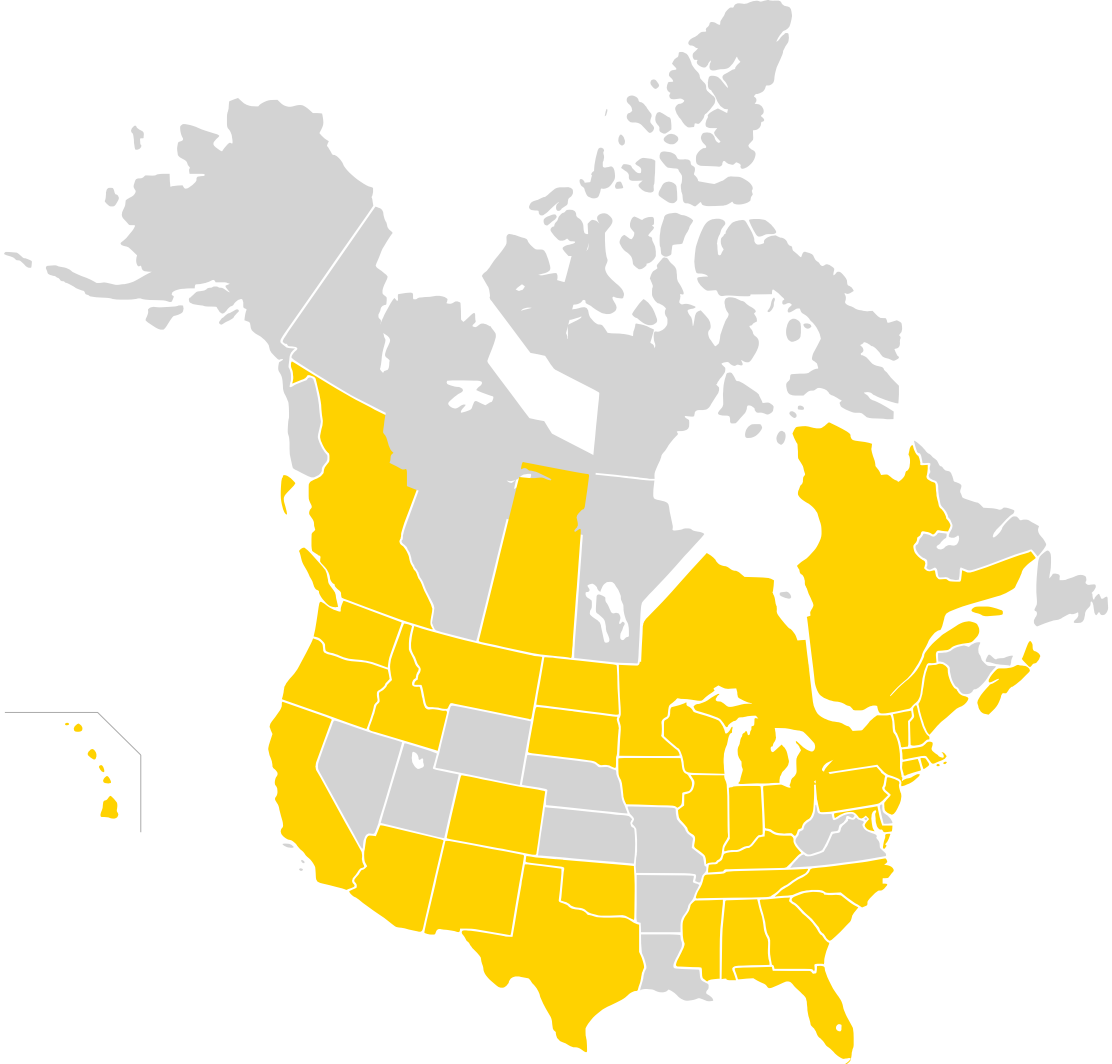
U.S. DEPARTMENT OF ENERGY

Today's Presenters

- Pranav Jampani: Las Vegas Sands Corp.
- Gabe Arnold: Design Lights Consortium
- Linda Sandahl (moderator): Pacific Northwest National Lab

DESIGNLIGHTS CONSORTIUM®

Tell us about your organization and what you are working on



DesignLights Consortium drives efficient lighting
by defining quality,
facilitating thought leadership, and
delivering tools and resources to the lighting market through
open dialogue and collaboration


ALLIANT ENERGY
efficiency NOVA SCOTIA
Hawaii Energy YOUR CONSERVATION & EFFICIENCY PROGRAM
OUC The Reliable One
DESIGNLIGHTS CONSORTIUM Member Utilities
Ameren ILLINOIS
efficiency MAINE
HOOSIER ENERGY A Touchstone Energy® Cooperative
Natural Resources Canada
SMECO Southern Maryland Electric Cooperative
BC hydro REGENERATION
EFFICIENCY$MART
Hydro Québec
BGE
Efficiency Vermont
IDAHO POWER An IDACORP Company
PG&E
PNM
SMUD
BONNEVILLE POWER ADMINISTRATION
The Electric Company El Paso Electric
ieso Independent Electricity System Operator
PECO An Exelon Company
SOUTHERN CALIFORNIA EDISON An EDISON INTERNATIONAL Company
Liberty Utilities
BURLINGTON Electric DEPARTMENT
EnergyTrust of Oregon™
SNOHOMISH COUNTY PUD PUBLIC UTILITY DISTRICT NO. 1
SOUTHERN MINNESOTA MUNICIPAL POWER AGENCY Bringing power to your life.
LIPA Long Island Power Authority
EUMMOT ELECTRIC UTILITY MARKETING MANAGERS OF TEXAS
AEP PUBLIC SERVICE COMPANY OF OKLAHOMA A unit of American Electric Power
SRP Delivering more than power.™
MEEA Midwest Energy Efficiency Alliance
Cape Light Compact
EVERSOURCE
MidAmerican ENERGY OBSESSIVELY, RELENTLESSLY AT YOUR SERVICE.
TACOMA POWER TACOMA PUBLIC UTILITIES
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focus on energy Partnering with Wisconsin utilities
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Seattle City Light
Xcel Energy

Commercial Advanced Lighting Control Project

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Demonstration Projects in Partnership with US DOE

