LED Outdoor Area (Parking Lot) Lighting Technology Procurement

A Retailer Energy Alliance Project

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May 23, 2008

Presentation Overview

* LED Parking Lot Lighting Working Group – Overview
* LED Technology Application in Retail Parking Lots
* Critical Specification Issues for the REA to Address
* Early Investigations by Wal-Mart
* Working Group Discussion

Working Group Overview

In April 2008, the REA established a working group to help speed the market introduction of advanced, reliable, energy-efficient, and competitively priced outdoor area Solid-State Lighting (SSL) luminaires.

This working group is designed to:

- **Investigate the field and laboratory performance of candidate luminaires**
- **Investigate the life and reliability issues of candidate luminaires**
- **Develop product specifications and evaluation procedures for use in a coordinated Request for Proposals to be released by participating REA members (or PNNL on their behalf)**
- **Maximize the sales of "selected" products**

Working Group Overview

Milestone	Date
Establish REA Working Group	Apr-08
Complete Retailer Needs/Wants Assessment	May-June 2008
Identify LED products to be investigated	May-June 2008
Perform laboratory and field testing on selected products	Jun-Oct 2008
Develop draft specifications & request manufacturer feedback	Jun-Aug 08
Complete technical specifications	Oct-08
Coordinate release of REA Request For Proposal	Nov-08
Evaluate proposals and select "winners"	Jan-09

LED Parking Lot Lighting

Photo courtesy of Beta LED

Typical Decision Process in Lighting Design

1. Review lighting criteria
2. Determine average illuminance
3. Determine appropriate light source
4. Lay out luminaires
5. Review code and ordinance compliance
6. Plan for operations and maintenance
7. Conduct budget review
8. Develop specifications
9. Review

Comparison of Technologies

Current Parking Lot Lighting

- Majority of retailers use Metal Halide (MH) sources
  - Some use High-Pressure Sodium (HPS)
- Poles contain multiple luminaires (heads)
- Most retailers have illuminance requirements that well exceed RP-20
- Lighting can operate 12+ hours per day
- Environmental issues with current technology

New LED Parking Lot Lighting for Retail

- Poles contain multiple luminaires (heads)
- Needed for both retrofit and new construction
- Shift in illuminance recommendations
- Good for some new energy code requirements
- Limited environmental issues

Comparison

Why LEDs make sense for retail parking lots:

- Reduced maintenance
  - LEDs last longer than HID sources
- Saves energy
  - Enhanced optical efficiency
  - Better luminaire efficacy (lumens per watt)
- Better neighbor
  - Better optical control prevents light pollution
- Improved uniformity
  - Better optics leads to no "hot-spots"
  - Leads to better visibility, enhanced perception of safety
- Environmentally friendly
  - Product is Mercury free

Lighting Criteria

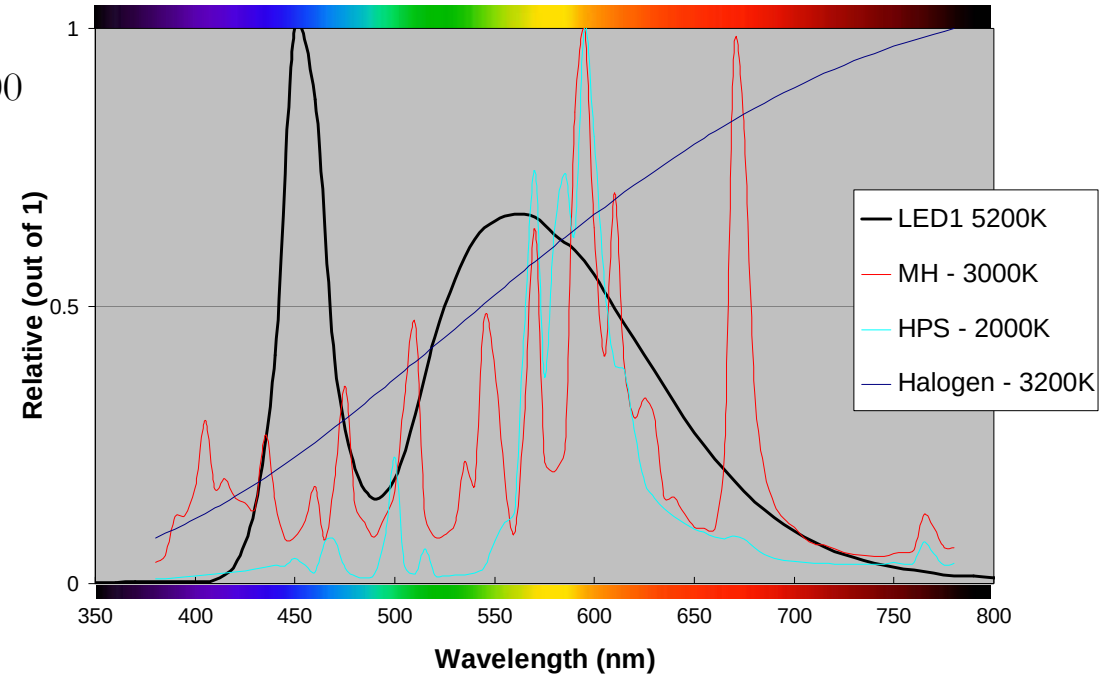
Design issues when lighting Parking Lots:

