

FEMP Exterior Solid-State Lighting Initiative: High Performance Parking Lot Lighting



FEMP Webinar
January 24, 2012

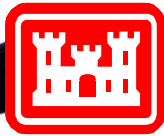
Michael Myer, PNNL
Jeff McCullough, PNNL

- FEMP Exterior Solid-State Lighting (SSL) Initiative
 - Forthcoming Army Policy
 - FEMP-Designated Performance Levels
 - DesignLights™ Consortium (DLC)
 - Resources
- Update on the L Prize™ Competition
- **Featured Topic:** High Performance Parking Lot Lighting
- Questions and Answers

***Solid-State Lighting** is an umbrella term that encompasses both organic light emitting diodes (OLEDs) and inorganic light emitting diodes (LEDs). Present applications focus on LEDs, but OLEDs may find their way into the marketplace as technology improves.*

FEMP Exterior SSL Technology Deployment

With support from FEMP, the U.S. Army Corps of Engineers (USACE) is developing a policy and implementation plan (including guidance materials, training, qualified product lists, and performance specifications) in support of the widespread adoption of exterior SSL in the Federal sector.



USACE

Collaboration



Army Exterior SSL Policy Announcement



Widespread deployment in Army and other agency facilities



Outreach

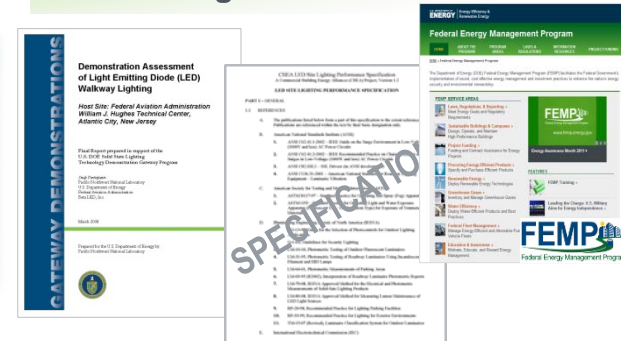
Training



Webinars

Support Resources

FEMP Designated Products



- Technical Assistance to Exterior SSL Policy Development
 - Provide technical guidance to the USACE (and others) on a policy to standardize SSL technology in exterior areas
 - Construction Standard Specifications
- FEMP-Designated Exterior SSL Performance Levels and Product List
 - Utilize DesignLights™ Consortium Qualified Products List
- SSL Exterior Lighting Outreach/Education
 - Guides, Training Materials, Field Guides, Fact Sheets, Etc.
- Federal Market Assessment for Exterior SSL
- FEMP Exterior SSL Initiative Website:
 - www.femp.energy.gov/technologies/solid_state_lighting.html

Technical Requirements Table v1.6

See a list of our category definitions here


| Designlights™ Consortium Qualified Products List- Non-Residential Applications – Submit any or all of the following product Information and Testing Results to Designlights for qualification <i>*please make note that it is ONE per submission*</i> PDF Download | | | | | | | |
|--|----------------------|----------------------------|----------------------------|------------------------------------|-------------|-----------------------|----------------------------|
| Application | Minimum Light Output | Zonal Lumen Density | Minimum Luminaire Efficacy | Allowable CCTs (ANSI C78.377-2008) | Minimum CRI | L70 Lumen Maintenance | Minimum Luminaire Warranty |
| 1) Outdoor Pole/Arm-Mounted Area and Roadway Luminaires | 1,000 lm | =100% 0-90°, <10% 80-90° | 60 lm/W | ≤5700K | 50 | 50,000 hrs | 5 years |
| 2) Outdoor Pole/Arm-Mounted Decorative Luminaires | 1,000 lm | ≥65%: 0-90° | 40 lm/W | ≤5700K | 50 | 50,000 hrs | 5 years |
| 3) Outdoor Wall-Mounted Area Luminaires | 300 lm | =100% 0-90°, <10% 80-90° | 60 lm/W | ≤5700K | 50 | 50,000 hrs | 5 years |
| 4) Bollards | 500 lm | <15%: 90-110° 0%: >110° | 35 lm/W | ≤6500K | 50 | 50,000 hrs | 5 years |
| 5) Wall-wash Luminaires | 575 lm | ≥50%: 20-40° | 40 lm/W | ≤5000K | 50 | 50,000 hrs | 5 years |
| 6) Parking Garage Luminaires | 2,000 lm | ≥30% 60-80°, ≤25% 70-80° | 60 lm/W | ≤5700K | 50 | 50,000 hrs | 5 years |

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

FEDERAL ENERGY MANAGEMENT PROGRAM

A FEMP Outdoor SSL Initiative

Resources for Outdoor SSL Applications



LED lighting installed in the parking garage of the Frances Perkins Building, U.S. Department of Labor headquarters, Washington, D.C.

Outdoor Solid-State Lighting in the Federal Sector

The Federal Energy Management Program (FEMP) is encouraging Federal agencies to accelerate the thoughtful application of outdoor solid state lighting luminaires. The FEMP Outdoor SSL Initiative offers a unique opportunity for the Federal sector to lead a large-scale implementation effort focused on an SSL application that is ripe for near term implementation through a process that recognizes the technology's potential, as well as its challenges. This initiative is intended to help Federal energy managers overcome the widespread misinformation they are encountering, learn about this technology and its unique attributes, and provide the tools needed to make good decisions that result in cost effective energy savings, and good quality lighting.

As part of this initiative, FEMP will leverage existing SSL outdoor tools and materials, and will develop new ones as needed to meet the unique needs of Federal agencies. This paper provides an overview of existing outdoor SSL resources developed by the US Department of Energy's SSL Program and other Federal initiatives including:

- SSL Street/Roadway Lighting
- SSL Site (Parking Lot/Garage) Lighting
- General SSL Resources

Street/Roadway Lighting

A variety of resources are available for facility managers interested in pursuing SSL street and roadway lighting, including DOE SSL GATEWAY demonstration project results, a Fitted Target Efficacy Calculator, and DOE CALiPER test results.