Performance Spec and Qualified Products List

Training Programs for Designers and Installers

Advanced Control Savings Calculator

PG&E®

Support for Industry Standards

New Nationally Adopted EE Program Offerings

Commercial Advanced Lighting Controls Project

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Goal

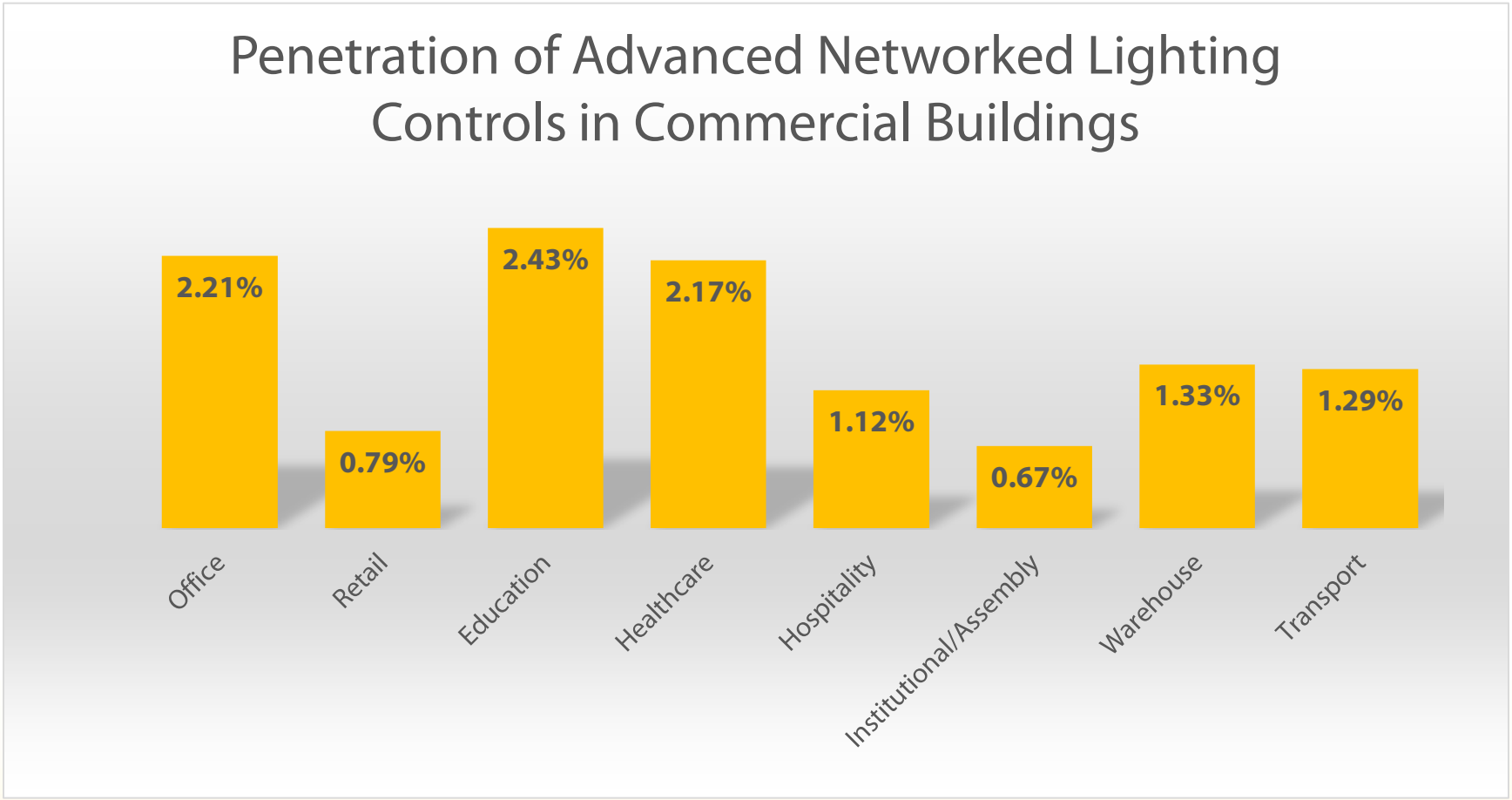
Support utilities, industry, designers, and other stakeholders with full scale deployment of Advanced Lighting Control Technologies

Objectives

Create tools and resources to:

- **Reduce or eliminate market barriers that prevent large-scale adoption**
- **Enable energy efficiency programs to scale up with the technology**
- **Support industry, designers, and other market actors in scaling up with the programs**

Advanced Lighting Controls – A Missed Opportunity



Source: DLC, Navigant Consulting 2014

Adoption Barriers

- Knowledge and Experience
- Complexity
- Lack of Standardization
- High Costs
- Weak Value Proposition

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Can you tell us more about this specification and qualified products list and how that will be useful to building owners?

Networked Lighting Control Specification and Qualified Product List

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DLC Qualified Systems:

- Have been independently reviewed to meet a minimum level of performance
- Are pre-qualified for utility rebates
- Are required to meet applicable industry standards

Structure of Specification and Qualified Product List

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…coming Q4 2016

'Required' System Capabilities

- *Networking*
- *Occupancy Sensing*
- *Daylight Harvesting*
- *High-End Trim*
- *Zoning*
- *Luminaire and Device Addressability*
- *Continuous Dimming*

Understand, Identify, Compare Control Systems

What capabilities?

How?

Wired? Wireless?

'Optional' System Capabilities

- *Type of User Interface*
- *Luminaire Level Control*
- *Integrated Luminaire Level Control*
- *Localized Processing / Distributed Intelligence*
- *Scheduling*
- *Personal Control*
- *Load Shedding (DR)*
- *Plug Load Control*
- *BMS/EMS/HVAC Integration*
- *Energy Monitoring*
- *Device Monitoring / Remote Diagnostics*

BMS/EMS Compatible?

Open Standard? Proprietary?

Stand-Alone, Local Server, or Cloud?

Case Studies?

Energy Monitoring?

IT Server Required?

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What about the demonstration projects? Can you tell us more about those?

Demonstration Projects

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- Enlighted
- Daintree ControlScope
- Philips Connected PoE
- Digital Lumens
- Cree SmartCast
- Philips SpaceWise
- Lutron Energi Tri-pak
- OSRAM Encelium
- Eaton DLVP

- Selected Technologies by RFQ
- Scoring Criteria heavily weighted to products that used innovative approaches to overcome technology adoption barriers

Features that were scored highly

- “Embedded” or “Integrated” Sensors
- Wireless
- Open-standards based or as interoperable as possible
- Distributed Intelligence
- Embedded energy meter
- Auto-Commissioning
- Well-executed programing interface or GUI

First Five Projects

Two Roads Brewing Company – Stratford, CT

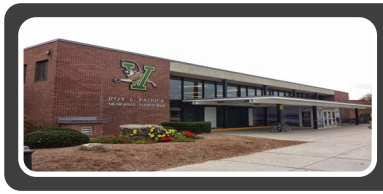
- Install Complete
- Status: Analyzing Metering Results

Rhode Island Public Utilities – Warwick, RI

- Install Complete
- Status: Post-Metering

Multi-Tenant Medical Office Building – Avon, CT

- Install Complete
- Status: Post Metering



University of Vermont PFG Sports Complex – Burlington, VT

- Status: Finalizing Scope/Budget
- Install over Summer

Super Stop & Shop – New Bedford, MA

- Status: Scope Budget Complete, Developing M&V Plan
- Install begins July 8

Early Metering Results

- To Be Updated week before event

Demonstration Projects – Next Five

- Philips Connected POE
- Lutron Energi Tri-pak
- OSRAM Encelium
- DLVP
- TBD

- Site Recruitment Underway

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As building owners are considering troffer and interior lighting improvements, what advice do you have for them regarding controls? What options should they consider?