- Appearance of colors
- Illuminance
- Peripheral Detection
- Light Pollution/Trespass
- Glare
- Security (both cameras and as personal)

Design Criteria: Color

Color Rendering Index

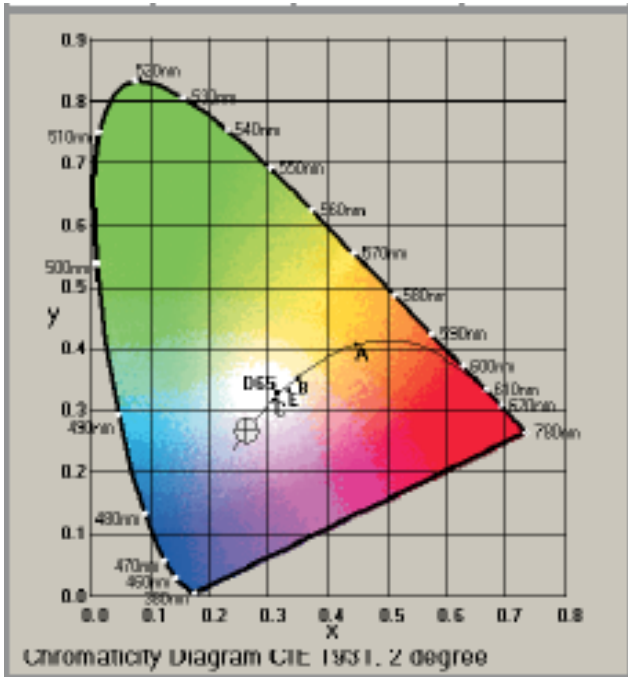
- How accurately source represents color
  - Typical HPS ≈ 20
  - CRI over 50 is sufficient for exterior applications
  - Typical MH ≈ 60 - 70
  - LEDs are typically 70+
  - Incandescent/Halogen ≈ 100



Design Criteria: Color

Correlated Color Temperature

- The appearance of the source
  - Typical HPS – 2200K (amber/orange)
  - Typical MH – 3000K (white like halogen)
  - Typical MH – 4100K (white with a hint of blue)
  - Typical LED – 5500K (white with a blue tint)



Design Criteria: Illuminance

Recommended Maintained Illuminances for Parking Lots per IESNA RP-20-98

	Basic	Enhanced Security
Minimum Horizontal Illuminance (amount of light falling on pavement)	0.2	0.5
Uniformity Ratio - Maximum to Minimum	20:1	15:1
Minimum Vertical Illuminance (measured 5.0' above parking surface)	0.1	0.25

Design Criteria: Illuminance

How Parking Lots are currently being lighted:

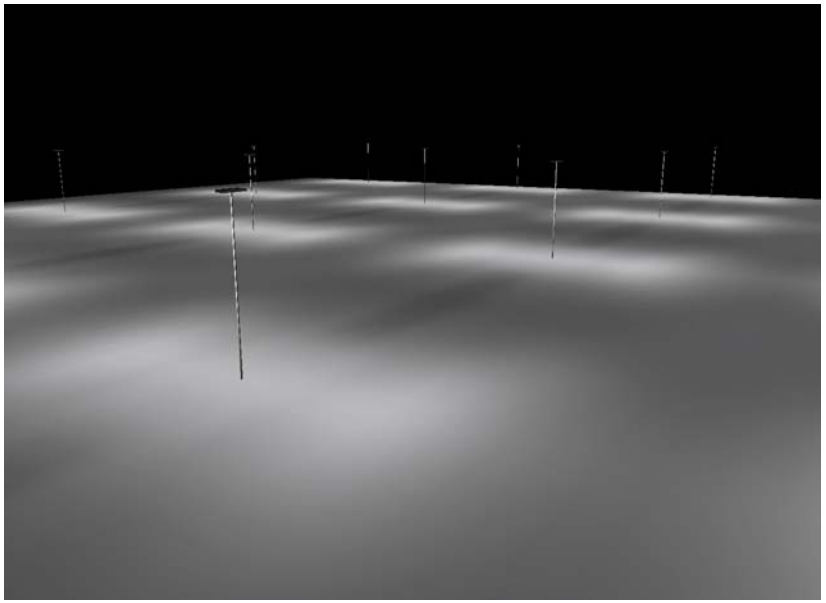
- Currently retailers commonly require between 2 – 5 fc
- IESNA minimum recommendations vary on needs
- Recommendations based on conventional light sources
  - Optics often create a hot spot
  - Wide variation in uniformity results from difficulties in technology

