



## Save Energy and Money in Troffer Lighting: Join the Interior Lighting Campaign Now

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# Agenda

- Overview of DOE's Better Building Alliances
- Overview of troffers
- Interior Lighting Campaign
- Yamaha Motor Corporation's Lighting Study
- Questions and answers

# Better Buildings Challenge

**Launched December 2011**

## **Goals:**

- Make commercial and industrial buildings, & multifamily housing 20%+ more efficient in 10 years
- Save more than \$80 Billion+ for US organizations
- Create American jobs; improve energy security
- Mitigate impacts of climate change



## **How:**

- ✓ Leadership
- ✓ Results
- ✓ Transparency
- ✓ Best Practice Models
- ✓ Recognition
- ✓ Catalyzing Action

**Launched 2011, Now 200+ Partners**  
*Commercial, Industrial, Public, Private*

## **Represent:**

3+ Billion Square Feet  
\$2 Billion Private Financing  
600+ Manufacturing Plants  
\$2 Billion Federal Commitment



# Better Buildings Challenge Partners and Allies



# Why Do Partners Join Better Buildings ?

## The Big 3:

1. Access to experts, tools, and resources
2. Peer to peer learning
3. Public recognition

# Better Buildings Technical Teams



## Lighting & Electrical

Indoor and outdoor lighting including related sensors and controls



## Space Conditioning

Heating, ventilation, air conditioning, and related sensors and controls



## Plug & Process Loads

Plug-in equipment that is unrelated to general lighting, heating, ventilation, cooling, and water heating



## Food Service

New commercial food service/food preparation equipment



## Refrigeration

New refrigeration systems and components, including display cases, coolers and freezers, compressor systems, and controls



## Laboratories

Laboratory facilities, with a focus on cost-effective measures including operational best practices and specifications for more efficient equipment



## Energy Management Information Systems

Energy information systems (EIS), equipment-specific fault detection and diagnostic systems, and other tools to manage commercial building energy use



## Renewables Integration

Strategic use of renewables including solar PV and biogas systems

# Better Buildings

- Sectors
  - Commercial Real Estate
  - Hospitality
  - Food Service & Grocery
  - Healthcare
  - Higher Education
  - Retail
  - Multifamily
  - Industrial
  - Public: K-12
  - Public: Government
- Technology solutions
  - Lighting
  - Space Conditioning
  - Refrigeration
  - Plug and Process Loads
  - Food Service
  - Renewable Integration
  - Energy Management Information Systems
  - Laboratories
- Market solutions



# How do we Decide what to Focus On?

- Input from Better Buildings members
- The Prioritization Tool: “P-TOOL” based on the following criteria:
  - Unit savings
  - National technical potential
  - Deployment readiness level
  - Stakeholder interest
  - Other program efforts
  - Potential manufacturing capacity
  - Cost effectiveness
  - Cost reduction potential

The image shows a complex spreadsheet titled 'P-TOOL' used for prioritizing energy-saving measures. The columns include: Name, Description, Measure, Technology Area, National Technical Potential (kWh), Unit Savings (kWh), Peak Demand Reduction (kW), Energy Savings Potential (\$/yr), Peak Demand Reduction (\$/yr), and Deployment Readiness Level (1-5). The rows list various measures such as 'LED Lighting', 'HVAC Controls', 'Water Heating', etc., with corresponding numerical values and readiness ratings. Some cells are highlighted in yellow, indicating specific data points or areas of interest.



# Other Campaigns...

- Lighting Energy Efficiency in Parking (LEEP)



- Advanced Rooftop unit Campaign (ARC)



