Best Practices in Retail Lighting, especially Retrofits

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Today's Program

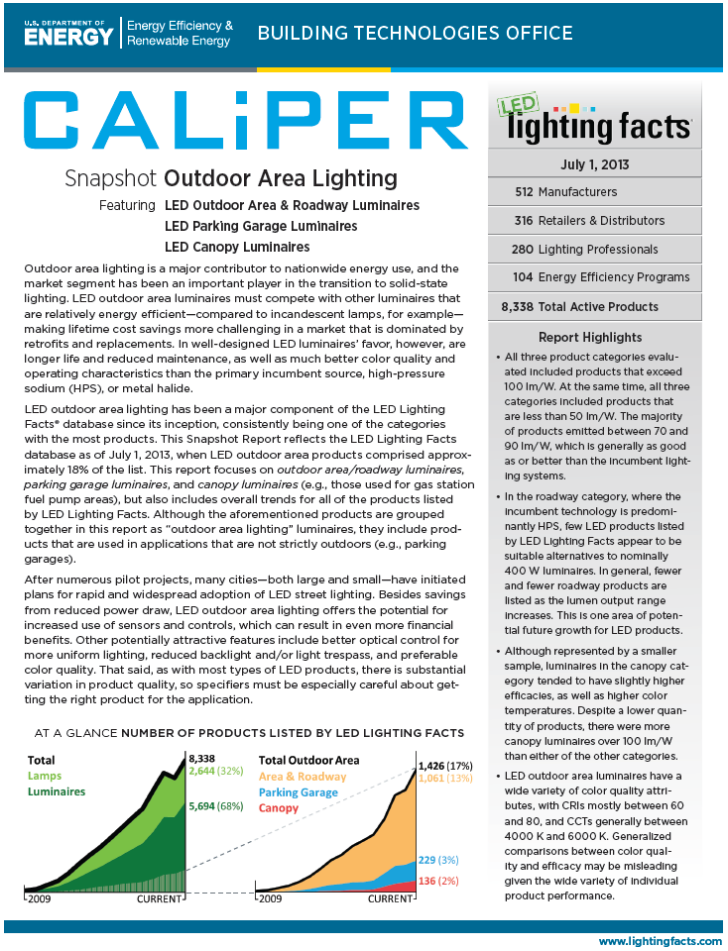
- LED Awareness
- Display Lighting
- General Lighting – normal ceiling height spaces
- General Lighting – high bay spaces
- Outdoor Area Lighting
- Skylights
- Commentary on Lighting Controls Possibilities

Best Practices in Retail Lighting, especially Retrofits

LED AWARENESS

Testing Must Be Done and Certified

- DOE Caliper Reports
- LightingFacts Listing
- DLC Listings
- CEE Listings



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy — BUILDING TECHNOLOGIES OFFICE

CALiPER

Snapshot **Outdoor Area Lighting**

Featuring **LED Outdoor Area & Roadway Luminaires**
LED Parking Garage Luminaires
LED Canopy Luminaires

Outdoor area lighting is a major contributor to nationwide energy use, and the market segment has been an important player in the transition to solid-state lighting. LED outdoor area luminaires must compete with other luminaires that are relatively energy efficient—compared to incandescent lamps, for example—making lifetime cost savings more challenging in a market that is dominated by retrofits and replacements. In well-designed LED luminaires' favor, however, are longer life and reduced maintenance, as well as much better color quality and operating characteristics than the primary incumbent source, high-pressure sodium (HPS), or metal halide.

LED outdoor area lighting has been a major component of the LED Lighting Facts® database since its inception, consistently being one of the categories with the most products. This Snapshot Report reflects the LED Lighting Facts database as of July 1, 2013, when LED outdoor area products comprised approximately 18% of the list. This report focuses on *outdoor area/roadway luminaires*, *parking garage luminaires*, and *canopy luminaires* (e.g., those used for gas station fuel pump areas), but also includes overall trends for all of the products listed by LED Lighting Facts. Although the aforementioned products are grouped together in this report as "outdoor area lighting" luminaires, they include products that are used in applications that are not strictly outdoors (e.g., parking garages).

After numerous pilot projects, many cities—both large and small—have initiated plans for rapid and widespread adoption of LED street lighting. Besides savings from reduced power draw, LED outdoor area lighting offers the potential for increased use of sensors and controls, which can result in even more financial benefits. Other potentially attractive features include better optical control for more uniform lighting, reduced backlight and/or light trespass, and preferable color quality. That said, as with most types of LED products, there is substantial variation in product quality, so specifiers must be especially careful about getting the right product for the application.