Potential LED Parking Lot Lighting Characteristics

- Recommend 0.5 fc minimum
- Uniformity 5:1
  - 3:1 might be possible

Design Criteria: Illuminance

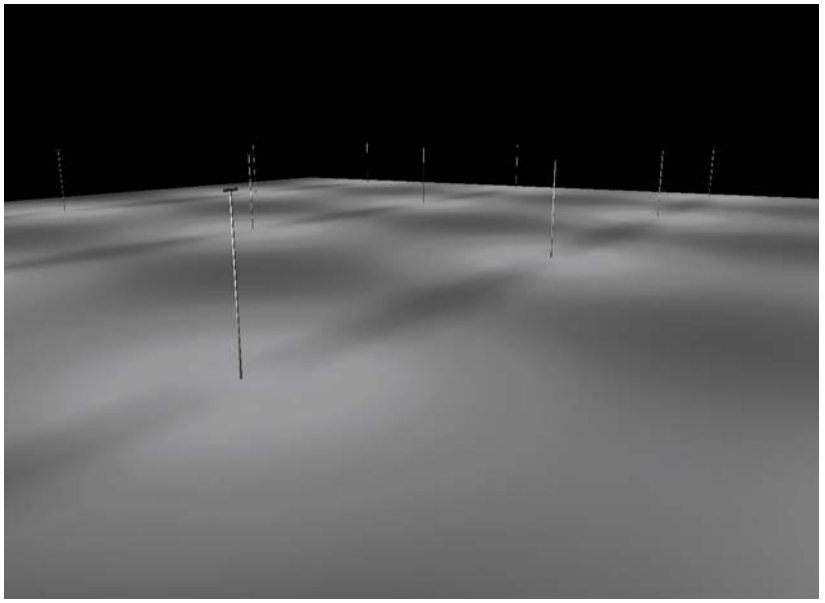
MH Parking Lot



Average: 3.5
Maximum: 9.0
Minimum: 0.9
Max : Min: 10.0

455W PMH

LED Parking Lot



Average: 2.8
Maximum: 5.2
Minimum: 1.2
Max : Min: 4.3

218W LED

Design Criteria: Illuminance

New LED Parking Lot Lighting

- Set illuminance by location (urban or rural)
- Include Model-Lighting Ordinance (MLO) recommendations
  - Developed in conjunction with IESNA and IDA
  - Typical code language for easy adoption by municipalities
- Less light is needed than currently being required by retailers
- Uniformity is bigger issue than illuminance
  - Security cameras work in low light, but are severely affected by uniformity ratios
  - Vision is affected by changes in uniformity
- Uniformity of 5:1 (max/min)
  - 3:1 or better might be possible
- Needs to be driven by retailers

Design Criteria: Illuminance

Different visual states of the eye:

- Photopic Vision
  - Occurs in high light levels
  - Uses the cones
  - Attuned to longer wavelengths
  - Basis for the standard Lumen
- Mesopic Vision
  - Occurs between Photopic and Scotopic
  - Uses both rods and cones
  - Uses a combination of wavelengths
  - Formal definition not accepted
- Scotopic Vision
  - Occurs in very-low light levels
  - Uses the rods
  - Attuned to shorter wavelengths

Light Source Selection: Lumen Package

Selecting lumen package with HID:

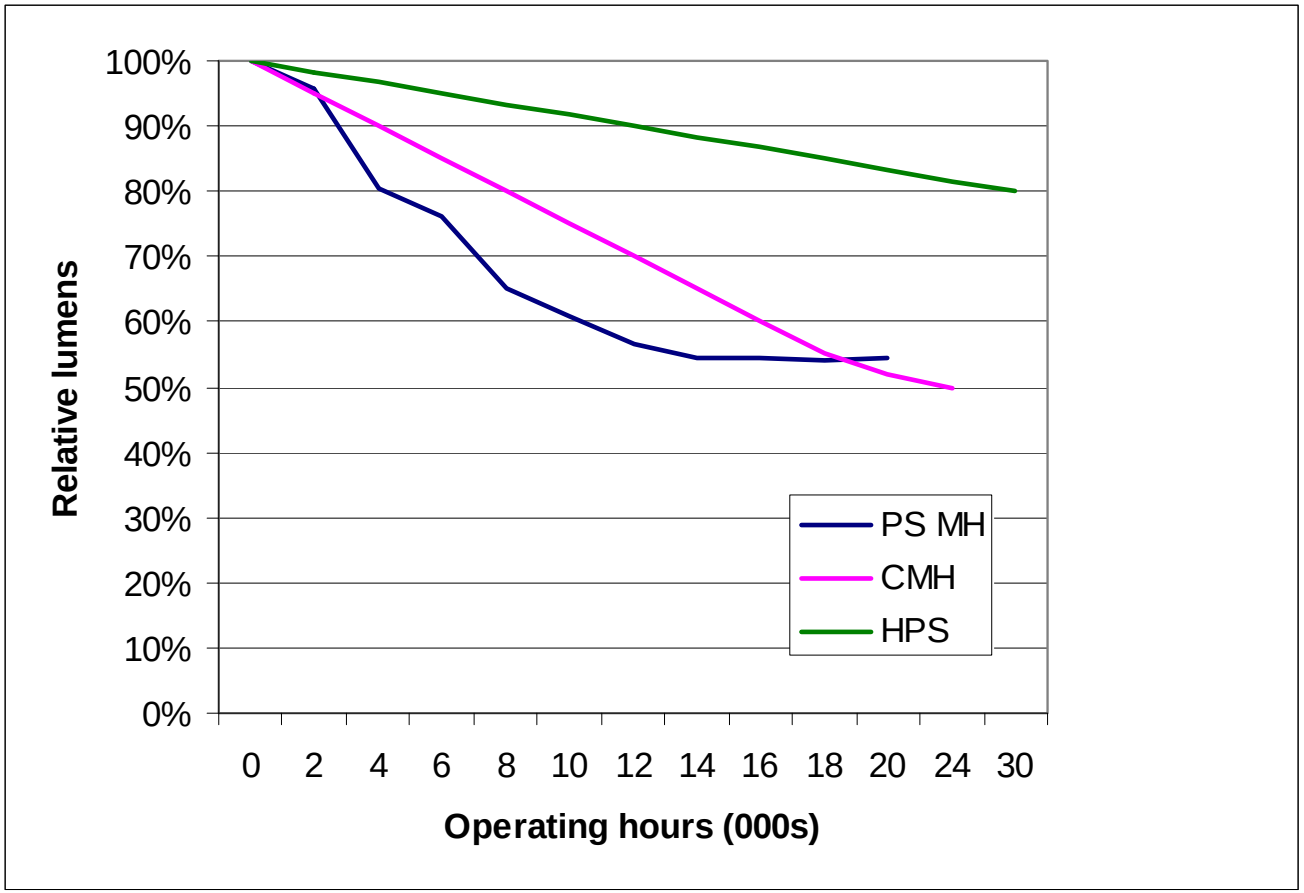
- MH and HPS lumen packages
  - Lamps available with specific amounts of lumens
  - Lamp wattages increase in 50 – 70 W increments
  - Each increase in lamp wattage is about 350 – 500 additional lumens

Selecting lumen package with LEDs:

- Manufacturers use arrays
  - Arrays allow for flexibility
  - Array contains 10 – 30 LEDs
  - Each LED produces ≈ 70 lumens
  - Prevents over or under lighting

Light Source Selection: Lumen Package

Output of HID sources over time



Light Source Selection: Distributions

Current designs with HID luminaires use standard IESNA distributions

- Type III (symmetric oblong)
  - Ideal for roadway
- Type IV (asymmetric forward throw)
  - Good for perimeters
  - Can be good for poles located in islands
- Type V (symmetric)
  - Can have circular or square symmetry
  - Good for poles located in islands

LED Parking Lot Lighting

- Some manufacturers have deviated from these distributions

Luminaire Layout: Pole Spacing

Rule of Thumb for HID luminaires pole spacing:

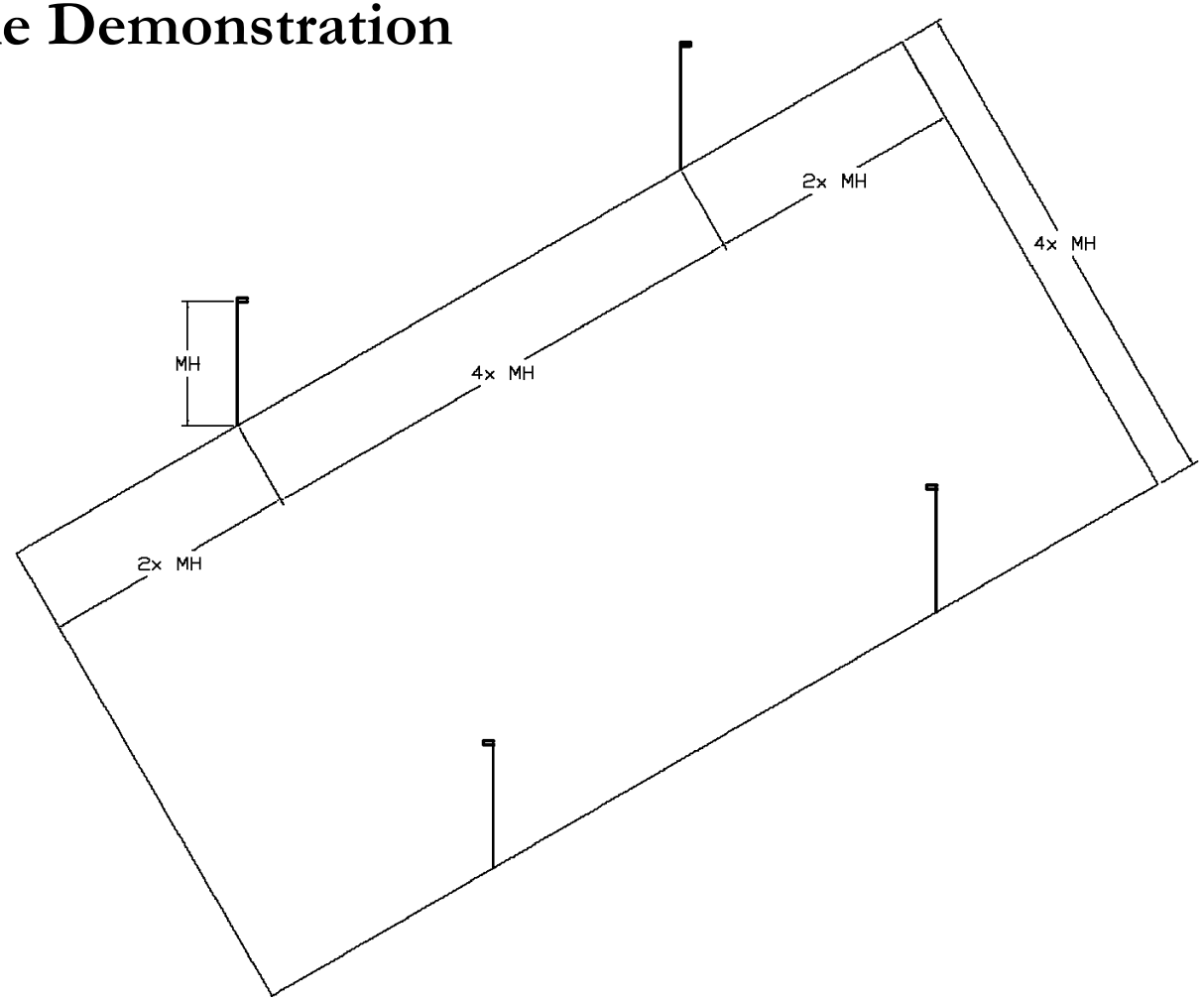
- 2x – 4x Rule
  - Pole ≥ 2x Mounting Height from edge of area to be lighted
  - Poles ≥ 4x Mounting Height from adjacent pole
- Poles contain multiple luminaires (heads)
  - Most expensive equipment
  - Requires trenching
- Typical Design
  - Poles in center with many heads
  - Sometimes perimeter poles

LED Parking Lot Lighting

- Should be able to reuse existing pole location – Retrofits
- Better optics allow for new / different layouts – New Construction

Luminaire Layout: Pole Spacing

2 x 4 Rule Demonstration



Luminaire Layout: Luminaire Mounting Height

Typical HID luminaire mounting parameters:

- Typical MH mounting height:
  - 20 – 30' with a 400W lamp
- Typical HPS mounting height:
  - 18 – 25' with a 250W lamp
  - 25 – 35' with a 400W lamp
- Higher the mounting height, less poles
- Higher the mounting height, more power needed

LED Parking Lot Lighting

- Set illuminance level & reverse engineer
- Anticipated height 22' – 30'

Code Compliance: Environmental Issues

Environmental concerns with HID Luminaires:

- HID Lamps Contains Mercury
  - Small amount, used in starting operations
  - Should be recycled, see applicable laws
  - Neurotoxin
- Luminaires lens can be polycarbonate
- Lead can be in the solder of the electronics

Characteristics of LED Luminaires:

- Mercury free products
- Luminaires lens can be polycarbonate
- Lead can be in the solder of the electronics

Code Compliance: Environmental Issues

Environmental concerns with HID Parking Lot Lighting:

- HID currently best in class, however still inefficient technology
  - 20%+ light does not leave luminaire
  - Ballasts are only 80% - 90% efficient
- Inefficiencies require more power and energy
  - Leads to more Green House Gases (GHG) emissions

Characteristics of LED Parking Lot Lighting:

- More optically and electronically efficient
- Less power and energy is needed due to better energy efficiency
- Energy saved reduces GHG emissions

Code Compliance: Energy Codes

Comparison of energy codes

	Std. 90.1-2010	Title 24* 2005
Parking Lot - Zone 4 High ambient lighting	0.13 W/sf	0.19 W/sf
Parking Lot - Zone 3 Moderately high ambient lighting	0.10 W/sf	0.15 W/sf
Parking Lot - Zone 2 Moderate ambient lighting	0.06 W/sf	0.08 W/sf
Parking Lot - Zone 1 Low ambient lighting	0.04 W/sf	0.05 W/sf

* As PNNL understands it, Title 24 is converting from W/sf to lumens per square foot

Code Compliance: Light Pollution

Light Pollution

- Light Trespass
- Skyglow
- Glare

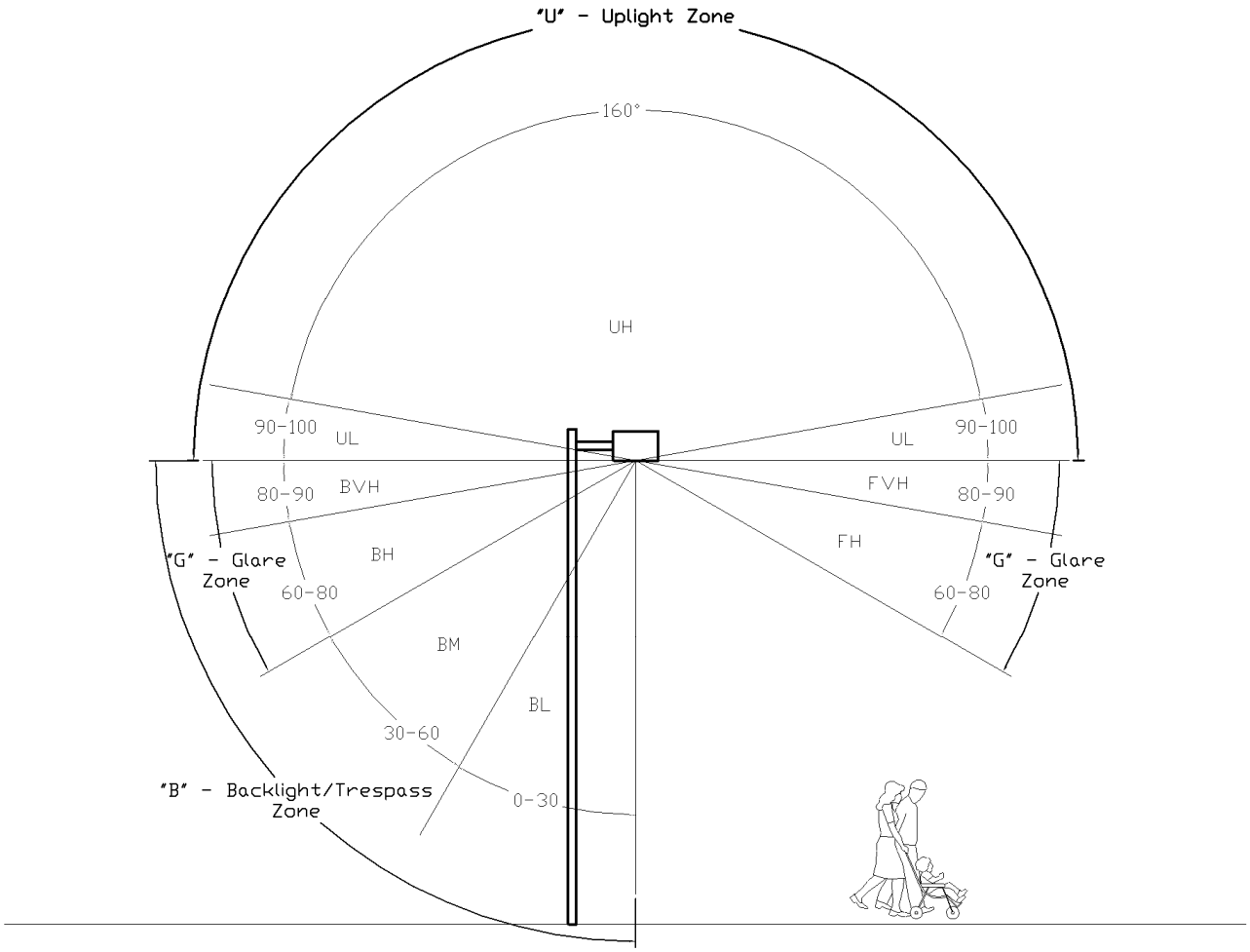
Old Remedies (regardless of source)