Recommendations

- New fixtures or retrofit kits over LED tubes
- Integrated/Embedded Controls
  - But make sure it is networked so you can create zones
- Wireless for retrofits
- The right system for the right customer and application
  - Sophisticated systems for sophisticated applications and customers
    - Attributes of a sophisticated system
  - Simpler systems for simpler customers
    - Attributes of a simpler system

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Interior LED Lighting Projects

Pranav Jampani
Las Vegas Sands Corp.

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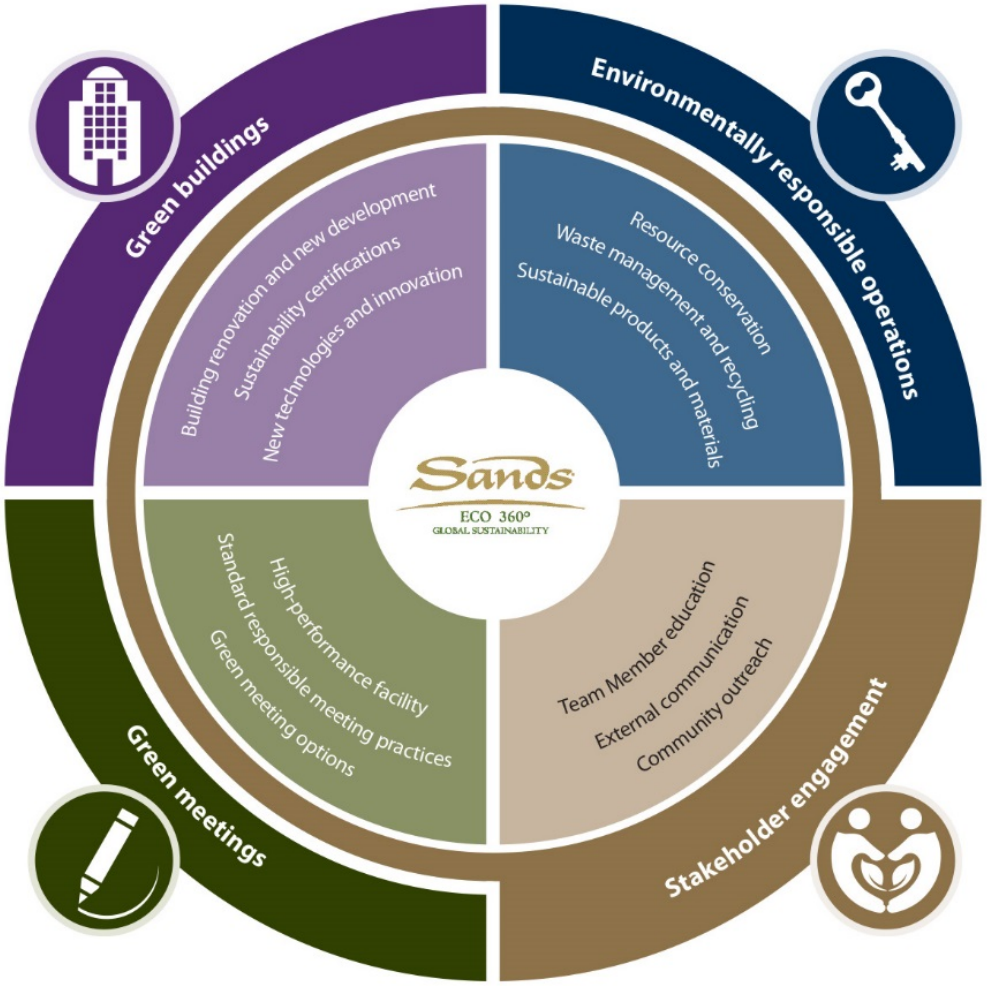
Las Vegas Sands Corporation

Total Number of Employees:	over 51,000
Total Hotel Rooms:	19,300 rooms
Total Integrated Resort Space: (includes Gaming, Convention, Retail, Hotel, Theaters etc.)	43 million sq. ft.
Number of Restaurants:	324
Number of Theater/Arena Seats:	56,500

Sands ECO360 Global Sustainability Strategy



Award-winning Program

MEMBER OF Dow Jones Sustainability Indices
In Collaboration with RobecoSAM

bsi. ISO 20121 Sustainable Events Management

U.S. GREEN BUILDING COUNCIL LEED GOLD USGBC

BCA GREEN MARK

EARTHCHECK

CDP DRIVING SUSTAINABLE ECONOMIES

greenleaders tripadvisor

GREEN KEY Eco-Rating Program

What has been your company's experience with adopting LED lighting?

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Our LED Lighting Journey

2011
- When LED was still a new concept in the market, we set up our own lighting lab and started evaluating the technology.

2012
- After testing thousands of LED light bulbs, we became a topic expert and standardized global implementation based on our own life-cycle cost analysis tool.

2013
- We partnered with several manufacturers to design and develop new LED lamps specific to our buildings and space types.

2015
- St. Regis and Parisian properties in Macao were designed to be our first 100% LED properties.
- We have replaced more than 520,000 inefficient light bulbs with LEDs globally since 2011, achieving more than 82 million kWh of energy savings (**equivalent of 7,500 U.S. annual household usage**)

2016+
- We are researching and evaluating LED lighting for high-bay and outdoors spaces where previously available technology did not fully meet our requirements.

How did you evaluate options and select projects to pursue?