# Why An Interior Lighting Campaign?

## Why Troffers?

### Because science (and math)

Name	Measure Description	Sector	Technology Area	Relevant BBA Team	Units	Unit Energy Savings		National Installed Base and Savings Potential				Savings Potential (2016)		Comments	
						Efficient Operation	Baseline Operation	P-Trial Technical Potential (2016)	P-Trial Installed Base Annual Consumption (2016)	Tech Swap Technical Potential (2016)	Tech Swap Installed Base Annual Consumption (2016)	P-Trial Technical Potential (2016)	Existing WPI or CB Efforts		
LED lighting retrofits on ceilings	Replace high-efficiency, uncontrolled LED troffers with solid controls	Commercial	Lighting	Lighting	Energy Savings (%)	0.51	0.00	236.39	1236.81			236.39	Yes	11% unit energy savings over baseline	
High intensity discharge in low color rendering index applications	Research, develop and demonstrate electronic ballast (EBC) in commercial, industrial and outdoor nonresidential lighting	Commercial/Industrial/Outdoor	Lighting	Lighting	Lumens/Watt	85.04	33.00	512.18	135.92			812.18	Yes	75% improvement in lumens/watt over baseline	
Parabolic aluminized reflector LEDs	Commercial and facility LED parabolic aluminized reflectors as replacement for incandescent lighting, commercial and outdoor lighting	Commercial/Industrial/Outdoor	Lighting	Lighting	Lumens/Watt	63.04	15.00	335.38	438.54	144.27	145.00	355.88	Yes	100% improvement in lumens/watt over baseline	
Replace downlights w/ LEDs	Replace all non-LED downlighting (downlights, surface downlights, or pin-point LEDs) with LEDs	Commercial/Residential	Interior	Solid State Lighting	Lumens/Watt	60.00	20.00	240.00	360.00	225.00	360.00	240.00	Yes	100% improvement in lumens/watt over baseline	
Auto shut-off beam heads	Replace non-LED beam heads (beams with automatic shut-off) with LED. This technology has automatic shut-off control by an occupancy sensor.	Commercial	Laboratories	Laboratories	Energy Savings (%)	0.70	0.00	470.00	670.00	0.00	163.00	355.00	Yes	Targets experimental and users, less profit-motivated, often with explicit energy focus in mission. 20% unit energy savings over baseline.	
Replace MR16 w/ LEDs	Replace all MR16 with LEDs	Commercial and Residential	Lighting	Solid State Lighting	Lumens/Watt	50.00	17.00	47.73	72.31	59.50	70.00	47.73	Yes	104% improvement in lumens/watt over baseline	
High-efficiency ultra-low temperature laboratory fixtures (ULTF)	Replace high-efficiency ultra-low temperature laboratory fixtures	Commercial	Laboratories	Laboratories	Energy Savings (%)	0.25	0.00	4.24	17.00	4.21	17.00	4.21	Yes	Targets experimental and users, less profit-motivated, often with explicit energy focus in mission. 25% unit energy savings over baseline.	
Low photovoltaic	Deploy photovoltaic sector lighting cover	Commercial	Manufacturing	Manufacturing	Energy Savings (%)	1.00	0.00	0.00	0.00			0.00	Yes		
Wireless smart metering (WPM)	Develop and deploy a low cost wireless metering system. Objectives: (1) to support the challenge to produce a low cost metering system that has the essential requirements for accurate energy measurement and provides wireless data transmission to an onsite collection point; (2) to support the sub-metering campaign efforts. This project supports both measurement and phase metering energy efficiency improvements with the primary focus on commercial buildings. Many federal and non-federal buildings have only a building level meter with no sub-metering. To realize cost-effective metering systems, real-time energy use data can be available to guide improved building operation and support efficiency strategies.	Commercial	Building Controls	Lighting	Energy Savings (%)	0.24	0.00	2247.30	8547.21			2247	Yes	Challenge currently underway; 24% unit energy savings over baseline.	
Advanced phosphor - LEDs	Commercial and facility advanced phosphors to improve LED efficiency for use in all commercial and residential lighting	Commercial and Residential	Lighting	Solid State Lighting	Lighting	Subst. consumed	3.40	4.00	1708.00	1697.30		1708.00	Yes	30% total energy savings over baseline	
Commercial vehicle building diagnostics	Replace commercial vehicle building diagnostics (AVD)	Commercial	Building Controls	Lighting	Energy Savings (%)	0.40	0.00	295.00	2030.00			295.00	Yes	10% unit energy savings over baseline	
Building control optimization / energy management systems	Optimize whole-building control system (base building) that controls the operation of multiple systems to minimize space based on a variety of factors, such as occupancy, weather, fuel price, etc. This measure is applicable to systems in large buildings (100,000 sq ft) with energy performance control systems. It also includes retro-commissioning adjustment of thermostats, reheat, set points, calibration. It does not include equipment replacement (bad sensors, broken devices, etc.) or an air-seal.	Commercial	Building Controls	Lighting	Energy Savings (%)	0.40	0.00	295.00	2030.00			295.00	Yes	10% unit energy savings over baseline	
Advanced / smart power strips	Replace advanced smart power strips for all IT and non-IT office equipment. The basis for this measure is an NREL deployment plan measure from the P-Trial. Suggested steps include: (1) develop a guidance on how to apply P-Trial in building smart devices section; (2) develop "how-to" installation guidance; (3) develop specific demonstration cases; (4) connections to utility meters; (5) clarity on pricing specific plug loads to the most appropriate product; and (6) train users for participation in a campaign.	Commercial	Electronics	Lighting	Energy Savings (%)	0.24	0.00	2247.30	8547.21			2247	Yes	Challenge currently underway; 24% unit energy savings over baseline.	
LED lighting troffer 1-to-1 replacement	Replace high-efficiency LED troffers	Commercial	Lighting	Lighting	Energy Savings (%)	0.51	0.00	236.39	1236.81			236.39	Yes	11% unit energy savings over baseline	
Device electronics - LEDs	Reduce power consumption in commercial and residential device electronics for LEDs	Commercial and Residential	Lighting	Solid State Lighting	Lighting	Energy Savings (%)	0.51	0.00	236.39	1236.81			236.39	Yes	11% unit energy savings over baseline