- Full cutoff, semi-cutoff, cutoff, non-cutoff

New Remedies (regardless of source)

- Lighting Classification System "BUG"
  - B – Backlight
  - U – Uplight
  - G - Glare

Code Compliance: Light Pollution



Code Compliance: Light Pollution

Backlight

- Restrict only for perimeter luminaires
  - Typically Type IV (asymmetric forward-throw)
  - Creates the light trespass

Uplight

- Direct cause of skyglow
  - Reflected light from pavement causes small amount
  - Controllable for any technologies, easiest with LEDs

Glare

- Can be discomforting or disabling
  - Critical zone is 70° to 90°, LEDs can be problematic in this regard

Code Compliance: Lighting Curfew

Lighting Curfew

- Reduction of exterior lighting to save energy and reduce skyglow
- Some existing codes and ordinances already requiring curfews, more expected

Curfew & HID luminaires:

- Switch every-other fixture
- Dim with electronic ballast
- Use a secondary capacitor for bi-level
- California Lighting Technology Center developing a bi-level sensor

Curfew & LED luminaires:

- LED luminaires can be easily dimmed

Operations & Maintenance: Weather Conditions

Water / Dirt

- UL Wet Location
  - Old standard, limited in definition
- Ingress Protection (IP)
  - New Standard
  - Recommended minimum rating of IP-65
  - 1st number (6) refers to solid objects – totally protected against dirt
  - 2nd number (5) refers to liquids – protected from water jets

Temperature

- Heat can damage LEDs, good luminaire design can handle heat
- LEDs perform better in cold temperatures

Operations & Maintenance: Maintenance

Unexpected Device Failure

- Typical HID luminaire warranty
  - 5 years
- Acceptable for LED luminaire warranty
  - 5 years

Expected Device Failure

- MH lamps will typically fail after 10,000 – 20,000 hours
- HPS lamps will typically fail after 18,000 – 36,000 hours
- SSL luminaires are different
  - Typical rated life is 50,000 hours – maintenance savings
  - Treat end of life differently

Budget Review: Initial Price

Initial Outdoor HID Luminaire Price

- Many decisions are solely made on initial costs
  - Not a true cost of ownership/operation
  - Shift away from this mind-set
- HID luminaires are not cheap