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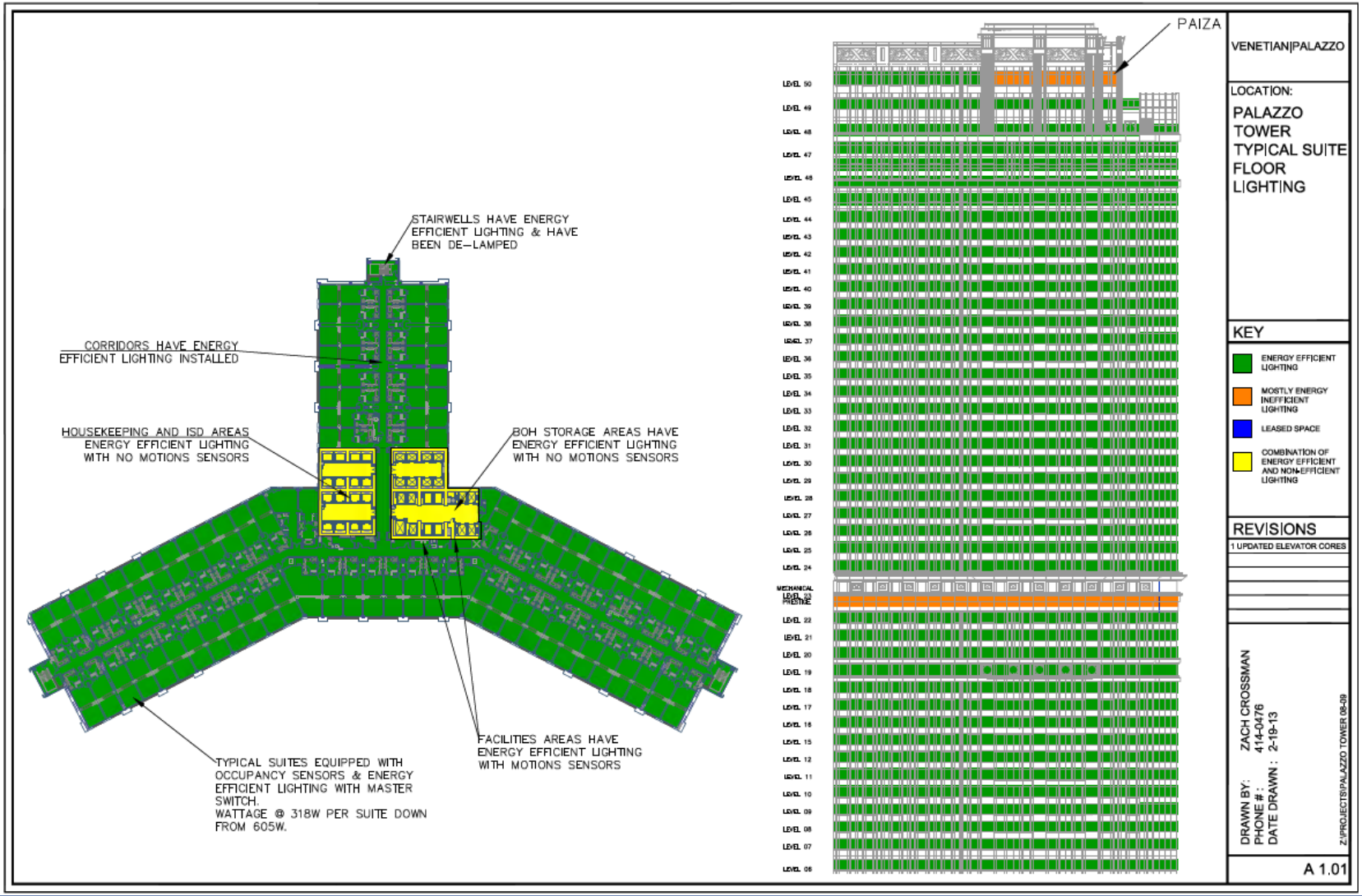
Lighting Property Database

Sample Property Lighting Database

Area	Sub-Area	Light Fixture	Lamp Type	Manufacturer	Bulb Number	Quantity	kWh	CCT	CRI	Lumens	Efficacy	Rated Life	HOU	Life Span in years	Cost	Lighting Control Type	Air Conditioned
BOH	Offices	Ceiling (such as T8s)	T8	GE	F32T8/SPP 35/ECO	3	32	3500	80	2900	91	17000	9	5.2	$ 4	Switch	Yes
BOH	Offices	Downlights	MR16 Halogen	GE	Q50MR16/ C/CG55	8	50	3050	80	775	16	6000	24	0.7	$ 16	Switch	Yes
Hotel	Lobby	Dowlights (such as cans)	T4 CFL	GE	F26TBX/83 5/A/ECO	34	26	3500	82	1800	69	17000	24	1.9	$ 23	Switch	Yes
Hotel	Lobby	Wall washers	MR16 LED	Philips	5MR16/EN D/F24 3000	14	5.5	3000	82	300	55	25000	24	2.9	$ 18	Switch	Yes
Hotel	Hotel Hallways	Dowlights (such as cans)	A19 LED	Sylvania	LEDA19/F/ 827/G2	300	10	2700	80	850	85	25000	24	2.9	$ 5	Switch	Yes
Hotel	Elevator	Dowlights (such as cans)	R12 LED	TCP	LE2WGBF	9	2.2	3000	80	110	50	25000	24	2.9	$ 11	Breaker	Yes
Casino	Mass gaming	Cove lighting	T5	GE	F35W/T5/8 41/ECO	238	35	4100	85	3650	104	36000	24	4.1	$ 20	Breaker	Yes
Casino	Mass gaming	Dowlights (such as cans)	PAR 20 HID	GE	CMH39UPA R20FL25	1920	39	4200	90	1950	50	10000	24	1.1	$ 46	Breaker	Yes
Food Court	Seating	Dowlights (such as cans)	T4 HID	GE	CMH20T/U 830GU6.5	40	20	3000	81	1615	81	12000	24	1.4	$ 49	Breaker	Yes
Meeting Rooms	Lehigh Room	Dowlights (such as cans)	T4 CFL	GE	F26TBX/83 5/A/ECO	24	26	3500	82	1800	69	17000	24	1.9	$ 23	Switch	Yes
Exterior Lighting	Garage	Downlights (exterior)	ED18 HPS	GE	LU400/H/E CO	75	400	2100	22	51000	128	24000	24	2.7	$ 27	Breaker	No
Retail	Common Areas	Downlight	T4 HID	GE	CMH39/T/ U/930/GU6 .5	158	39	3000	88	3400	87	10000	24	1.1	$131	Switch	Yes
Restaurants	Chop House	Uplights	MR16 HID	GE	CMH39MR 16/930/FL	21	39	3000	90	2200	56	10000	12	2.3	$ 93	Switch	Yes

Lighting Building Maps



LED Lighting Evaluation Criteria

Seven step review process to evaluate each LED product:

1. Research and select LED technologies for evaluation.
2. Review manufacturers products for photometric performance, chromaticity, and lumen maintenance (watts, lumens, efficacy, CCT, CRI).
3. Test product in lighting lab for performance and compatibility with the dimming system.
4. Product mockups to evaluate each product for performance, maintenance, durability and ease of installation.
5. Lighting design and on-site lighting measurements.
6. Select top 3 samples and conduct ROI analysis.
7. Management walk through for feedback on product mockups and review and approval of funding for the project.