Municipal Solid-State Street Lighting Consortium Fact Sheet

The Consortium shares technical information and experiences related to LED street and area lighting demonstrations. The Consortium also serves as an objective resource for evaluating new products on the market intended for street and area lighting applications. http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/consortium_fs.pdf

DOE SSL GATEWAY Demonstration Project Results

DOE GATEWAY demonstrations showcase high-performance LED products for general illumination in a variety of commercial and residential applications. Demonstration results provide real-world experience and data on state-of-the-art solid-state lighting (SSL) product performances and cost effectiveness. The following studies have been completed on Street/Roadway lighting:

• LED Roadway Lighting: Palo Alto, California

Assessment of energy, economic, and performance impacts of replacing high-pressure sodium street lights with LED and induction street lights. http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/gateway_palo_alto.pdf

According to the U.S. Department of energy, no other lighting technology offers as much potential to save energy and enhance the quality of our building environments, contributing to our nation's energy and climate change solutions.

http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/gateway_market_factsheet.pdf

• LED Street Lighting: Lija Loop, Portland, OR

Analysis of the energy and performance impacts of replacing eight high-pressure sodium street lights on one residential street with LED luminaires.

http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/gateway_lija-loop.pdf

• LED Roadway Lighting: I-35W Bridge

Analysis of Phase 1 results, completed in September 2008, Phase 2 involves long-term monitoring to evaluate lumen depreciation, physical effects, and performance impacts over time. http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/gateway_i-35w-bridge.pdf

continued >

Street/Roadway Lighting

- Municipal SSL Consortium
 - Performance Specification
- U.S. Department of Energy (DOE) SSL Gateway Demos
- CALiPER Test Results

Parking Lot/Structure Lighting

- DOE SSL Gateway Demos
- CBEA Performance Specs
 - Lot and Structure Lighting

General Resources

- DOE SSL Program
- Design Lights Consortium
- Qualifying Products Lists

What is the L Prize?

- Technology competition to spur innovation and exceptional performance
- Created under Section 655 of the Energy Independence and Security Act (EISA) of 2007
- Two key lamp replacements:
 - 60W Incandescent
 - PAR 38 Halogen
- Future focus: 21st century lamp
- Cash prizes, federal purchasing, utility programs



L Prize 60W incandescent replacement will use 10 watts.

L Prize Competition Requirements

- Exceptional efficacy
- Long life
- Form factor identical to lamps they replace
- Additional details specified for
 - Quality
 - Performance
 - Mass manufacturing

Competition Requirements

60W Incandescent Replacement Lamp

- *More than 90 lm/W*
- *Less than 10 watts*
- *More than 900 lumens*
- *More than 25,000 hour life*
- *More than 90 CRI*
- *Between 2700-3000 K CCT*

PAR 38 Halogen Replacement Lamp

- *More than 123 lm/W*
- *Less than 11 watts*
- *More than 1,350 lumens*
- *More than 25,000 hour life*
- *More than 90 CRI*
- *Between 2700-3000 K CCT*

21st Century Lamp

- *To be defined in a future L Prize Program Announcement*

Winning Lamp Coming to Market Soon



L PRIZE[®]
WINNER

Focus on Promotion of Winning Lamp

- Philips planning for commercial rollout February 2012
- Consumer rollout in April 2012
- Coordinating plans and promotions with partners
- Partner feedback on production lamp has been very good, noting:
 - Improved dimming
 - Streamlined/improved appearance
 - Excellent light output
 - Excellent color