Shoebox

$300-$650

Architectural

$800-$1000

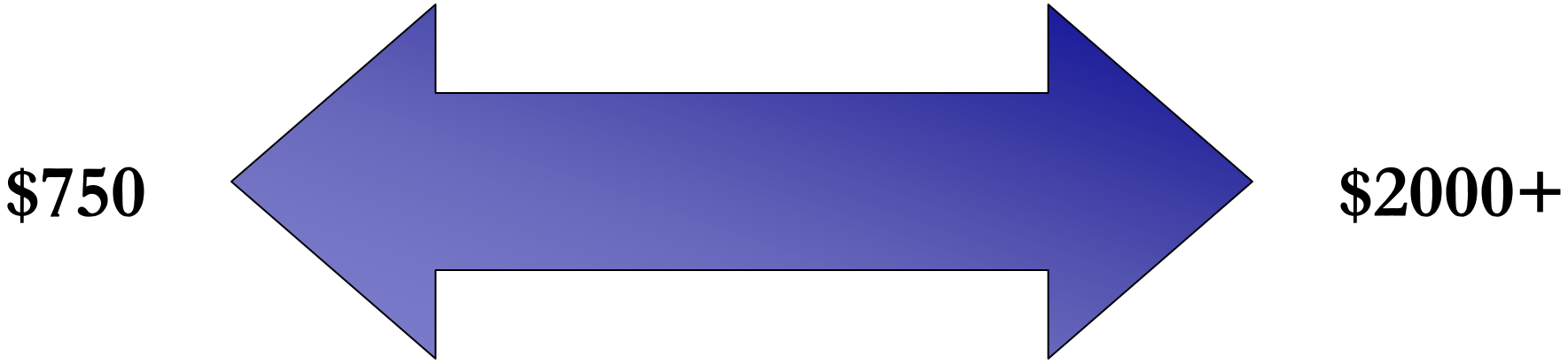
Lamp

$18-$48

Budget Review: Initial Price

Initial Outdoor LED Luminaire Price

- Prices widely vary
- Varies by light output more than HID
- DOE projects price reductions over next 5 years
- Varies by quality as well



Budget Review: Life Cycle Cost

Life Cycle Cost Analysis of LED luminaires

- Use less energy, pay lower utility bills
  - Luminaires more energy efficient
  - Additional savings through controls
- Reduced Maintenance Costs
  - Luminaire lasts longer less maintenance
  - Relamping involves multiple people
  - Relamping involves a lift truck
- Possible incentives
  - Utilities
  - Energy Efficiency Program Sponsors (EEPS)
  - Equipment based or for kWh saved

Specification Discussion: Illuminance

Illuminance Specifications

- Determine desired minimum illuminance
- Determine desired uniformity max:min
- Consider different specifications for environmental zones

Specification Discussion: Design Criteria

Color

- Require a CRI greater than 75
- Allow for a ±500K deviation in CCT but allow user to choose appropriate nominal value?
- Select CCT preferences
  - Higher CCT (over 4000K) might seem brighter
  - Higher CCT can lead to glare
  - LEDs more efficient at higher CCTs

Specification Discussion: Luminaire Layout

Pole location

- Current pole spacing?
- Ratio of retrofit to new construction applications?

Luminaire Mounting Height

- How high are existing luminaires mounted?
- How tall are the poles?

Specification Discussion: Energy Savings

What are your target energy savings?

- Current parking lot power density?
  - Or current lamp wattage and typical spacing?
- Desire to save 20% or more energy?
- Interested in non-power energy savings?
  - Using a curfew?
  - Using occupancy sensors?

Specification Discussion: Light Pollution

Light Pollution

- Restrict Uplight High and Uplight Low to 0.1% of luminaire lumen output
- Restrict lumen output in Forward Very High & Backward Very High zones (glare)
- Restrict Backward Light for type IV luminaires at perimeter

Specification Discussion: Luminaire Performance

Photometry

- Verified via IESNA LM-79
  - Requires absolute photometry
  - Sets the ambient test conditions (25° C)
  - DOE assisted in development of standard

Specification Discussion: Quality Control

Rated Life

- LED will slowly diminish over time – but do not typically "burn out"
- Effective "life" of LED is commonly considered the point where light output is too low
- IESNA LM-80 being developed to measure lumen depreciation
  - Evaluates the rated lumen depreciation of a luminaire
  - Depreciation characteristics used to estimate time at specified lumen output level
- "L_{70}" is considered appropriate end of life metric
  - "L_{70}" = hours of operation when output drops to 70% of initial lumens
  - Some manufacturers are using a feed-back system to simulate typical end of life

Specification Discussion: Next Steps

Retailer Considerations

- Illuminance
  - Converge on minimum and uniformity requirements
- Energy Savings
  - Determine installed power savings against code
  - Determine installed power savings against current store practices
  - Determine if other energy savings will be sought (controls)
- Luminaire layout
  - Pole spacing and luminaire height will vary per Retailer

Specification Discussion: Immediate Next Steps

Manufacturers of LED Parking Lot Luminaires

- Current number small
  - Limits selection
  - Limits competition
  - Drives up price
- Lightfair
  - Lighting trade show at end of May
  - Expect more products announced here
- REA
  - REA Supplier Summit

Questions,

Discussion,

Next Steps