Advanced ETL (IEEE 802)	This is the largest performance level for the high-efficiency ETL (undergoing certification)	Commercial	ETL	Lighting	Energy Savings (%)	0.51	0.00	236.39	1236.81			236.39	Yes	11% unit energy savings over baseline	
Advanced refrigeration controls	Use advanced controls in new refrigeration system installations	Commercial	Refrigeration	Lighting	Energy Savings (%)	0.51	0.00	236.39	1236.81			236.39	Yes	11% unit energy savings over baseline	
Advanced display case glass door retrofits	How efficient are all-wireless meters, why? Composite door frames, and high-performance glass to display case doors	Commercial	Refrigeration	Lighting	Energy Savings (%)	0.51	0.00	236.39	1236.81			236.39	Yes	11% unit energy savings over baseline	
Variable speed compressors for refrigeration	Use variable speed compressors to select new commercial refrigeration equipment	Commercial	Refrigeration	Lighting	Energy Savings (%)	0.51	0.00	236.39	1236.81			236.39	Yes	11% unit energy savings over baseline	
High efficiency gas vent heaters	Deploy high-efficiency gas vent heaters	Commercial	HVAC	Lighting	Energy Savings (%)	0.11	0.00	38.85	263.00	38.85	263.00	38.85	Yes	How has been developed and demo has been completed. 11% unit energy savings over baseline.	
Automated building lighting	Deploy automated building automation systems in commercial and industrial buildings	Commercial/Industrial	Lighting Controls	Lighting	Energy Savings (%)	0.50	0.00	1379.81	4432.81			1379.81	Yes	30% unit energy savings over baseline	
Meters, ECM, max tech (all applications)	Deploy wireless smart meters in place of plug-load meters in multiple residential & commercial applications	Commercial and Residential	Electricity	Plug & Process Loads	Energy Savings (%)	0.50	0.00	1580.38	1527.30			1580	Yes	30% unit energy savings over baseline	
Replace all lighting with LEDs	Replace all commercial lighting with LEDs	Commercial	Lighting	Solid State Lighting	Lighting	Energy Savings (%)	0.40	0.00	1008.00	4467.00			1008.00	Yes	100% improvement in lumens/watt over baseline
Site outdoor lighting	Commercial and facility LED lighting for outdoor lighting	Commercial	Lighting	Lighting	Energy Savings (%)	1.00	0.00	1133.00	1133.00			1133.00	Yes	100% improvement in lumens/watt over baseline	
Heat pump water heaters (all applications)	Deploy high-efficiency heat pump water heaters in residential and small commercial buildings	Commercial	Water Heating	CO2	Energy Savings (%)	2.00	0.00	1133.00	3605.33	140.00	360.00	1133.00	Yes	Goal developed, but large difficulties have been encountered in finding appropriate demo sites, as this requires high hot water needs and a lack of incentives or gas fuel availability. 200% improvement in CO2 over baseline.	
Low-CRI LEDs	Deploy LED specific art/collections or replacement to incandescent in low-CRI commercial lighting and museum support (MUSE) and high-bay (HB) replacements in commercial, industrial, and outdoor lighting	Commercial/Industrial/Outdoor	Lighting	Lighting	Lumens/Watt	67.90	34.80	912.00	1440.00			912.00	Yes	175% improvement in lumens/watt over baseline.	
Lighting dimming sensors	Deploy dimming sensors in commercial and residential buildings	Commercial/Industrial/Outdoor	Lighting	Lighting	Energy Savings (%)	0.30	0.00	762.00	1332.00	1037.00	507.00	762.00	Yes	10% unit energy savings over baseline	
Indoor daylighting devices and controls in existing buildings	Install indoor daylighting devices for exterior spaces, and add photovoltaic controls and dimming	Commercial	Lighting	Lighting	Energy Savings (%)	0.21	0.00	844.12	2850.12			844.12	Yes	Goal developed, but large difficulties have been encountered in finding appropriate demo sites, as this requires high hot water needs and a lack of incentives or gas fuel availability. 200% improvement in CO2 over baseline.	
Indoor lighting occupancy sensors	Deploy non-wireless occupancy sensors to reduce energy use for commercial lighting	Commercial	Lighting Controls	Lighting	Energy Savings (%)	0.13	0.00	562.72	4467.00	191.13	507.12	562.72	Yes	15% unit energy savings over baseline	
Wireless lighting occupancy sensor system	Deploy wireless occupancy sensors and corresponding wireless lighting strip-on-strip in commercial buildings	Commercial	Lighting Controls	Lighting	Energy Savings (%)	0.13	0.00	562.72	4467.00	191.13	507.12	562.72	Yes	15% unit energy savings over baseline	
Small meters, ECM, max tech (all applications)	Small meters, beyond standards. Would include high-efficiency LEDs	Commercial and Residential	Meters	Plug & Process Loads	Efficiency (%)	0.51	0.00	516.33	1553.13			516.33	Yes	100% efficiency improvement over baseline	
LED dimmable ballasts	Deploy LED dimmable ballasts in commercial, industrial, and outdoor HID and fluorescent lighting	Commercial/Industrial/Outdoor	Lighting	Lighting	Energy Savings (%)	0.15	0.00	501.46	3343.00			501.46	Yes	15% unit energy savings over baseline	
Heating / cooling devices	Commercial and facility heating and other shading devices on commercial buildings	Commercial	Thermostat	Energy Savings (%)	0.06	0.00	311.00	3140.00	101.00	2140.00	311	Yes	Goal has been developed, but finding a demo partner has been difficult due to long product lifetime and high capital cost. 65% unit energy savings over baseline.		
Dry distribution transformers, Medium-High voltage	Installation Transformer Dry, Medium Voltage Efficiency Improvement	Commercial	Transformers	Plug & Process Loads	Energy Savings (%)	0.07	0.00	207.00	397.00	20.00	98.00	207.00	Yes	100% improvement in lumens/watt over baseline	
LED General Illumination applications	Replace all indoor, non-LED lighting	Commercial	Lighting	Solid State Lighting	Lighting	Energy Savings (%)	0.51	0.00	236.39	1236.81			236.39	Yes	11% unit energy savings over baseline
Perimeter zone daylighting	Research, develop, and demonstrate daylight-responsive dimming (PhotoSensor-Daem) lighting controls in commercial buildings	Commercial	Daylighting	Lighting	Energy Savings (%)	0.48	0.00	217.20	543.12	1037.01	307.00	217.20	Yes	40% unit energy savings over baseline.	