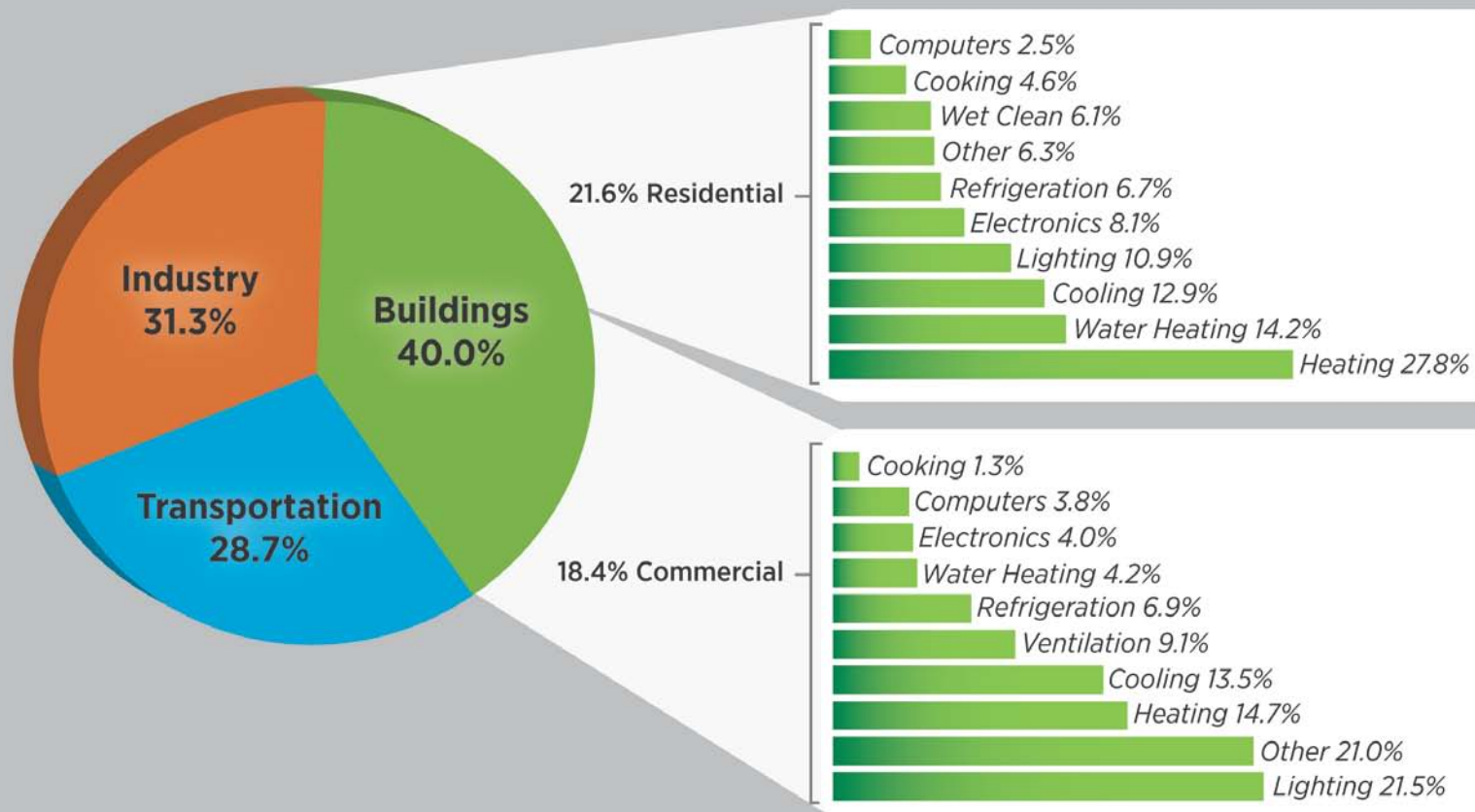
Philips LED L Prize Audit Tool

- Calculate energy savings for the 10 Watt A-shape retrofit LED
- www.usa.lighting.philips.com/lightcommunity/trends/l-prize/
- Additional resources available

- Overview
- Illuminance
- Lighting Power Density (LPD)
- Economics
- Reliability
- Specifications in Practice

Overview: U.S. Energy Use

2008 Buildings Share of U.S. Primary Energy Consumption End-Uses



Source: Building Energy Data Book <http://buildingsdatabook.eren.doe.gov/>
Tables 1.1.3, 2.1.5, 3.1.4

Note: The "Adjust to SEDS" percentage for the residential and commercial end-use splits were distributed among the other categories.

Performance Specification:

- Adopted by end user/site
 - E.g., Walmart, Walgreens, Regency Centers
- Product must deliver X (e.g., lumens, foot-candles (fc), uniformity) for Y energy units (e.g., W/sf, W, kWh)

Technology Specification:

- Can be done via RFP/mass procurement
- Can be incentivized by utility or energy efficiency program
- Example of lighting, product X delivers Y lumens for Z watts
- Examples: ENERGY STAR[®], CEE Premium T8s, Etc.

Illuminance: What is required?

Illuminance

| Recommendation per RP-20-00 | Basic | Enhanced Security |
|---------------------------------------|--------|-------------------|
| Minimum Horizontal Illuminance | 0.2 fc | 0.5 fc |
| Uniformity Ration: Maximum to Minimum | 20:1 | 15:1 |
| Minimum Vertical Illuminance | 0.1 fc | 0.25 fc |

- RP-20-00 sets a relatively low **MINIMUM** illuminance
- Sites actually require:
 - 3 fc average
 - 5 fc average
 - 10 fc average
 - “As much allowed by code”
- Average is misleading:
 - 18, 0.3, 7, 2, 3 = Average of 6.0
 - 4, 0.8, 2, 3, 2.5 = Average of 2.5

**RP-20 is being revised;
Value will probably
change**

Illuminance Requirements

Main (General) Parking Area

| Ambient Condition | Horizontal Illuminance | Vertical Illuminance |
|-------------------|------------------------|----------------------|
| Lighting Zone 0 | N/A | N/A |
| Lighting Zone 1 | N/A | N/A |
| Lighting Zone 2 | 0.50 fc | 0.25 fc |
| Lighting Zone 3 | 0.75 fc | 0.40 fc |
| Lighting Zone 4 | 1.00 fc | 0.50 fc |

Notes:

1. Values in table are minimum values
2. Horizontal illuminance is on the parking surface
3. Vertical illuminance is taken 5' above finished grade (AFG)

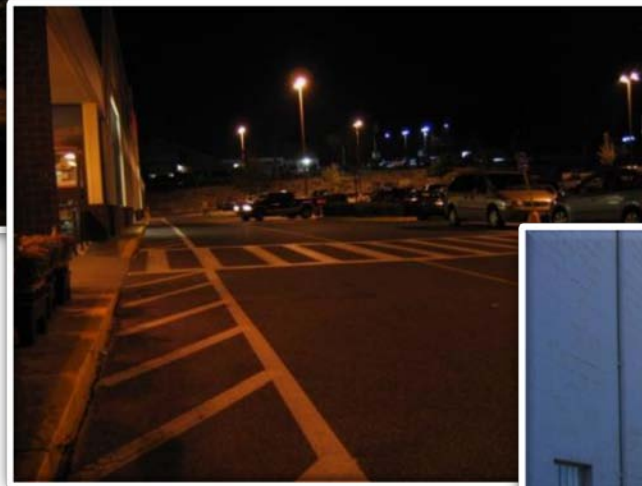
Illuminance levels will probably change in response to RP-20

Illuminance: What is required?

Parking Lot Areas



Perimeter Parking



Front Aisle



Loading/Rear Drive

Illuminance: What is required?