AT A GLANCE **NUMBER OF PRODUCTS LISTED BY LED LIGHTING FACTS**

LED lighting facts

July 1, 2013

512 Manufacturers
316 Retailers & Distributors
280 Lighting Professionals
104 Energy Efficiency Programs
8,338 Total Active Products

Report Highlights

- All three product categories evaluated included products that exceed 100 lm/W. At the same time, all three categories included products that are less than 50 lm/W. The majority of products emitted between 70 and 90 lm/W, which is generally as good as or better than the incumbent lighting systems.
- In the roadway category, where the incumbent technology is predominantly HPS, few LED products listed by LED Lighting Facts appear to be suitable alternatives to nominally 400 W luminaires. In general, fewer and fewer roadway products are listed as the lumen output range increases. This is one area of potential future growth for LED products.
- Although represented by a smaller sample, luminaires in the canopy category tended to have slightly higher efficacies, as well as higher color temperatures. Despite a lower quantity of products, there were more canopy luminaires over 100 lm/W than either of the other categories.
- LED outdoor area luminaires have a wide variety of color quality attributes, with CRIs mostly between 60 and 80, and CCTs generally between 4000 K and 6000 K. Generalized comparisons between color quality and efficacy may be misleading given the wide variety of individual product performance.

www.lightingfacts.com

Testing and Approving Agencies

- UL Standards and Listings by UL or other testing agencies
- LED Photometric performance IES LM79
- LED Lumen maintenance IES LM80
- DOE Lighting Facts information
- Design Lights Consortium listings of approved luminaires and commercial lighting systems
- ENERGY STAR listings of approved LED products
- Consortium for Energy Efficiency Listings (fluorescent)

Special Note

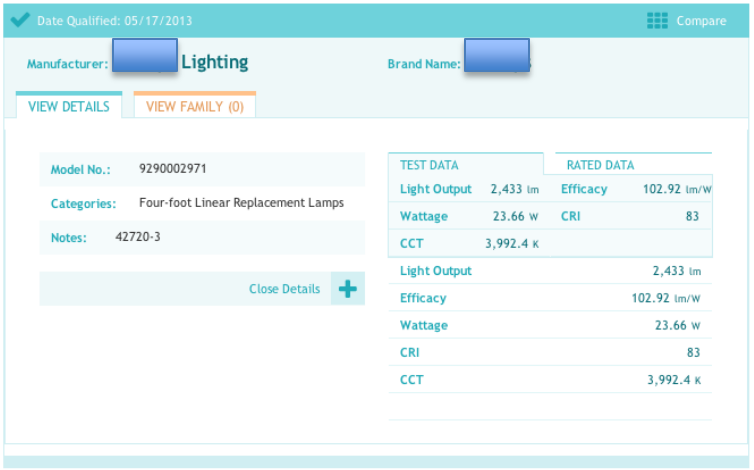
- Efficiency Vermont does not endorse any particular brand or product
- Photos in this program of current products and applications are examples only
- Products listed by agencies like DLC, CEE, US DOE Caliper, and US EPA ENERGY STAR® have been tested and determined to perform according to listing rules and should be given top consideration

Problems of the LED industry

- Unsubstantiated performance claims
- No data (LM79 or LM80)
- Published claims differ from measured data
- Not DLC listed or listing misrepresented
- Use of Scotopic to Photopic ratio (S/P ratio) in marketing materials and “white papers”
- Promoting blue-white light as “better” for any reason
- “Healthy” lamps and lighting systems
- Poor product quality, color and/or performance
- Rapid depreciation
- No warranty or lack of warranty service

Example: What About TLEDs (tubular LED)?

Presently, over 1,400 products are DLC listed. For example, 1 Brand P lamp is listed; Brand P sells other TLED's.



Product Number	Ordering Code	Nom. Watts	Volts	Initial Lumens[4]	Base	CRI	Color Temp. (K)	Pkg. Qty	Rated Avg. Life (Hrs.)[5]	MOL (in.)	Beam Angle
42182-6	10T8/END/24-3500 UNV 10/1	10	100-277	825	G13	85	3500	10	40,000	24	120
42183-4	10T8/END/24-4000 UNV 10/1	10	100-277	825	G13	85	4000	10	40,000	24	120
42186-7	19T8/END/48-3500 UNV 10/1	19	100-277	1650	G13	85	3500	10	40,000	48	120
42187-5	19T8/END/48-4000 UNV 10/1	19	100-277	1650	G13	85	4000	10	40,000	48	120
Number	Code	Watts	Volts	Type	(in.)	Lumens[4]	Base	CRI	(K)	Qty	(Hrs.)[5]
42719-5	22T8/EXT/48-3500K UNV	22.5	100-277	T8	48"	2500	G13	85	3500K	10	50,000
42720-3	22T8/EXT/48-4000K UNV	22.5	100-277	T8	48"	2500	G13	85	4000K	10	50,000
42721-1	22T8/EXT/48-6500K UNV	22.5	100-277	T8	48"	2500	G13	85	6500K	10	50,000