2x4 Lighting troffers with controls

# Interior Lighting



- Represents a significant amount of energy consumption in buildings
- New, more energy efficient technologies exist
- Some of the new technologies offer benefits in addition to energy savings

# Interior Lighting by the Numbers - Commercial Buildings



- Commercial lighting is  $\approx$  2.6% of **ALL** primary energy consumption in the U.S.
- Troffers  $\approx$  1% of **ALL** energy use
- $\approx$  20% of building energy is lighting and troffers are  $\approx$  50% of that energy



# Troffers by the Numbers

- Estimated 367 million troffers in the US
- $\approx 1$  troffer for every 240 square feet
- $\approx 1$  troffer per person in the U.S.



# Troffer Efficacy

- Lighting Efficacy – how effectively a light source converts input power into light output (lumens/Watt [lm/W])
- Luminaire Efficacy (LE) or Luminaire Efficacy Rating (LER) is an energy efficiency metric for lighting
  - Very similar to miles per gallon for cars



- $LER = \text{Lamp lumens} \times \text{ballast factor} \times \text{fixture efficiency} / \text{input power}$

# Fluorescent Troffer Performance

- Lensed
  - 64% - 89% fixture efficiency
  - $\approx 70$  lm / W LER



- Direct/Indirect (basket)
  - 33% - 79% fixture efficiency
  - $\approx 52$  lm / W LER



- Parabolic Louvers
  - 51% - 72% fixture efficiency
  - $\approx 57$  lm / W LER



- HP Lensed (volumetric)
  - 67% - 91% fixture efficiency
  - $\approx 73$  lm / W LER



- Note:
  - LER calculated as average of reported fixture efficiency \* lamp/ballast system efficacy of 92 lm/W
  - LER values will vary greatly based on lamp, ballast, and optical options

# Troffer Efficacy

- Current average troffer LER = 66 lm/W
- New troffers are 85 to 120 lm/W



- New equipment more efficient & more features



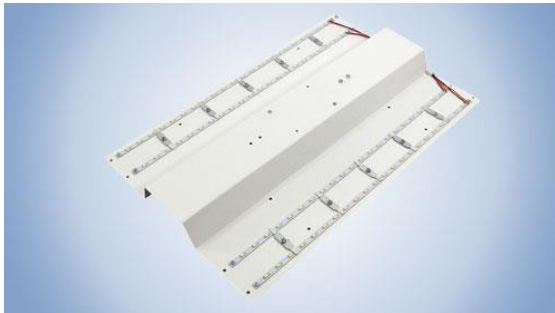
# Troffer Conundrum – What do I do?



Fluorescent Lamps



Tubular LED (TLED)