Illuminance Requirements

| Other Parking Areas | | | |
|---------------------|-------------------|-------------|--|
| Ambient Condition | Perimeter Parking | Front Aisle | Entry Drives, Loading Areas, Rear Drives |
| Lighting Zone 0 | N/A | N/A | N/A |
| Lighting Zone 1 | N/A | N/A | N/A |
| Lighting Zone 2 | 0.20 fc | 1.00 fc | 0.20 fc |
| Lighting Zone 3 | 0.40 fc | 1.50 fc | 0.40 fc |
| Lighting Zone 4 | 0.50 fc | 2.00 fc | 0.50 fc |

Notes:

1. Values in table are minimum values
2. Horizontal illuminance is on the parking surface

Illuminance levels will probably change in response to RP-20

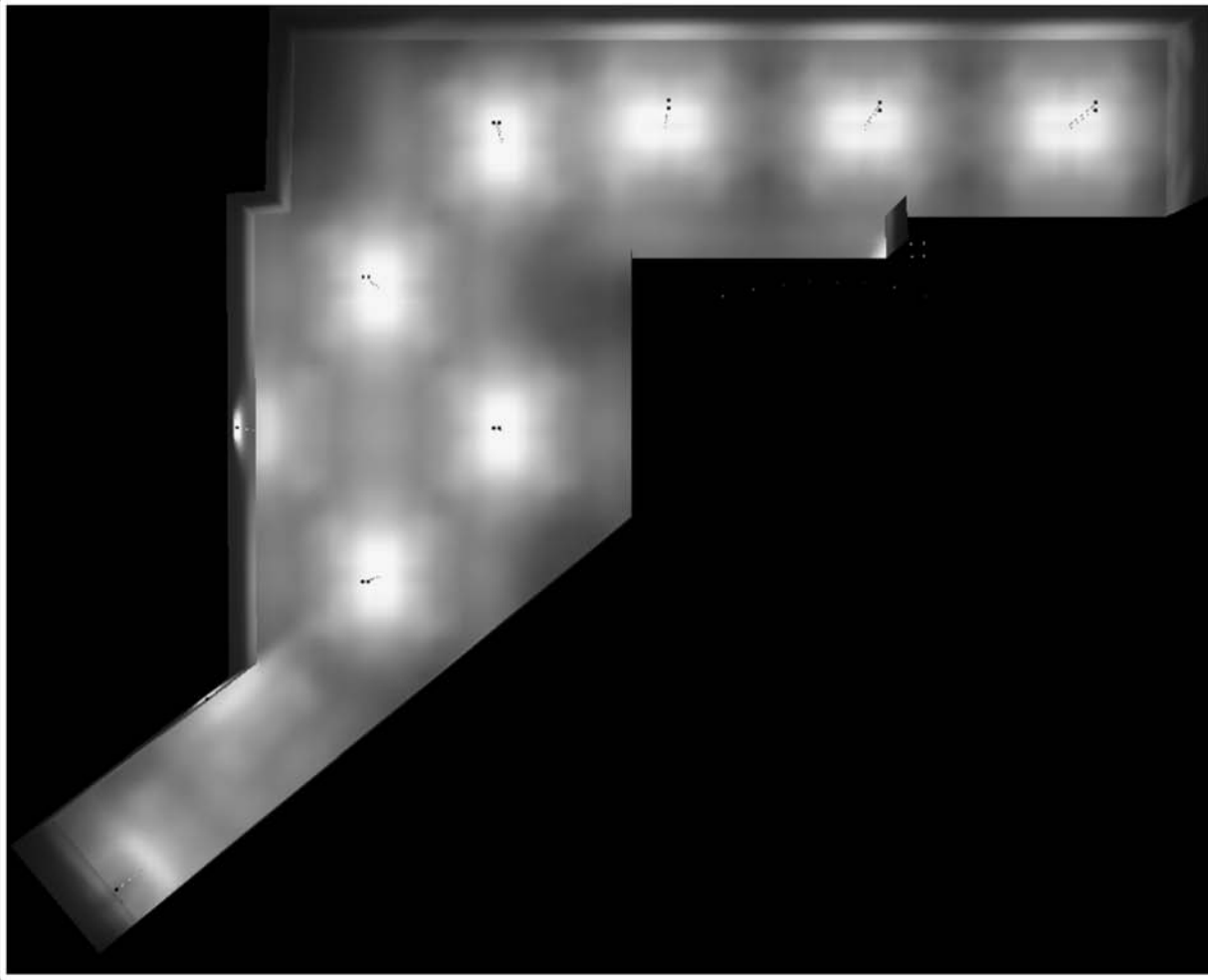
Comparison of Power Density

| Zone | CBEA Spec | ASHRAE/IESNA Std. 90.1-2007 | ASHRAE/IESNA Std. 90.1-2010 | CA Title 24-2008 |
|-----------|-----------|-----------------------------|-----------------------------|-----------------------|
| All Zones | | 0.15 W/sf | | |
| 4 | 0.08 W/sf | | 0.13 W/sf | 0.115 W/sf +1,030W |
| 3 | 0.06 W/sf | | 0.10 W/sf | 0.092 W/sf +770W |
| 2 | 0.05 W/sf | | 0.06 W/sf | 0.045 W/sf +510W |
| 1 | 0.04 W/sf | | 0.04 W/sf | 0.036 W/sf +340W |