Comparing a Pair of Four Foot Lamps

Brand P Line Voltage T8 LED	Brand P External Driver T8 LED	Brand P T8 Fluorescent
• Rewire fixture • Integral driver • 1650 lumens per lamp • 19 watts per lamp • $40 per lamp • Lamp rated 40,000 hours • LLD = .85	• Replace ballast with driver • Rewire fixture • 2433 lumens per lamp (per DLC) • 48 watts per 2 lamps input to driver • $50 each per lamp • $22 driver • Lamp rated 50,000 hours • LLD = .85	• Replace ballast with efficient .71BF ballast program start 46 watts • 3100 lumen T8 lamps F32T8/841/HP • $4 per lamp • $22 per ballast • Lamp rated 36,000 hours@ 12 hrs (PS) • LLD = .97

DESIGNLIGHTS CONSORTIUM

CEE

LLD = Lamp lumen depreciation at 50% of rated life

Comparing a Pair of Four Foot Lamps

Brand P Line Voltage T8 LED	Brand P External Driver T8 LED	Brand P T8 Fluorescent
• 87 initial lumens per watt	• 104 initial lumens per watt	• 96 initial lumens per watt
• 73.8 mean lumens per watt	• 88.5 mean lumens per watt	• 92.8 mean lumens per watt
• $80 plus labor to install	• $122 plus labor to install	• $34 plus labor to install
• Initial light output 3300 lumens from 2 lamps (33% less light)	• Initial light output 4866 lumens from 2 lamps	• Initial light output 4402 lumens from 2 lamps (9% less light)
• Initial power input 38 watts (37% reduction)	• Initial power input 48 watts (20% reduction)	• Initial power input 46 watts (23% reduction)
• Lamp life 40,000 hours	• Lamp life 50,000 hours	• Lamp life 36,000 hours

Summary: TLED Replacement Lamps

- Fluorescent is comparably energy efficient and long life, but less expensive
- Most TLED's reduce light levels to save impressive amounts of energy
- Fluorescent color is comparable or better
- Fluorescent can be dimmed and still cost less
- TLED makes sense in some circumstances, e.g. in cold temperatures
- LED cost will fall over time
- There is a lot of dishonest TLED marketing

Best Practices in Retail Lighting, especially Retrofits

DISPLAY LIGHTING

Display Lighting Types

- Track lighting
- Monopoint accents
- Low voltage/monorail lighting
- Display case lighting
- Freezer case lighting
- Shelf/undershelf lighting

Point Source Light Sources

Most existing light sources include

- PAR38 halogen
  - typically 60-90 watts
- PAR30 halogen
  - 50-75 watts
- MR16 halogen
  - 37-50 watts

The Market, Plymouth, MA
Courtesy of Retail Design Blog

PAR38 replacement

- Average existing lamp 75 watts, 1100 lumens, CRI~97, 3000K, 3000 hours
- Replacement LED lamp nom. 20 watts, 1100 lumens, CRI~90, 3000K, 25,000 hours

Buyer Considerations

- Quality of Product
- Color rendering index and color quality
- Beamspread, center beam candlepower and beam quality

Recent US DOE/PNNL Testing

Comparing spot lamps (15°)

PAR38 Replacement

Halogen 75 watt

- 6000 annual hours
- 3 months life
- Lamp cost $6.00
- Lamp cost/year $12.00
- Energy cost/year $20.25
- Annual cost $32.25

LED 20 watt

- 6000 annual hours
- 4 years life
- Lamp cost $40.00
- Lamp cost/year $10.00
- Energy cost/year $5.40
- Annual cost $15.40
- PAYBACK in 28 months

PAR30 Replacement

Halogen 50 watt

- 6000 annual hours
- 3 months life
- Lamp cost $6.00
- Lamp cost/year $12.00
- Energy cost/year $13.50
- Annual cost $25.50

LED 12 watt

- 6000 annual hours
- 4 years life
- Lamp cost $30.00
- Lamp cost/year $7.50
- Energy cost/year $3.24
- Annual cost $10.74
- PAYBACK in 24 months

MR16 Replacement

Halogen 35-50 watt

- 6000 annual hours
- 3 months life
- Lamp cost $5.00
- Lamp cost/year $10.00
- Energy cost/year $13.50
- Annual cost $23.50

LED 12 watt

- 6000 annual hours
- 4 years life
- Lamp cost $30.00
- Lamp cost/year $7.50
- Energy cost/year $3.24
- Annual cost $10.74
- PAYBACK in 28 months

Downlight replacement

- LED
- Match color of other lights (2700K, 3000K, 4000K)
- CRI>80
- 850 lumens – 8.8 watts
- 1250 lumens – 12.8 watts
- 2000 lumens – 20.6 watts
- 3000 lumens – 30.9 watts
- Dimmable