LED retrofit kit



New Fixture

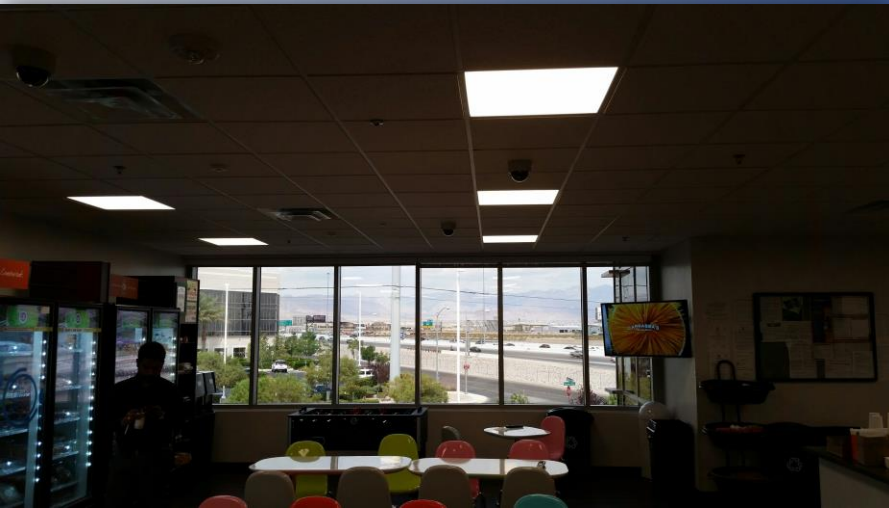
# Troffer Conundrum

## What do I do?

Option	Action	Light Source	Risk	Controls	Energy Savings Potential
1	Do nothing	Fluorescent	---	OS or dimming w/ new ballast	
2	Replace lamps	Long life fluorescent	---	OS or dimming w/ new ballast	
3	Replace lamps	TLED+FL ballast on existing socket	●●	OS	☀
4	Replace lamps	TLED on mains voltage in existing socket	●●	Yes w/ paired controls	☀ ☀
5	Replace lamps	TLED (hybrid) mains or ballast in existing socket	●●	OS or if ballast replaced	☀ ☀
6	Replace lamps	TLED w/ proprietary power supply in existing socket	●●	Yes paired w/ controls	☀ ☀
7	Retrofit Kit	Fluorescent or LED	●●	Many options	☀ ☀ ☀
8	New Fixture	Fluorescent or LED	●	Most options	☀ ☀ ☀ ☀

18 OS = Occupancy Sensor

# MGM Resorts International



- Presented at the 2015 Better Buildings Summit
- New IT office space
- 755 2' x 2' troffers
- 68% energy savings

# MGM Resorts International

## ■ Summary:

- Includes full dimming controls
- LED upgrade over specified linear fluorescent fixtures
- \$165 K cost (\$69 K incremental)
- 125 K kWh saved annually
- 33.9% ROI



Option	Source & Controls	10-Year Energy Usage (million kWh)	10-Year Cost of Ownership
1	T8	2.23	\$401,691.50
2	T8 + Controls	1.56	\$354,136.25
3	T8 Ext. Life	1.95	\$355,353.00
4	T8 Ext. Life + Controls	1.37	\$318,091.00
5	LED	1.02	\$300,273.75
6	LED + Controls	0.59	\$282,146.50



# Additional Cost & Ancillary Benefits

- For standard AC LED troffers: \$69 of conduit and labor per traditional LED fixture and 1/15<sup>th</sup> of a wired light switch
- For remote driver: \$17 of Cat5 to each fixture and wireless switches @ 1/15<sup>th</sup> of \$20/ea
- Savings from remote driver in regards to implementing low cost battery back up solution
- Ability to continuously commission individual & group spaces
- Downloadable App
- Ease of office reconfiguration
- Training & education obtained by electrical contractor
- Maintenance trouble shooting
- Occupancy data

# Princeton University



- Presented at the 2015 Better Buildings Summit
- Carl Icahn Laboratory
- 815 2' x 2' troffers
- 24% energy savings before controls factored into analysis

# Princeton University

## ■ Summary:

- Retrofit kits
- Labor prohibited fixture replacement being cost effective
- Wireless sensors
- Works with larger building control system
- Equal or better lighting results

	FL <sub>horiz</sub>	LED <sub>horiz</sub>	LED/FL
Mean	53.0	96.8	1.83
Max:Min	1.19	1.24	
	FL <sub>vert</sub>	LED <sub>vert</sub>	LED/FL
Mean	30.4	53.5	1.76
Max:Min	1.34	1.16	

LED/FL – is a comparison of the mean LED values compared to the mean fluorescent values



# Interior Lighting Campaign



# Interior Lighting Campaign Organizers

- Interior Lighting Campaign officially launched May 28, 2015 by:
  - Building Owners and Managers Association (BOMA),
  - U.S. Department of Energy (DOE),
  - U.S. General Services Administration (GSA),
  - Illuminating Engineering Society (IES), and
  - International Facility Management Association (IFMA)
- Phase 1 awards submission deadline is May 2016
- Join today at <http://www.interiorlightingcampaign.org/>
- #IntLtgCampaign



# Interior Lighting Campaign Organizers



- 91 associations
- 10 billion square feet of U.S. office space
- Supporting 3.7 million jobs
- Primary source of information on building management and operations, development, leasing, building operating costs, and codes



- 9,000 members (manufacturers, architects, engineers, consultants, and contractors)
- 95 technical committees
- 1,000 volunteers setting standards, guidelines, and recommended practices



- Largest commercial real estate entity in the U.S.
- Has 1.53 million troffers under their auspices
- Supports federal agencies



- 134 chapters
- 39 billion square feet of property
- Purchase U.S. \$100 billion in products
- Conducts research that strengthens facility management
- Provides educational courses