Please describe the projects, expected versus observed performance, and key challenges and lessons learned

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LED Lighting Showcase Projects
The Venetian, The Palazzo, and Sands Expo

T8 LED Lighting Project for Back of House and Parking Garage Areas

Project Description:

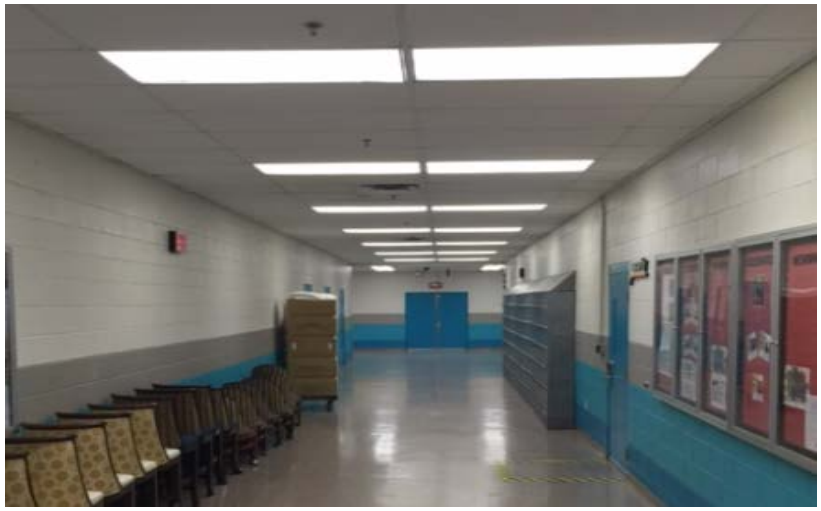
- Installation of 38,000 high-performance and high-efficiency T8 LED lamps for the parking garages, stairwells and back of the house areas.
- Total Area: over 3 million sq. ft.

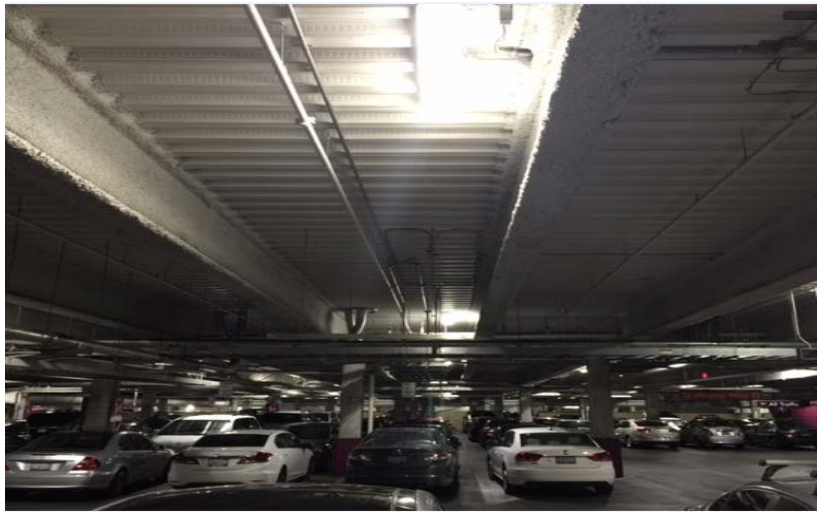
Project Details:

- Project cost: $1.45 million
- Op Ex savings: $0.35 million
- Payback: 4.1 years (3.7 years with utility rebate included)

Project Results:

- Electricity reduction: 4.3 million kWh/year
- Utility Rebate: $156K





T8 LED Lighting Project for Back of House Areas & Parking Garages

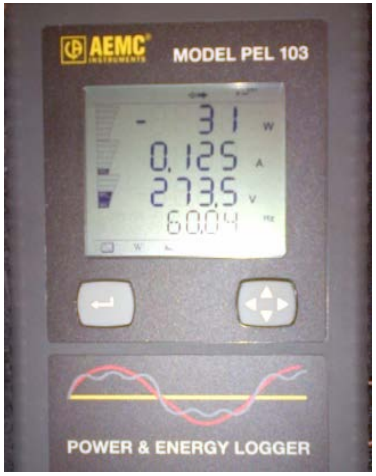
	OLD LIGHTING	NEW LED LIGHTING
Light Source	Standard T8 fluorescent lamp	T8 LED lamp
Quantity	38,000 lamps	38,000 lamps
Wattage	32 watts (28.5 watts actual draw)	16 watts (15.5 watts actual draw)
Efficacy	89 lumens/watt	110 lumens/watt
CCT	3000K	4000K
Lamp Life	20,000 hours	50,000 hours
Warranty	2 years	5 years
Controls	No	No
Annual Operating Hours	8,760	8,760

T8 LED Lighting Project for Back of House and Parking Garage Areas

Lamps Testing:

- From distribution panels
- From AEMC power & energy logger

					Before retrofit			After retrofit			Savings Watts/Lamp
Location	Panel	circuit#	quantity of lamps	print#	volts	amps	watts	volts	amps	watts	
BOH Hallway	LBHBK01	1	24	E4.05J/K	278.1	3.3	917.73	278.8	2.21	616.14	12.6
	LBHBK01	3	8	E4.05J/K	275.2	3.524	969.81	276.3	3.37	931.13	4.8
Security Hall	XAEHBF01	9	30	E4.05F/K	277	4.89	1354.53	276.8	3.8	1051.3	10.1
	NEHBF01	24	30	E4.05F/K	276.2	3.99	1102.03	279.6	2.71	757.71	11.5
Sustainability Office	NEHBF01	26	16	E4.05E	277.3	3.69	1023.23	277.9	2.88	800.35	13.9
Stairwells	XAFHBFN02	1	30	E4.05E	277.1	6.273	1738.46	277.2	4.802	1331.11	13.6
P4 Garage	JEHP1G01	2			277	2.825	782.53	277.4	2	554.8	
	JEHP1G01	4			279.3	2.752	768.64	279.7	1.968	550.45	
Total/Average			232				15,048			12,016	13.1
Bench Testing of Single 2 Lamp Fixture at 277V with precision meter:											
Fixture			2				57.0			31.0	13.0



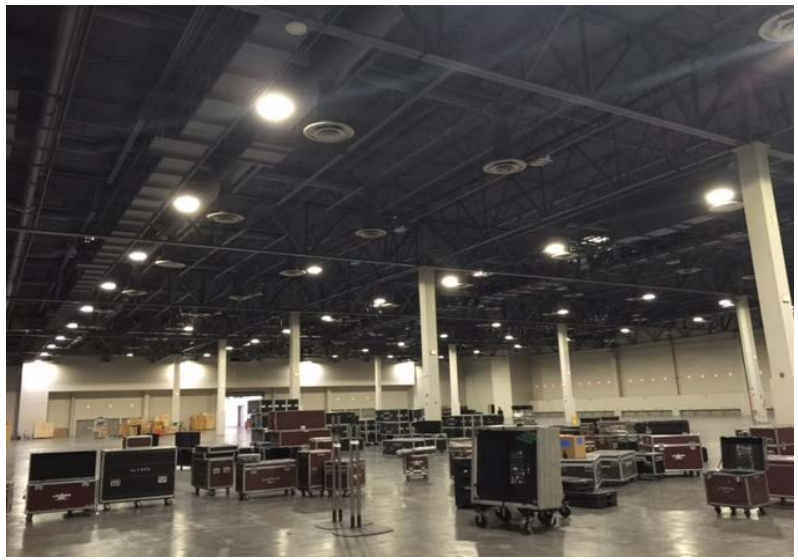
Best Practices & Lessons Learned:

- Replacement of entire fixture did not appear cost competitive due to the cost of the equipment and labor.
- Evaluated various products and conducted long-term tests to ensure manufacturer specifications are not exaggerated.
- Challenging to keep track of areas completed and missed due to the property size.
- Did not anticipate lamp failures due to extreme heat in non-conditioned spaces and vehicle vibration in multi-level parking garages resulting in increased maintenance costs.