What to Look For

Key Features & Benefits

- 95 typical CRI
- Excellent color quality – within a 3-step MacAdam ellipse
- R9 greater than 60
- Assembled in USA
- No warm up time, instant on with full light output and stable color
- Lasts up to 20 times longer than comparable PAR lamps
- Available in 2700K and 3000K color temperature
- Reduces energy consumption up to 80%
- UV and IR free
- RoHS compliant
- Dimmable to 10%*
- Mercury and lead free
- Long life: up to 50,000 hours (L_{70})
- Suitable for damp locations

Application Notes

1. Operating Temperature -40°F and +113° F (-40°C and +45°C)
2. Suitable for outdoor use when used in a UL rated fixture where protected from weather
3. Use in fixtures that support 2lb. lamp
4. Not for use with emergency light fixtures or exit lights
5. Not for use in enclosed fixture

Suggested Choices

General Merchandise

- Color temperature 3000K
- Color rendering index 80 minimum

Color Critical Merchandise

- Color temperature 3000K
- Color rendering index 90 minimum

Incentives for incandescent display replacement

- ENERGY STAR/DLC LED Replacement Lamps
  - Replacing PAR38 $35/lamp (over 2000 products!)
  - Replacing PAR30 $25/lamp
  - Replacing MR16 $15/lamp
- LED Fixtures: Downlights/Accent lights/Track
  - $20 (standard) to $50 (DLC) per track luminaire
  - $14 (standard) to $35 (DLC/ES) downlights

Potential Problems for Replacement Lamps

- Does not last 4 years (24,000 hours)
- Dimming issues (rarely a concern in retail)
- Color quality issues
  - 80 CRI common
  - 85-90 desirable
  - >90 possible and may be needed for some displays
- Beam quality issues
  - Very few can produce a tight beam 15° or less (Spot)
  - Some can produce a decent 25°beam (Narrow Flood)
  - Most can produce a flood 40°beam (Flood)
  - Too many have terrible field and spill control

Other Display Lighting Systems

LED is good in close quarters

- Refrigerated and freezer
- Enclosed display
- Jewelry
- Open display

Best Practices in Retail Lighting, especially Retrofits

GENERAL LIGHTING TO 14’

Normal Ceilings and Mounting Heights

Lighting mounted below ~14’

- T-bar ceiling tile systems
- Sheet rock ceilings
- Clouds
- Open to structure

Troffer Alternatives (including surface versions)

Parabolic – 55 to 80% efficient

Basket 45-75% efficient

Lens troffer– **70 to 88%** efficient

High performance lens – **80 to 90%** efficient

Fluorescent versus LED Troffers

Fluorescent

- System 85 mean lumens per watt
- Standard color temperatures
- 82-86 CRI
- Dimmable
- Lamp life 36,000 hours or more
- 5100 initial lumens @ 56 w
- $.0245 per lumen

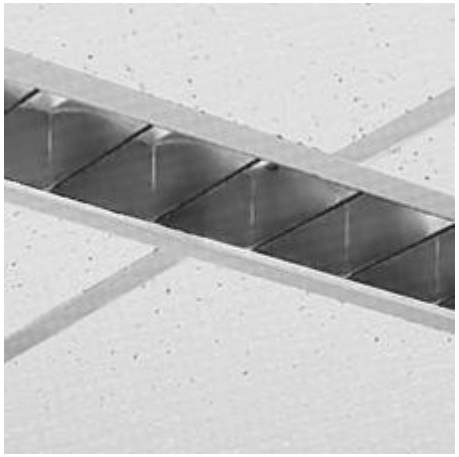
LED

- System 105 mean lumens per watt
- Standard color temperatures
- 80 or 90 CRI
- Dimmable
- Fixture life >>50,000 hours
- 5000 initial lumens at 50 watts
- $0.06 per lumen