# Interior Lighting Campaign Goal

- 100,000 troffers either retrofit (tubes, kits, or new fixtures) or new construction by May 2016
- $\approx$  10,000,000 square feet of lighted area
- $\approx$  5,000,000 kWh savings annually or roughly the equivalent annual energy usage of 450 homes
- $\approx$  \$500,000 in savings

# Interior Lighting Campaign Awards

- Campaign provides an avenue for recognition for exemplary sites
- Awards for new construction and retrofit sites
- Awards for buildings with a few (under 25), some (25 – 200), and many (200+) troffers
- Awards for multiple sites and innovative use of lighting controls related to troffers

# Interior Lighting Campaign Participants & Supporters

## ■ Participants

- Entities that are end users are eligible to be participants
- Participants can be building owners, building managements, and tenants

## ■ Supporters


- Anyone not directly related to the operation / management of the lighting system(s)
- Supporters are designers, engineers, architects, energy efficiency organizations, utilities, and manufacturers

# Interior Lighting Campaign Benefits & Features – Participants

- Limited technical assistance available to participants
  - identifying appropriate sites for a high efficiency troffer installation or upgrade
  - properly applying specification guidelines
  - completing Join or Awards applications
- Campaign website offers:
  - High Efficiency Troffer Performance Specification (released April 2015)
  - case studies
  - technical reports
  - fact sheets
  - lists of available incentives
  - lighting project evaluator to estimate potential savings by comparing different lighting equipment and controls
- Recognition and possible award(s)




# Interior Lighting Campaign Resources



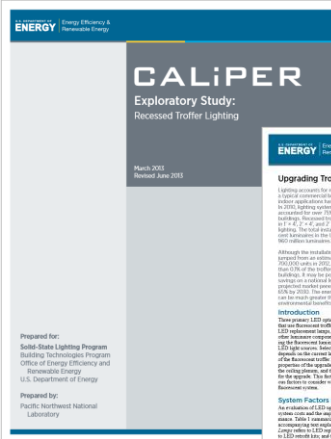
**High Efficiency Troffer Performance Specification**

Version: 5.0

17 APRIL 2015



Specifications




**CALiPER**  
Exploratory Study:  
Recessed Troffer Lighting

March 2012  
Revised June 2013

Prepared for:  
Solid-State Lighting Program  
Building Technologies Office  
Office of Energy Efficiency and  
Renewable Energy  
U.S. Department of Energy

Prepared by:  
Pacific Northwest National  
Laboratory

Reports  
Fact Sheets



**Upgrading Troffer Luminaires to LED**

Lighting accounts for roughly 20% of the electricity used in a typical commercial building, and the potential for energy and cost savings is high. This fact sheet provides the information needed to help building owners and facility managers understand the benefits of upgrading troffer luminaires to LED technology.

Although the installation of LED troffer-style luminaires represents an investment of \$100,000 to \$200,000 for every 100,000 sq ft of office space, LED technology offers a payback period of 1 to 2 years, depending on the specific building and lighting system. The payback period can be as short as 6 months for a typical office building with a high percentage of troffer lighting.

**Introduction**  
This report provides information on the benefits of upgrading troffer luminaires to LED technology. It includes information on the types of troffer luminaires available, the benefits of LED technology, and the steps involved in upgrading a building's lighting system.

**System Factors to Consider**  
The benefits of LED technology are realized only when the lighting system is designed and installed correctly. This report provides information on the factors that can affect the performance of a lighting system, including the type of troffer luminaire, the type of ballast, and the type of control system.

System Factor	Benefit	Cost	LED	LED
Initial Cost	High	Low	High	Low
Energy Efficiency	High	Low	High	Low
Life Span	High	Low	High	Low
Control System	High	Low	High	Low
Ballast	High	Low	High	Low
Light Output	High	Low	High	Low
Heat Output	High	Low	High	Low
Control System	High	Low	High	Low
Ballast	High	Low	High	Low
Light Output	High	Low	High	Low
Heat Output	High	Low	High	Low



**Standard Measurement and Verification Plan for Lighting Retrofit Projects for Buildings and Building Sites**

EE Richman

October 2012

Pacific Northwest National Laboratory  
Funded by the U.S. Department of Energy

M&V guidance





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

**Lighting Project Evaluator**

The Lighting Project Evaluator allows you to estimate the energy savings of a new lighting system against a specified energy code. This tool can also compare proposed lighting upgrades to your existing conditions.

This tool is the preferred method of data submission for the Interior Lighting Campaign, which is a great place to go for troffer-specific lighting resources and to receive awards and recognition for implementing an energy saving lighting system using high-efficiency troffers and controls.

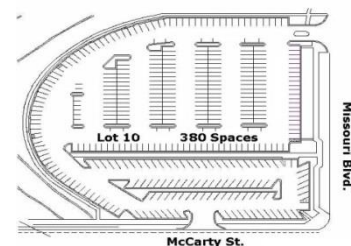
**Log In** Don't have an account? [Sign up now!](#)

email  password

Forgotten your password?