High-Bay LED Lighting & Controls Project For Convention Space

Project Description:

- Replaced existing (124) 1,080 watt metal halide fixtures with high-efficiency 270 watt LED fixtures in Sands Expo Exhibit Hall D.
- Wireless lighting control system was installed allowing automatic operation and the dimming of fixtures to various lighting levels by areas and individual zones.
- Total Area: 100,600 sq. ft.



Project Details:

- Project cost: $156 K
- Op Ex savings: $27 K
- Payback: 5.8 years

Project Results:

- Electricity reduction: 370,771 kWh/year
- Utility Rebate: $32K

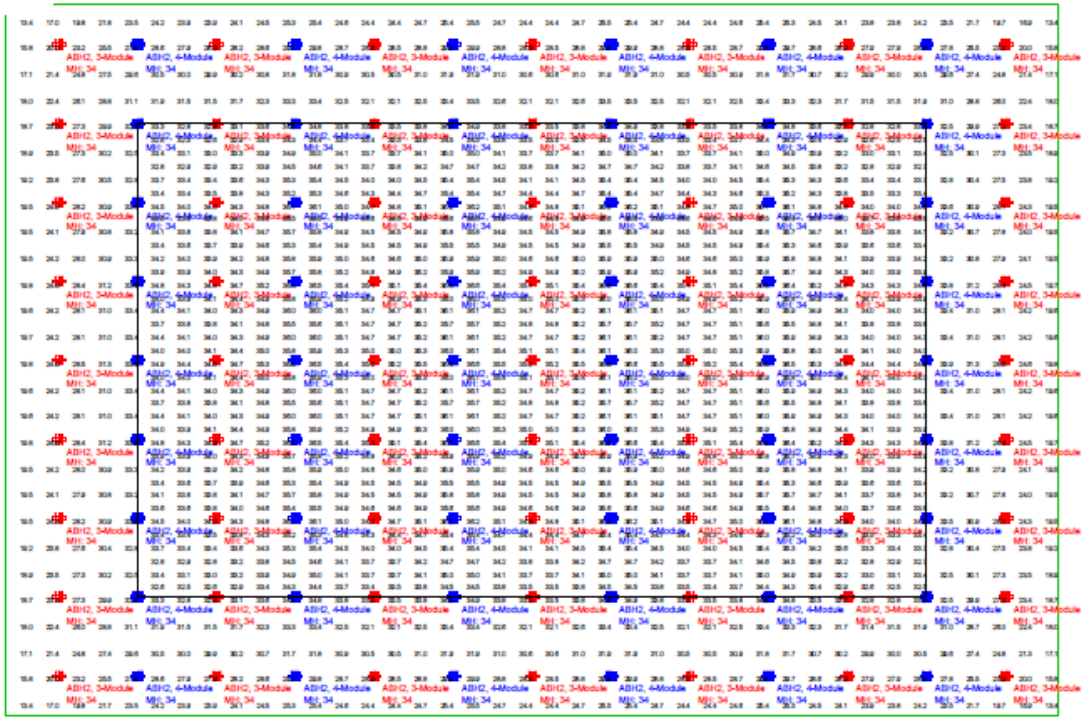
High-Bay LED Lighting & Controls Project For Convention Space

	OLD LIGHTING	NEW LED LIGHTING
Light Source	High bay metal halide fixture	High bay LED fixture
Quantity	124 fixtures	124 fixtures
Wattage	1,080 watts	270
Efficacy	65 lumens/watt	113 lumens/watt
CCT	3000K	4000K
Lamp Life	12,000 hours	100,000 hours
Warranty	1 year	5 years
Controls	Yes	Yes
Annual Operating Hours	3,075	3,075

High-Bay LED Lighting & Controls Project For Convention Space

Lighting Design:

New LED Lighting



Luminaire Schedule							
Symbol	Qty	Label	Arrangement	LLF	Description	Lum. Watts	Lum. Lumens
	63	ABH2, 3-Module	SINGLE	0.879	ABH2x3V471xxxxxxx at	270	28000
	54	ABH2, 4-Module	SINGLE	0.879	ABH2x4V471xxxxxxx at	359	37325

Fixtures modeled at 25,000 hours

Calculation Summary							
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min
Full Room	Illuminance	Fc	31.26	36.6	13.4	2.33	2.73
Inner Area	Illuminance	Fc	34.56	36.1	32.5	1.06	1.11

Illuminance Comparison

Metal Halide Lighting	LED Lighting
24.6 fc	31.3 fc

High-Bay LED Lighting & Controls Project For Convention Space

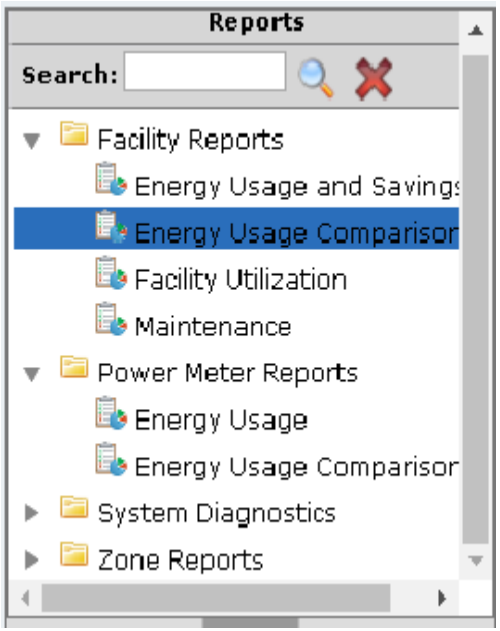
Lighting Control System:

Weekly Lighting Savings

	$ 1,869.32
	93 %
	20,035.63 kWh
	23,361.55 lb

Weekly Facility Usage

Lighting	
	$ 134.78
	1,444.95 kWh
Total	
	$ 134.78
	1,444.95 kWh



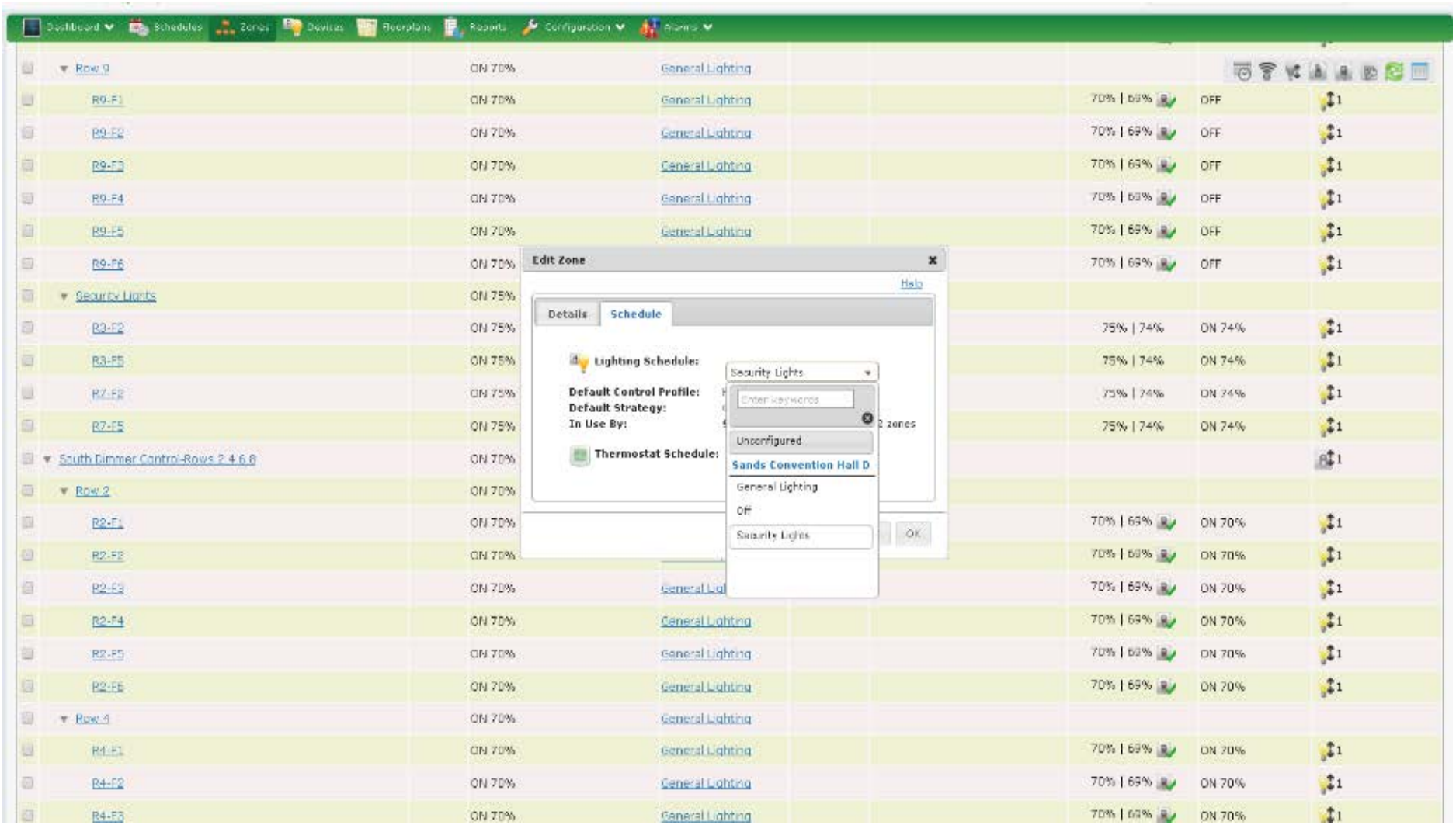
Schedules

OFF Manual ON Auto OFF Auto ON Auto OFF Auto ON Timed ON ON Use Parent's | OFF Heat Cool Auto Emergency Heat
Moderate Demand Response High Demand Response Special Demand Response Daylight Calibration Not Scheduled

Label	Facility	Default Control Strategy	Today's Events	In Use By
Sands Convention Hall D	Sands Convention Hall D		12:00 AM	
General Lighting	Sands Convention Hall D	ON 70%	12:00 AM	Sands Convention Hall D : 139 zones
Off	Sands Convention Hall D	OFF	12:00 AM	
Security Lights	Sands Convention Hall D	ON 75%	12:00 AM	Sands Convention Hall D : 12 zones

High-Bay LED Lighting & Controls Project For Convention Space

Lighting Control System:



What are the top 3 lessons learned?

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High-Bay LED Lighting & Controls Project For Convention Space

Major Benefits:

- Energy (electricity and heat load) and cost savings.
- Improve lighting requirements and provide better customer experience to our exhibition clients.
- Improve operational efficiencies as LED lamps turn on/off instantly and will last for more than 100,000 hours (8 times longer than MH fixtures).

Best Practices & Lessons Learned:

- Conducted in-depth lighting design study and mockups to ensure manufacturer specifications are not exaggerated.
- Tested first generation of the installed fixtures which seemed to work well, but the technology evolved and the efficiency of the fixtures and costs improved which helped our ROI.
- Lighting control system is performing better than expected. Easy to schedule and control and overall usability has improved lighting in the entire exhibit hall. System operators received robust training.

What projects are you considering moving forward?

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What’s next?

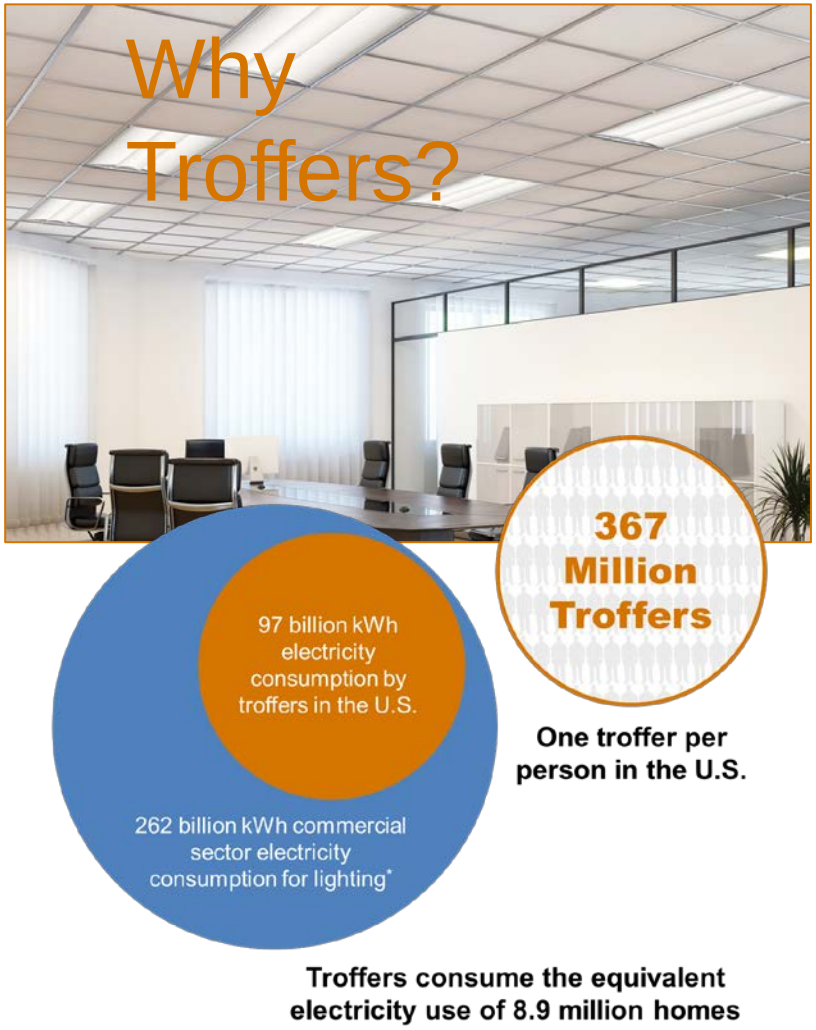
- LED troffer retrofit kits in Offices
- High-bay LED fixtures in Exhibit Halls
- LED cove lighting for Meeting Rooms
- Exterior LED lighting
- LED theatrical lighting for Showrooms & Theaters
- LED lighting for Hotel Towers