Consult specific code for all requirements

Limiting LPD → Energy Savings

Why a Performance Spec? Pulse-Start Metal Halide Example



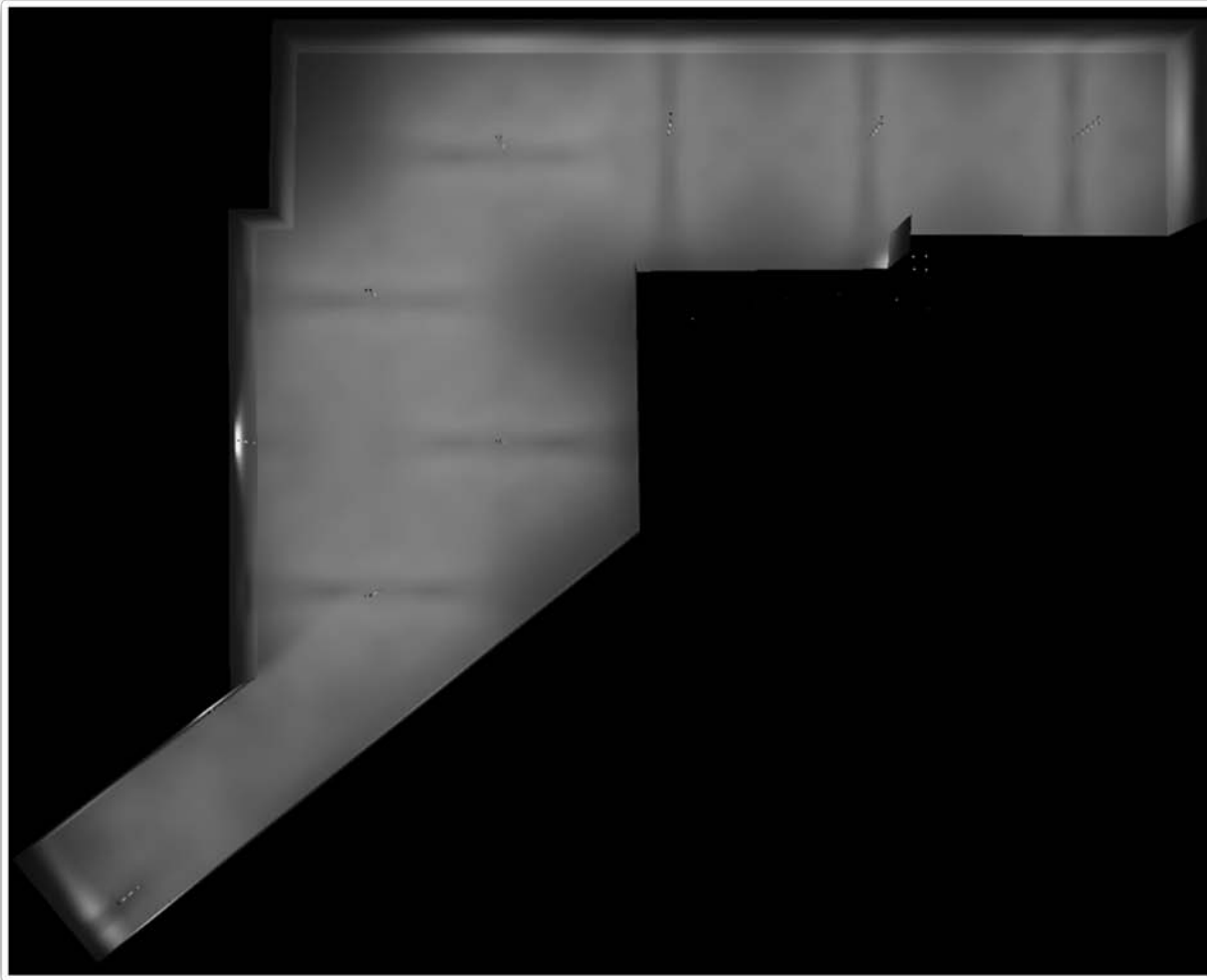
Computer Rendering

Lighting System:
400 W Pulse Start
Metal Halide fixture

Illuminance Data:
Average: 4.85 fc
Max: 15 fc
Min: 0.2
Max: Min: 75

Power Density:
0.10 W/sf

Why a Performance Spec? LED Example



Computer Rendering

Lighting System:
217 W LED fixture

Illuminance Data:

Average: 2.02 fc

Max: 3.5 fc

Min: 0.3

Max: Min: 11.67

Power Density:
0.06 W/sf

More than just LEDs – Use controls!

Highlights

Bi-level LED lighting uses motion sensors to reduce lighting levels when the parking area is not in use

Application

Bi-level LED lighting is appropriate for garage, parking lot, and pedestrian areas

Can also be applied to pathway lighting where appropriate

Key Factors for Deployment

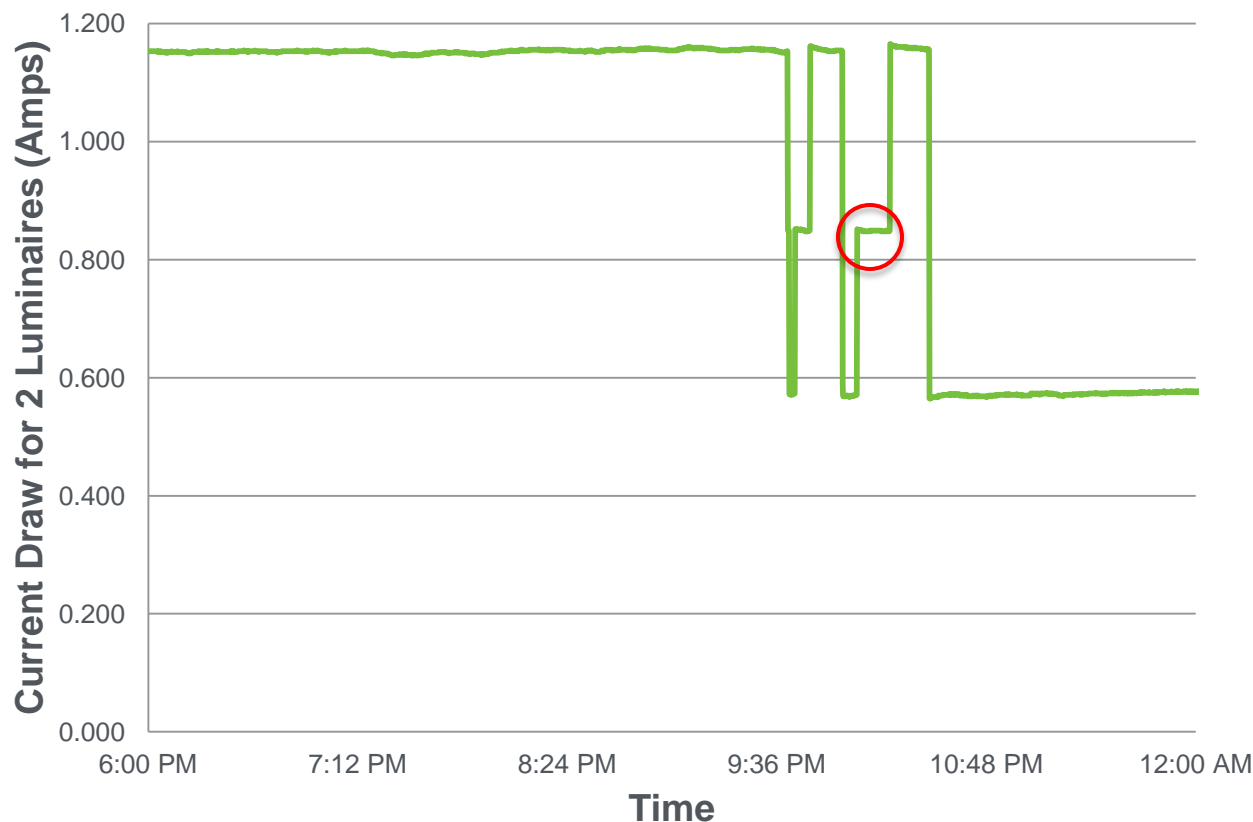
Evaluate specific lighting and environmental requirements before deployment