Linear recessed lighting

Recessed lens continuous row

Best with LED



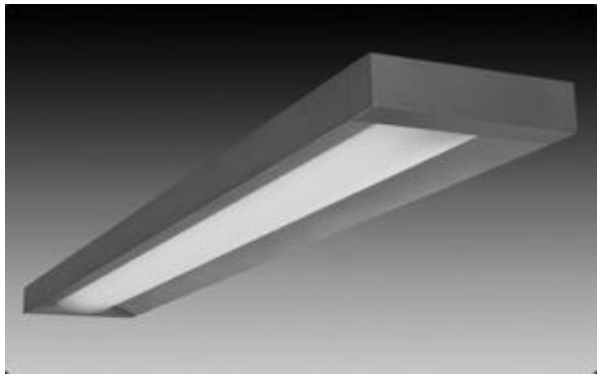
Recessed lens continuous row

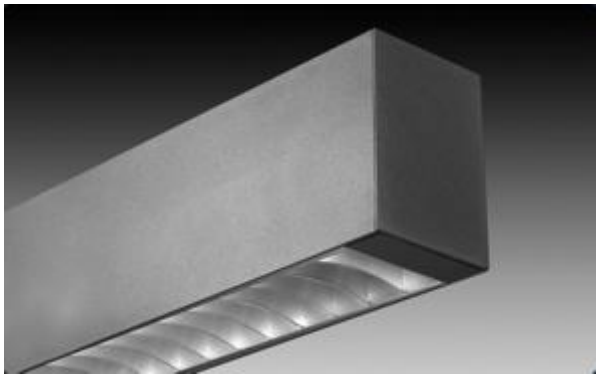
LED or Fluorescent

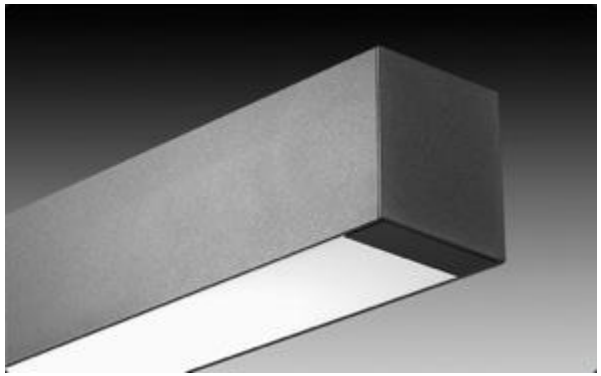
Recessed continuous trough (supermarket trough)

Fluorescent

Architectural Suspended Luminaires

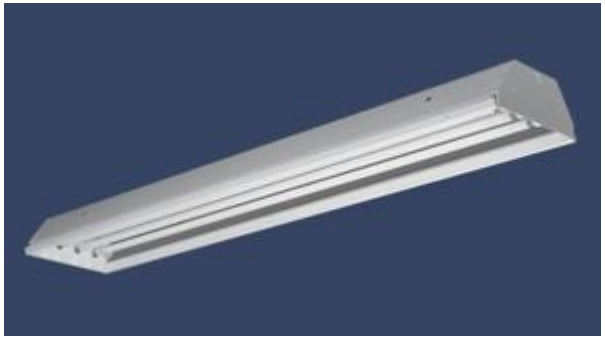


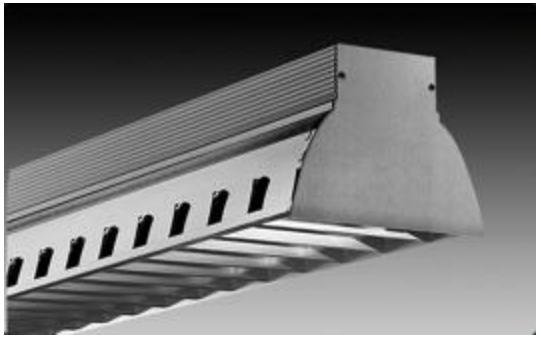




- Direct or direct indirect preferred for efficiency
- LED or fluorescent versions available
- Simple, stylish or themed

Suspended Industrial Style Luminaires





Best Choices for New Construction

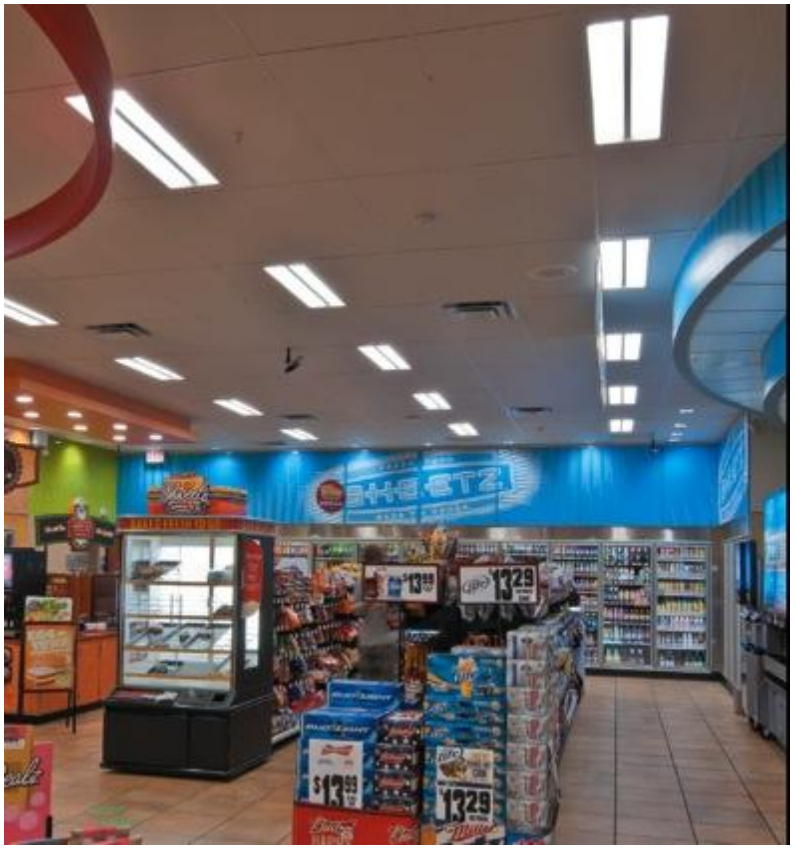
- High performance (“HPT8”) T-8 lamps or T-5 lighting systems with high efficiency ballasts (including high efficiency reduced wattage ballasts and/or lamps called “RWT8”)
- Dimming ballasts or stepped dimming ballasts
- Efficient luminaires
- Prefer direct or semi direct lighting