Interior Lighting Campaign – Overview

- Launched May 2015 by:

Illuminating Engineering Society · BOMA International · IFMA International Facility Management Association · Better Buildings U.S. Department of Energy · GSA

- First year focus
  - High-efficiency troffers and controls applications
- First year goal
  - Document by May 2016 - 1 M high-efficiency troffers installed or planned for installation by May 2018
  - Retrofit and new construction
  - Includes TLEDs, LED retrofit kits, high efficiency luminaires
  - Encourages use of controls for added energy savings



Better Buildings U.S. Department of Energy · U.S. Department of Energy

Interior Lighting Campaign – WIIFM

Resources

- ✓ Incentive lists
- ✓ Technology reports
- ✓ Case studies
- ✓ Calculation tools
- ✓ Webinars

Technical Assistance

- ✓ Site identification
- ✓ Technology option evaluation
- ✓ Application of specification
- ✓ Award entry content

Be Recognized

- ✓ Listed/linked on Campaign website
- ✓ Case studies of recognized projects
- ✓ Newsletter articles and tweets
- ✓ Awards for exemplary projects – **2016 BOMA International Conference and Expo, June 27 plenary event**
  - o New construction and retrofits awards
  - o Small, medium, large project awards
  - o Energy savings, portfolio adoption, and use of controls awards

Join as a Participant

- ✓ Building owners
- ✓ Building managers
- ✓ Others end users including federal, state, and municipal buildings

Join as a Supporter

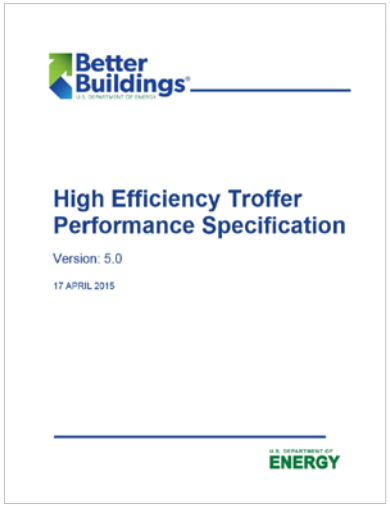
- ✓ Energy efficiency groups
- ✓ Manufacturers
- ✓ Utilities
- ✓ ESCOs
- ✓ Lighting designers
- ✓ Others who influence but don't directly manage buildings

Interior Lighting Campaign – Learn More

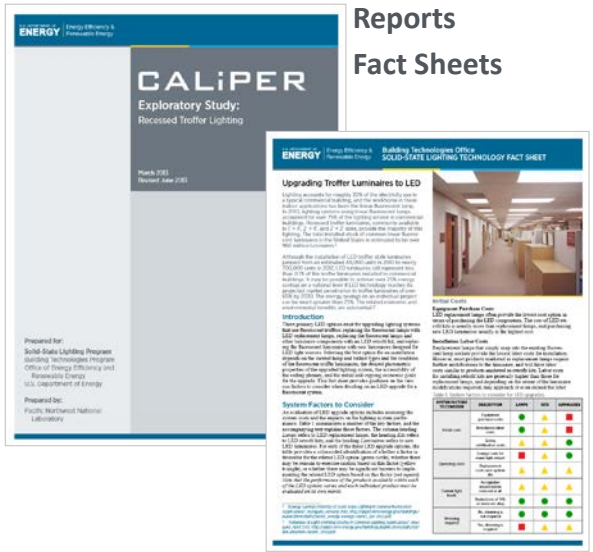
- Free resources
- Free to join
- Free technical assistance

http://www.interiorlightingcampaign.org

Interior Lighting Campaign – Resources

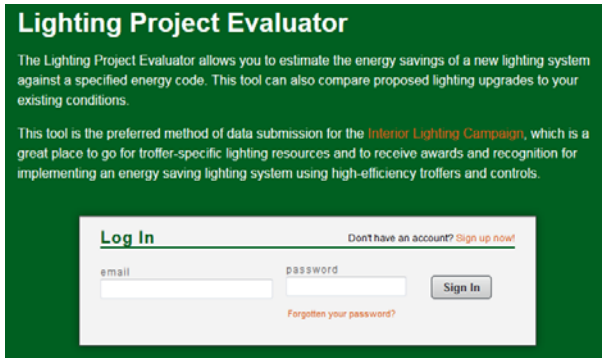


Specifications



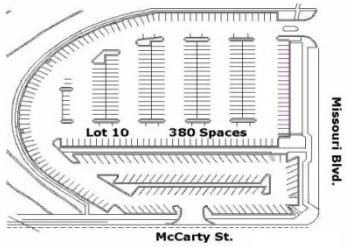
Reports

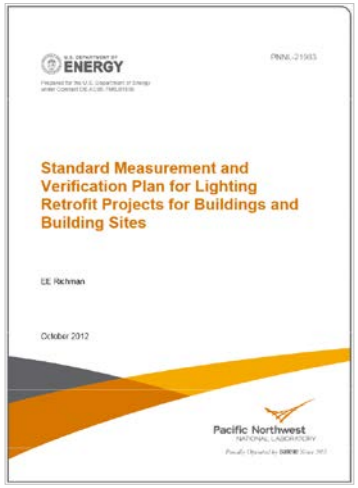
Fact Sheets



Energy Estimator to compare against code

Technical Assistance (limited)





M&V guidance

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LED lighting facts®
A Program of the U.S. DOE

Indoor Lighting - Troffers (incl retrofit kits), Controls

Utility	State	Technology	Product
PPL Electric	PA	Controls	Occupancy S
PPL Electric	PA	Fluorescent	High Perforn
PPL Electric	PA	LED	High Perforn

List of utility incentives

Discussion

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