Ranking Criteria

0 (low) – 5 (high) & Weighted Score: 0 (low) – 100 (high)

| Metric | Federal Energy Savings | Cost Effectiveness | Probability of Success | Weighted Score |
|---|------------------------|--------------------|------------------------|----------------|
| Weighting | 50% | 30% | 20% | 100% |
| Exterior LED Value | 2.2 | 3.0 | 4.8 | 59 |
| Bi Level Garage/Parking Lot/Pedestrian Lighting Value | 0.9 | 4.0 | 5.0 | 53 |

Measured Current Over Time



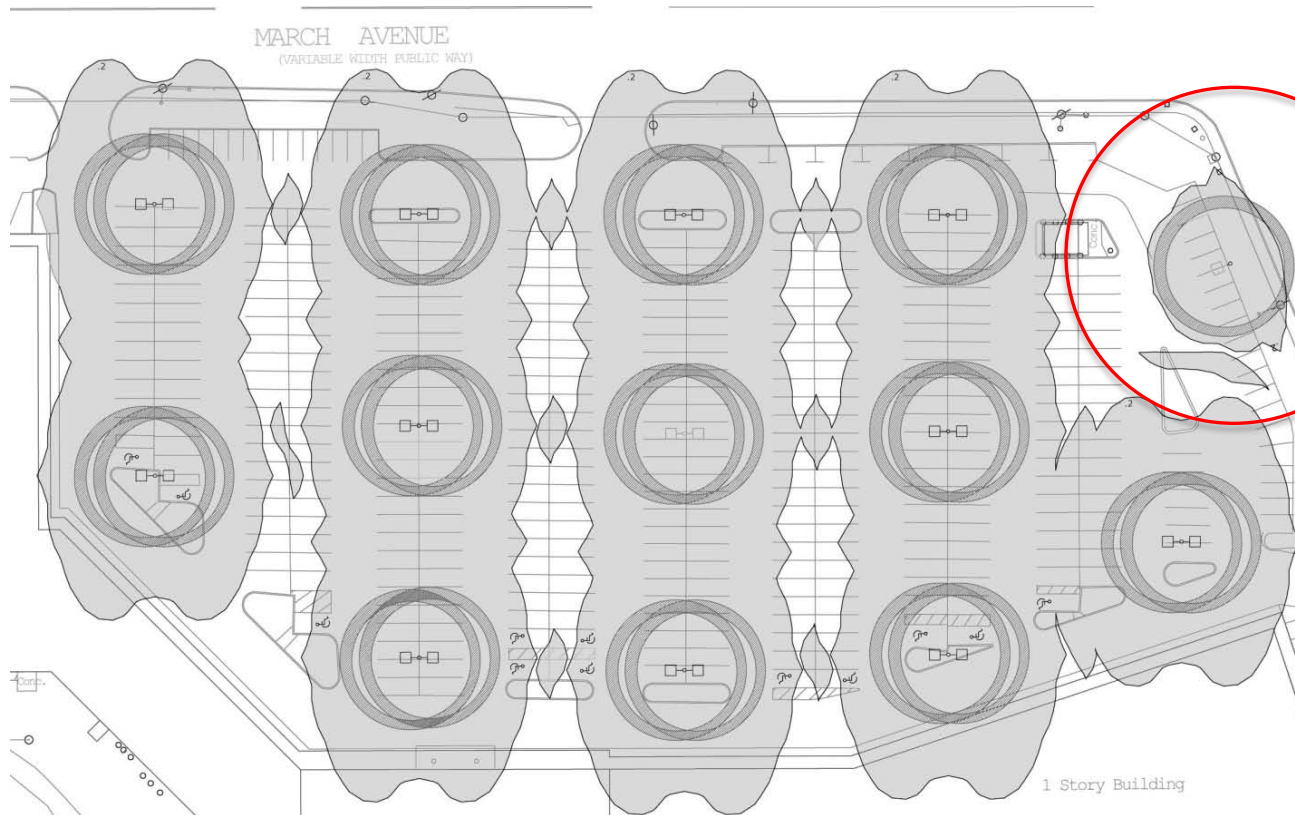
Overview:

- Retail parking lot
- November 2010
- High state – 1.16 A
2 luminaires
- Low State – 0.58 A
2 luminaires
- “Split-State” –
1 high & 1 low – 0.87 A
(red circle)

Energy #s:

- 45% of operating hours in “low state”
- 55% of operating hours in “high state”