Best Choices for Retrofits

- High efficiency T8 lamps and electronic ballasts (HPT8)
- Reduced wattage high efficiency T8 lamps and electronic ballasts (RWT8)
  - Low ballast factor ballasts
  - Low wattage lamps
- LED Panel Retrofit Kits (not TLED lamps)
- Consider dimming

Most Efficient

- Dedicated (not TLED) LED troffers or pendants
- With dimming to reduce light levels when full light is not needed



Some Linear Fixture Incentives

- High Performance fixtures (HPT8 or T5)
  - $10 to $60 per fixture
- HPT8 retrofits/RWT8 retrofits
  - $10 to $20/fixture

Best Practices in Retail Lighting, especially Retrofits

GENERAL LIGHTING HIGH BAY

Warehouse and High Ceiling Spaces

- Lighting mounted above ~ 14’
- Commercial lighting “high bay”
- Industrial lighting terms
  - Spaces up to 25’ called “low bay”
  - Taller spaces called “high bay”

Hint for efficiency: white ceiling

Alternatives in Fluorescent

High bay fluorescent

Representative Products

- 4 lamp T5HO @49 w = 208 watts
- 20,000 lumens @ 95% fixture efficiency = 19,000 lumens initial and 17,500 mean lumens
- Narrow, wide or aisle beam
- 6 lamp T5HO = 28,500 lumens initial and 26,250 mean lumens at 308 watts

Options include

- T8 lamps (longer life)
- Dimming and multi level ballasts

Alternatives in LED (all 4000K >75 CRI)

- 108, 145, 218 and 292 watt versions
- Narrow, medium and wide beams
- 108 w/8,856 lumens
- 292 w/23,944 lumens

DESIGNLIGHTS CONSORTIUM

- 93 watts , 6461 lumens
- Wide beam
- Aisle beam available

- 112, 139 and 169 watt versions
- Narrow, medium and wide beams
- 112 watts/7975 lumens (80 CRI)
- 139 watts/9969 lumens (80 CRI)

DESIGNLIGHTS CONSORTIUM

Alternatives in LED (all 4000K >75 CRI)

- 1 to 12 module versions
- Narrow, medium and wide beams
- Aisle beam available
- 79 to 125 watt modules
- 104 w/9,177 lumens

- 61-385 watt versions (80 CRI, 4500K)
- Medium (“high bay”) and Wide (“low bay”) beam
- 129 w/11,275 lumens

Summary

Typical Luminaire 4000-4500K

Typical efficacy of luminaire 75 to 90 initial LPW/ 63 to 77 mean LPW

Up to about 385 watts in one box/1500 watts using modular assemblies

Alternatives in HID

OLD - Original Probe Start Metal Halide w/magnetic ballast

- 400 watt/36,000 lumens/60% LLD/62 CRI @ 4200K – 458 watts
- 250 watt/20,000 lumens/60% LLD/62 CRI @ 4200K – 305 watts

NEW - Ceramic Metal Halide w/electronic ballast

- 400 watt/36,000 lumens/80% LLD/90 CRI @ 4200K – 422 watts
- 250 watt/22,000 lumens/80% LLD/90 CRI @ 4200K – 269 watts

Fixture Efficacies

OLD HID LIGHTING

400w lamp/magnetic ballast = 78 initial LPW/47 mean LPW

250w lamp/magnetic ballast = 65 initial LPW/39 mean LPW

NEW HID LIGHTING

400w lamp/electronic ballast = 85 initial LPW/68 mean LPW

250w lamp/electronic ballast = 82 initial LPW/65 mean LPW

Alternatives in Induction

- Long life alternative
- Representative Data
  - (2) 150 watt lamps, 24030 initial fixture lumens, 312 watts, 77 initial lumens per watt, 69 mean lumens per watt
  - Requires lamp specific optics
  - 100,000 hour lamp life
  - 4100K, 80 CRI

Which High Bay To Choose?