Energy Estimator to compare against code

Technical Assistance (limited)



**Indoor Lighting - Troffers (incl retrofit kits), Controls**


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

List of utility incentives

# Interior Lighting Campaign

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

[EERE Home](#) | [Programs & Offices](#) | [Consumer Information](#)



## INTERIOR LIGHTING CAMPAIGN

Home | About ILC | ILC News | ILC Resources | ILC Awards | Join ILC

### What is the Interior Lighting Campaign?

The Interior Lighting Campaign (ILC) is a recognition and guidance program designed to help facility owners and managers take advantage of savings opportunities from high efficiency interior lighting solutions. The initial campaign focus will be on troffer lighting, with a goal of replacing or newly installing 100,000 standard troffers with high efficiency troffer solutions by May 2016. Campaign organizers, Building Owners and Managers Association International (BOMA), Illuminating Engineering Society of North America (IES), the International Facility Management Association (IFMA), and the U.S. Department of Energy (DOE) serve on the ILC Organizing Committee.

### What are the benefits of joining the ILC?

- By adopting more efficient troffer lighting, such as systems that meet the Better Buildings Alliance [specification](#) for troffers, building owners can save up to 60% on a one-for-one basis, and up to 75% with the use of controls.
- Resources available from the ILC include specifications, case studies, utility incentive lists, and educational webinars to help building owners make sound lighting decisions.
- Limited technical assistance from the U.S. Department of Energy is available to site owners and managers who sign up.
- Sites that join the ILC will be recognized on the ILC web site, and those that show exemplary performance will be eligible for awards.
- Organizations that don't directly own or operate facilities but support the goals of the ILC can join as Supporters, and receive recognition for their involvement.

### How do I get involved in the ILC?

Join the ILC as either a [Participant](#) (e.g., site owner, manager, or operator) or a [Supporter](#) (e.g., utility, energy efficiency organization, ESCO, lighting designer/engineer, lighting manufacturer or distributor or other organization that supports the ILC goals).

### Related Efforts

Through the [Better Buildings Alliance](#), members in different market sectors work with the U.S. Department of Energy's exceptional network of research and technical experts to develop and deploy innovative, cost-effective, energy-saving solutions that lead to better technologies, more profitable businesses, and better buildings in which we work, shop, eat, stay, and learn. Visit the Better Buildings Alliance [Lighting and Electrical Technology Solutions Team web site](#) to learn more.

If you are also interested in high efficiency exterior lighting, visit the [Lighting Energy Efficiency in Parking \(LEEP\) Campaign](#).

Read more about saving energy with advanced lighting, and explore the innovative solutions being shared by Better Buildings partners in the [Better Buildings Solution Center](#).

[Join Today!](#)





#### EVENTS

[Official Launch – 2015 Better Buildings Summit](#)

**Save Energy and Money in Troffer Lighting: Join the Interior Lighting Campaign WEBINAR. June 24, 2015. [Register Today!](#)**

#### JUST RELEASED!

[High Efficiency Troffer Performance Specification](#)




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# Interior Lighting Campaign

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

EERE Home | Programs & Offices | Consumer Information



## INTERIOR LIGHTING CAMPAIGN

Home | About ILC | ILC News | ILC Resources | ILC Awards | **Join ILC**

[Home](#) » [Join ILC](#) » [Join the Interior Lighting Campaign](#)

### Join the Interior Lighting Campaign

Building owners, operators, and managers who are interested in using energy efficient troffer lighting solutions to minimize energy usage and reduce operating costs may join the campaign to receive free guidance and recognition. The ILC offers free access to tools and expertise that will aid in lowering energy costs through the thoughtful design of new construction, and through lighting retrofits in existing buildings. By joining, participants and supporters gain unique access to the technical expertise of the U.S. Department of Energy, and they have the opportunity to gain recognition for their lighting efficiency achievements.

#### Participants





Organizations including building owners, operators, and managers who formally join the campaign as participants will be provided with resources and technical assistance to assist them with lowering their troffer lighting energy use. Participants who achieve exceptional energy savings and fill out an Awards Submission Form will be eligible for recognition for their achievements at the ILC Awards Ceremony (date/location to be set). View the list of [Participants](#).

[Join as a Participant!](#)

#### Supporters

Supporting partners include utilities, manufacturers, energy efficiency organizations, lighting designers, and ESCOs who support the ILC goals and formally join the campaign. These organizations share information about their high efficiency troffer products and services, and also encourage their customers to join the campaign as participants. View the list of [Supporters](#).