Bi-Level Controls: Probability of Success



Overview:

- Retail parking lot
- Shaded area 0.2 fc
- Circles show coverage of sensor

- Sensor symmetrical/ affected by off site (**red circle**)

Hours of Operation

| Daily Hours of Operation | 4 | 8 | 12 |
|---------------------------|-------|--------|-------|
| Annual Hours of Operation | 1,460 | 2,920 | 4,380 |
| Possibility | Low | Medium | High |

- Energy = power X time
- Energy can be saved by:
 - Reducing power - Limiting LPD (see earlier slide)
 - Reducing time (operating hours)
 - Combination of both
- Combination – LEDs can be dimmed or controlled with occupancy sensors
- Sites need to evaluate operation

Maintenance

- Lamps and ballasts have to be monitored and replaced
- Maintenance is a real cost, not always factored in or known
- Actual price will vary by mounting height and geographical location
- Real numbers from real installations:
 - \$225 – average
 - \$65/person/hour – RSMeans
 - \$130 - \$150 – Minnesota
 - \$225 – California
 - \$400 – New Hampshire
- Deferred maintenance costs helps with payback of LEDs



LED Luminaire Lumen Output Correlates to Cost

| | LED | | MH Shoebox | | MH "Architectural" |
|------------------|------------|------------|-------------|-------------|-----------------------|
| Power | 110 | 220 | 288 | 456 | 456 |
| Luminaire Lumens | 7,000 | 14,000 | 16,476 | 28,421 | 29,307 |
| Price | \$1352 | \$2372 | \$625 | \$695 | \$911 |
| Lumen per Dollar | 5.18 lm/\$ | 5.90 lm/\$ | 26.36 lm/\$ | 40.63 lm/\$ | 32.17 lm/\$ |

Disclaimer: Price will vary per project. Values shown to highlight relationship between price and output



Source: Grainger

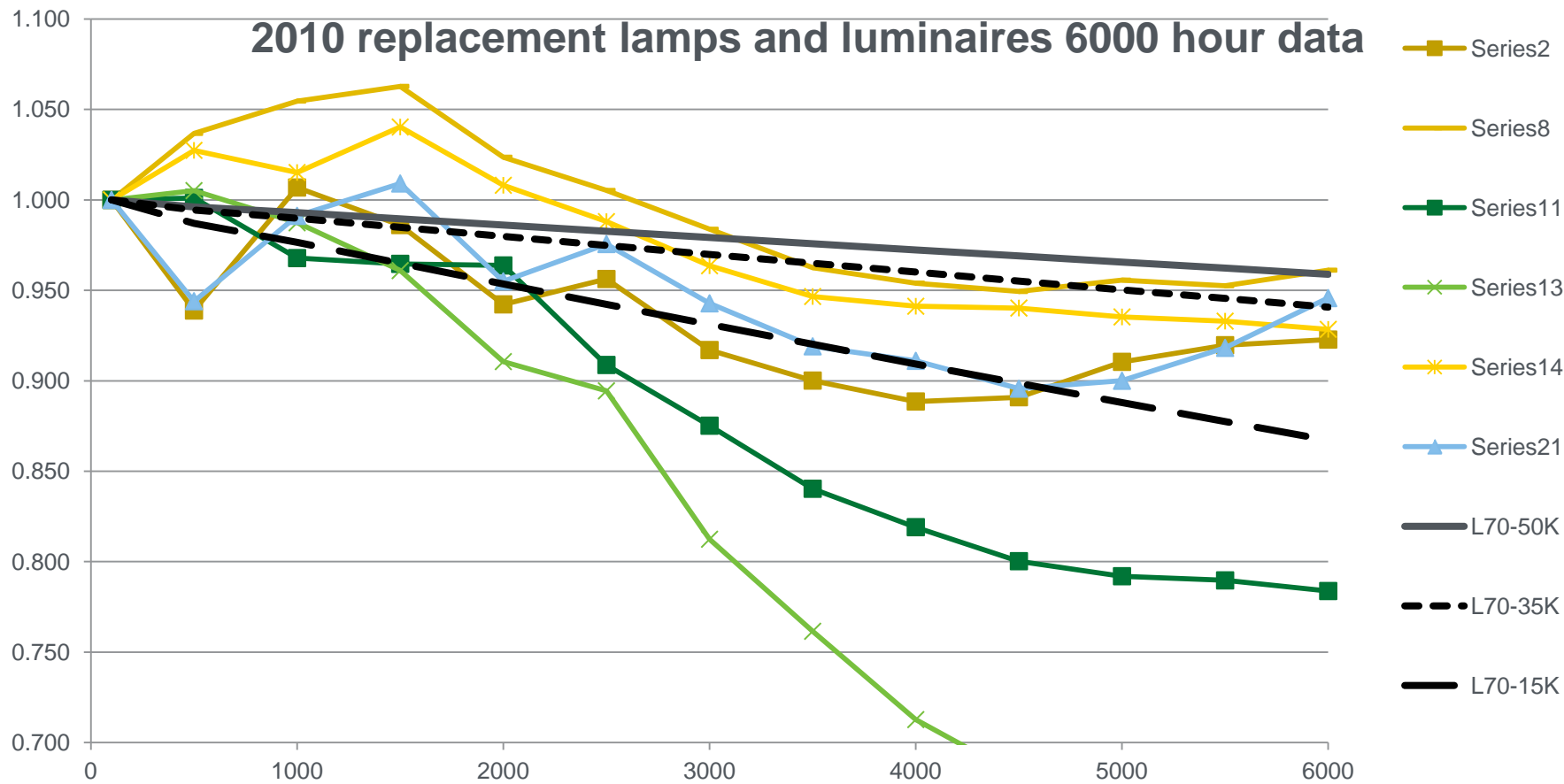
I paid how much? And how long is the warranty?