Lamp	Initial Fixture LPW	Mean Fixture LPW	Cost/initial lumen	Watts per 20K mean lumens	Lamp Life in hours	Notes
Fluorescent T5HO	91	85	$0.015	235	24K	Cold not OK
Fluorescent T8	97	**92**	$0.013	**217**	36K	Neither hot/cold
LED	75-90	63-77	$0.045	260-317	50K	Cold OK
HID Magnetic old	78	**47**	$0.005	**425**	20K	Cold OK
HID electronic new	85	68	$0.015	294	20K	Cold OK
Induction	77	69	$0.017	290	100K	Cold OK

HID Replacement LED Lamps

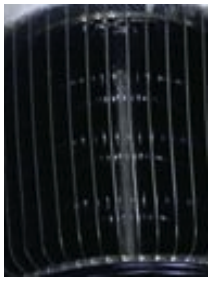
Sampling of several products

- 17,200 initial lumens, 5000K, 80 CRI, 140 degree beam (very wide), 180 watts
- 10,000 initial lumens, 5500K, 80 CRI, 130 watts, no beamspread information
- 12,000 initial lumens, 5700K, 84 CRI, 150 watts, no beamspread information
- 10,170 initial lumens, 5500K, 72 CRI, 122 watts, many beamspread options, DLC listed

All of these lamps claim to replace 400 watt metal halide.

SUMMARY OF OPTIONS

- Products are around 80 initial lumens per watt
- Most require internal rewiring of MH luminaire
- Most have no candlepower control
- A used 400 w metal halide is at least 20,000 lumens – can't be replaced without loss of light, but big energy savings are possible



High Bay incentives

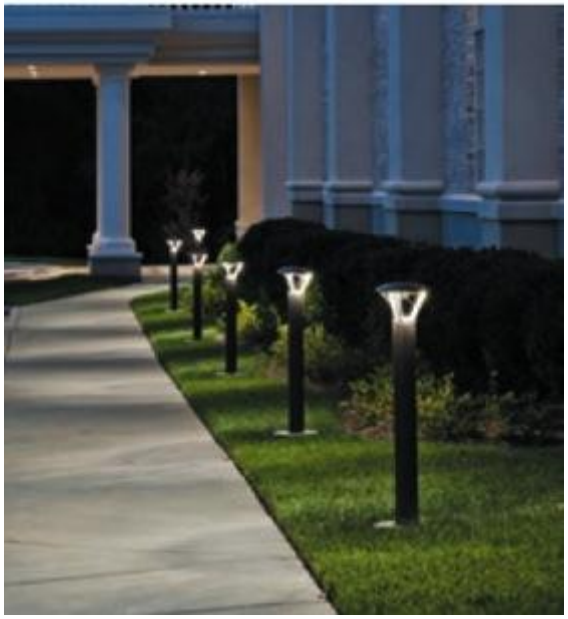
Must be permanent luminaire hard wired conversions of “old” metal halide to:

- High bay fluorescent (3-6 lamp T5 or T8)
- LED high bay fixture (or adaptor kit)
- $50-$125 per HID fixture replaced

Best Practices in Retail Lighting, especially Retrofits

OUTDOOR LIGHTING

Sites: Poles, Bollards, Wallpacks



Why LED is different

- More uniform lighting
- Less light at base of pole
- Lower average light level
- Lower wattage possible
- Same pole count and height
- Use 40% of the watts of magnetic ballasted metal halide
- Use 60% of the watts of HPS

Pole Lighting Options

Metal Halide

- White light CRI 65
- 39 mean lumens per watt (250 watt)
- Shoebox fixture $250 plus labor to install
- Average mean light level 1.5 footcandle
- Minimum light level 0.1 footcandle
- Lamp life 20,000 hours
- Energy $120/year

High Pressure Sodium

- Pink-yellow light CRI 21
- 78 mean lumens per watt (150 watt)
- Shoebox fixture $250 plus labor to install
- Average mean light level 1.8 fc
- Minimum light level 0.12 footcandle
- Lamp life 30,000 hours
- Energy $75/year

LED

- White light CRI 75
- 75 mean lumens per watt (90 watt)
- Shoebox fixture $600 plus labor to install
- Average mean light level 1.1 fc
- Minimum light level 0.12 footcandle
- Lamp life >50,000 hours
- Energy **$36**/year

LED Pole Light Incentives

- Pole Lights –replacing HID
  - HID to LED $40-$300/fixture

Wall Pack Lighting Options

Metal Halide

- White light CRI 65
- 26 mean lumens per watt (50 watt)
- Fully shielded fixture $150 plus labor to install
- Lamp life 10,000 hours
- Energy $31/year

High Pressure Sodium

- Pink-yellow light CRI 21
- 44 mean lumens per watt (35 watt)
- Fully shielded fixture $150 plus labor to install
- Lamp life 30,000 hours
- Energy $20/year