[Join as a Supporter!](#)



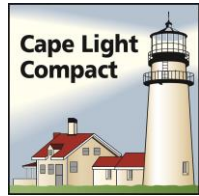
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# Interior Lighting Campaign

## Benefits & Features – Supporters

- Be recognized on the ILC website Supporter page
  - Show your organization supports the campaign goals
  - Includes link to your web site
- Share ILC resources with your customers
  - Help convince customers that high efficiency troffer lighting solutions are viable now
  - Utilities can leverage ILC resources as part of their troffer lighting incentive initiatives
  - Lighting project evaluator can help you estimate potential savings
- Help your customers gain recognition for their troffer projects
  - Your role in the project will be recognized if an award is received
- Work with ILC Organizers on a customized outreach strategy

# Interior Lighting Campaign Founding Supporters



# Yamaha Motor Corporation



# Facility Overview

## Cypress, California

- Yamaha Motor Corporation
- Corporate Offices – United States
- 350 Employees
- 278,000 Square feet
- Multi-Function Facility
  - Corporate Division – Motorcycle Operations
  - Yamaha Finance
  - New Business Planning
  - Research & Development
  - Accessories Distribution

# Lighting Challenges

- Energy
- Replacement
- Costs
- Age of troffers



# Lighting Particulars

- Quantity of troffers
- Quantity of lamps
- Lighting quality
- Lighting applications

# Offices

- Typical Office Layout
- 2' X 4' Troffers
- Note Glazing
- Opportunity for LED & controls



# Offices Part II

- No Task Lighting
- Work Disruption
- 2' X 4' Troffers
- Opportunities



# Hallways

- Way-finding vs. task
- Optimal for  
Daylight Harvesting
- Change to 2 lamp  
Fixtures
- Photometrics





# Stairwells

- Only Need Accent Lighting
- Originally T12 lamps



# Warehouse- High Bay

- Time Consuming
- Ballasts & Lamps
- Scissor Lift
- Fork Lift w/Cage
- Two Person Job



# High Bay Part II

- Fixtures over racks
- Inaccessible
- Age of fixtures



# Retrofit Rationale

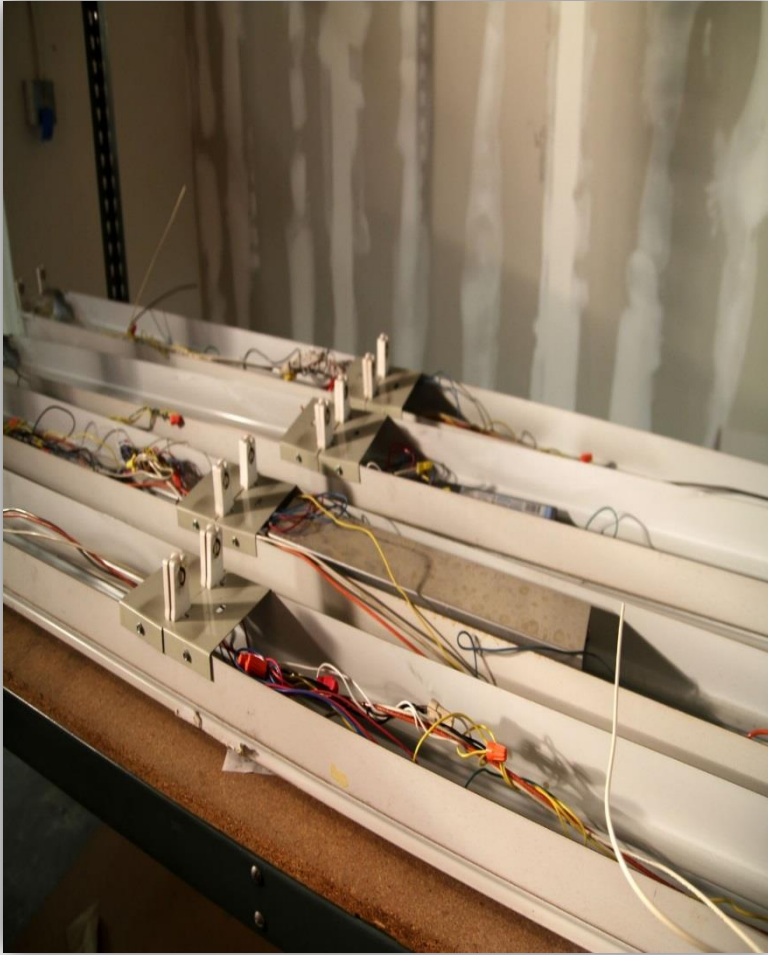
- Energy Efficiency
- Lamp life
- Lighting Quality
- Control of Energy Usage
- Minimize replacement needs

# Retrofit Options

- LED
- Lamp for Lamp
- Retrofit Kit
- Troffer Replacement



# Defunct Troffers



Gone, but not forgotten



# Cost of Energy

	# of troffers	# lamps / troffer	Input power / troffer	Operating hours / year	Cost of Energy
Fluorescent	3,201	2.45	71 W	2,080 hours	\$56,894
LED	3,201	2.45	47 W	2,080 hours	\$37,275

## Assumptions:

- 34% energy savings
- \$0.12 / kWh
- No controls
- Considering 19 W LED lamp options
- \$6.13 saved / troffer
- Total savings: \$19,619

# Questions?

- <http://www.interiorlightingcampaign.org/>
- #IntLtgCampaign