- Sites nervous about investing without sufficient warranty
- Industry moving towards 5-year warranty
- Warranty should cover light output, color, driver, and luminaire finish

5 minimum

10 optional

How long will the LED system live/operate?



Source: CALiPER

Overview:

- Manufacturers claim 50,000/88,000/100,00 hours
 - 11/20/23 years if operated 12 hrs/night
- Verification is hard
- Specification builds on TM-21
- Tested data of LEDs multiplied by a multiplier to project life
- Provides an estimate about LEDs, but still needs to be verified
- Driver specification and metrics coming



FAA William J. Hughes Technical Center

Specification in Practice: Leavenworth, KS



Source: GE

Highlights:

- Walmart
- 500,000 square feet (sf) (parking area)
- 92 LED luminaires
 - GE Evolve
- Pole height 37' AFG
- Avg: 1.27 fc Min: 0.8 fc (initial)
- Payback: 6 –10 years
- Cost of electricity: \approx \$0.06/kWh
- 63% energy savings compared to standard design
- 0.04 W/sf



Source: GE

Specification in Practice: Manchester, NH



Source: BetaLED

Highlights:

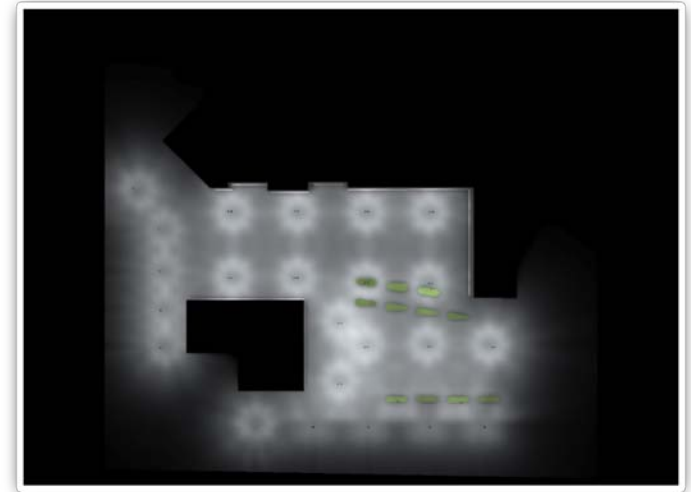
- T.J. Maxx (Anchor)
- 150,000 sf (parking area)
- 25 LED luminaires
 - BetaLED Edge
- Pole height 33' AFG
- Avg: 2.03 fc Min: 1.03 fc (initial)
- Payback: 3 – 10 years
- Cost of electricity: \approx \$0.14 / kWh
- 63% energy savings compared to previous installation design
- 0.04 W/sf



Specification in Practice: Falls Church, VA



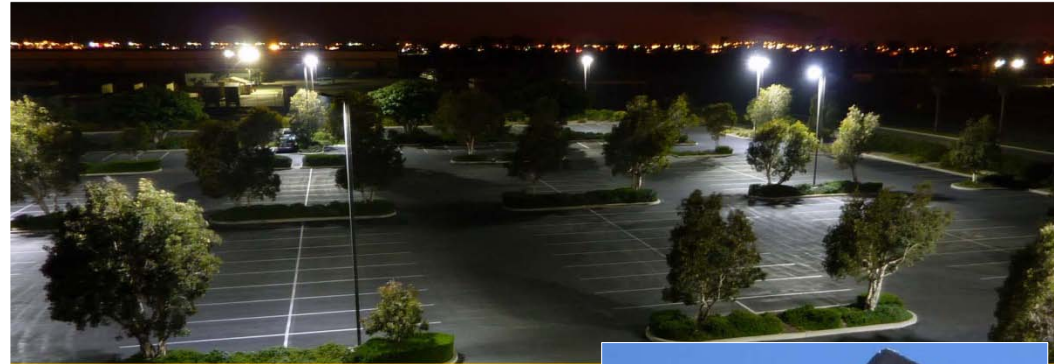
- Safeway (Anchor)
- 183,000 sf (parking area)
- 55 LED luminaires
 - Cooper
- Pole height 33' AFG
- Avg: 2.97 fc Min: 0.9 fc (initial)
- Payback: 6 years – 10 years
- Cost of electricity: \approx \$0.096/ kWh
- 70% energy savings compared to previous installation design
 - Previous 30-year old 1,000W fixtures



Computer Rendering

Naval Facilities Engineering Command (NAVFAC) - Engineering Service Center at Port Hueneme, CA

- Light levels increased by 18% in dimly lit areas
- Lighting power was reduced 74% to 2.81 kW from 10.88 kW
- Illumination distribution more uniform
- Higher color correlated temperature (CCT); 6500K for LED compared to 2000K for high pressure sodium (HPS)
- Instant on – No strike or re-strike delay
- Longer lamp life; an expected 50,000 hours for the LEDs and driver versus 24,000 hours average for HPS



New LED parking area lights at the NAVFAC Engineering Service Center at Port Hueneme provide high quality, evenly distributed light.



Close up view of new LED luminaires atop an existing light pole.

Source: PNNL

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- FEMP Exterior SSL Initiative
 - www.femp.energy.gov/technologies/solid_state_lighting.html
- Commercial Building Energy Alliance
 - www.buildings.energy.gov/alliances/parking_structure_spec.html
 - www.buildings.energy.gov/alliances/parking_lot_lighting.html
- Municipal Solid-State Street Lighting Consortium
 - www.buildings.energy.gov/ssl/consortium.html
- U.S. Department of Energy Solid-State Lighting
 - www.ssl.energy.gov

- DesignLights™ Consortium
 - www.designlights.org/
- Illuminating Engineering Society (IES)
 - www.iesna.org
 - TM-21:
 - www.ies.org/store/product/projecting-long-term-lumen-maintenance-of-led-light-sources-1253.cfm
- Philips L Prize Tool
 - www.usa.lighting.philips.com/lightcommunity/trends/l-prize