LED

- White light CRI 75
- 75 mean lumens per watt (20 watt)
- Fully shielded fixture $300 plus labor to install
- Lamp life >50,000 hours
- Energy **$9**/year

Wall pack Incentives

Wall Packs – replacing HID

- HID to LED $40-$300/fixture

Bollards

- Variety of styles to choose
- Many are fully shielded
- Replace metal halide bollards with 1/3 the watts
- Bollard HID to LED $40 to $175 incentive

Commentary about light color outdoors

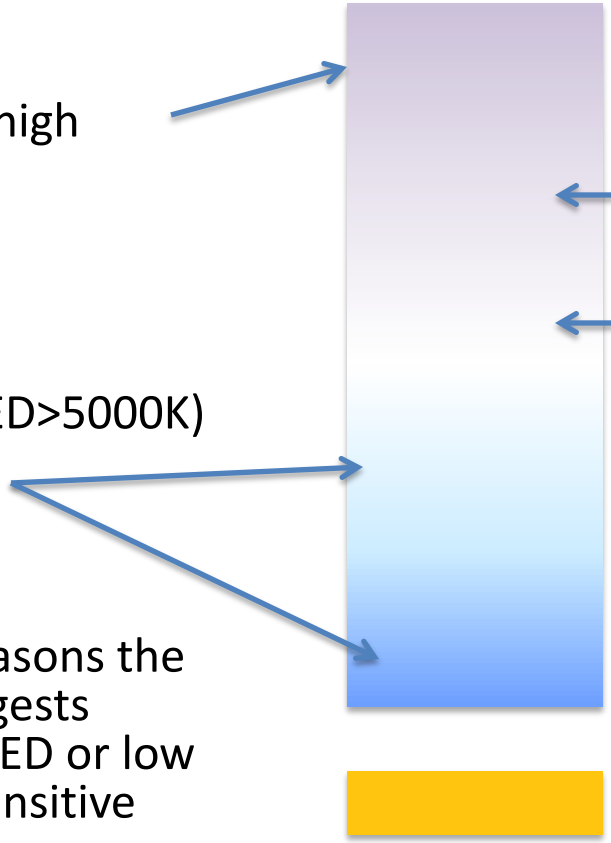
People ***don't*** like

- Very warm color (high pressure sodium)

People ***don't*** like

- Very cold color (LED>5000K)

For environmental reasons the current evidence suggests narrow band amber LED or low pressure sodium in sensitive locations



People *like*

- **Warm color (2700-3000K)**
- **Neutral color (3500-4500K)**

Canopies

Recessed canopy downlights

- Dark sky and neighbor friendly
- Standard light levels 50 fc
- Metal halide 250-400 watt
- LED 100-160 watt

Color Band

- Fluorescent 15 watt /sf
- LED 7.5 watt/sf (or less with color LED)

Canopy Incentives

- Canopy Incentives (Replacing HID)
  - LED $40-$200/fixture

Retrofit Kits

- An alternative to replacing fixtures
- For pole lights, canopy lights and almost all other types
- Requires ballast removal or disconnection
- Cost nearly the same as a new fixture
- Cooling of high wattage units requires a fan
- Most are >5000K and low CRI

Best Practices in Retail Lighting, especially Retrofits

SKYLIGHTS

Skylights for Big Boxes Work

Major Brands Use Them

- Wal-Mart
- Costco
- Home Depot

Benefits

- Significant energy cost reduction of 35-40%
- Better color rendering
- Happier, healthier work force
- Higher light levels by day

Two Approaches

Normal Big Box General Lighting Cost (24/7) = $1.05/sf

Full Skylighting

- 4-5% skylight to floor ratio
- Achieves 40-150 footcandles without electric lighting most days
- Dim or extinguish electric lighting
- Electric lighting 50-60 footcandles at night
- Annual electric cost ~70¢/sf (33% savings)
- Costs much more to build

Hybrid Electric Skylighting

- 2-3% skylight to floor ratio
- Electric lights operate 24/7 at 30-40 footcandles
- Daylighting adds 20-75 footcandles during the day
- Naturally adapts shoppers' eyes
- Annual electric cost ~ 60¢/sf (43% savings)
- Costs more to build but less than full skylighting

Best Practices in Retail Lighting, especially Retrofits

LIGHTING CONTROLS

Control System Options

Old School

Exterior

- Lights off by day

Interior

- Lights off when not open
- Reduced lighting during stocking and cleaning

New School

Exterior

- Lights off by day
- Lights dim after hours

Interior

- Lights off when not open
- Reduced lighting during stocking and cleaning
- Reduced lighting when shoppers are not present

Best Practices in Retail Lighting, especially Retrofits

QUESTIONS?