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Advances in Exterior Lighting and Design

Presenters-

Edward Bartholomew, LC, IES, LEED AP
Kelly M. Carls, LC -Reflex Lighting

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Exterior Lighting Criteria for Public Areas

- Deter Crime
- Decrease Fear
- Natural Surveillance
- Access Control
- Ownership

- Encourage Positive Activities and Use
- Activate Significant or Ignored Space
- Accommodate community activities
- Provide visual guidance for access and egress
- Signify important features

- Durable, Vandal Resistant Fixtures
- Low Life Cycle Costs
- Energy Effective Lighting
- Meets Specified Lighting Quantity and Distribution

- Historically and stylistically appropriate fixtures
- Design for visual comfort
- Scale fixtures proportional to site and users
- Visual place making
- Dark sky compliant for population density

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Safety & Security

- Deter Crime
- Decrease Fear
- Natural Surveillance
- Access Control
- Ownership

*Based on Seattle CPED Strategy

A. **Natural Surveillance:**
Light significant structures and landscaping to allow users and residents to notice activity. Legitimate users can identify trespassers and potential criminals will feel exposed because of increased visibility.

B. **Use good Color Rendering light sources (70+ CRI) to increase visual clarity for accurate observation, detection and threat assessment.**

C. **Highlight periphery landscaping , features or structures to define the park boundaries and reduce opportunities for visual concealment.**

D. **Access Control:**
Create visually defensible space by lighting park entrances, and walkways providing visually clear means of entrance and escape for users.

E. **Use high color temperature (4000K to 5000K) lamps for higher visual acuity.**

F. **Territorial Reinforcement:**
This can include the lighting of landscaping that tells a visitor that someone cares about a space. Expression of ownership reinforces territoriality, which in turn, can deter illicit behavior.

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Passage & Play

- Encourage positive activities and use
- Activate significant or ignored space
- Accommodate community activities
- Provide visual guidance for access and egress
- Signify important features

A. **Clearly define space entrances, exits and pathways to promote pedestrian passage and easy wayfinding.**

B. **Provide light in areas to encourage public & private use that promotes positive activities.**

C. **Program controls to reduce pathway lights during times that the park is closed while still providing minimum illumination or safe egress.**

D. **Create visual landmarks for easy identification and community ownership**

Still, he said that so long as increased lighting is thoughtfully implemented, the effect he has found in his studies is that they normally do decrease crime—though mostly property crimes. In addition to making criminals feel like they are being watched, the effort to improve the community can instill a sense of pride, he said. That may be why the program in Los Angeles has seen such apparent success, Mr. Welsh said

Guerrero, Jean. "Los Angeles uses Light to Fight Crime." 31, Aug. 2010.
Wall Street Journal

Maintenance & Performance

- Durable, Vandal Resistant Fixtures
- Low Life Cycle Costs
- Meets Specified Lighting Quantity and Distribution

A. Realistic lighting and controls budget based on stringent performance specifications, and the requirement for reliable service in demanding public spaces

B. Specify lighting that is easily maintained, durable and vandal resistant.

C. Specified a lighting system that reduces overall life cycle costs based on low maintenance, low energy use and ease of control.

D. Add additional replacement fixtures and lamps into initial system costs. Fixtures and lamps should be easy to replace if damaged or defective.

E. Specify fixtures and lamps from established manufacturers using proven reliable technologies.

F. Specify lamps that are energy effectatious (lm/W)

G. Easily maintained and programmable control system that turns lighting off when daylight is predicted and present using an astronomical time-clock

H. Fixtures should meet specified lighting performance specification including: light distribution, intensity and quantity.

I. Fixtures to be specified to be exterior rated and meet EPA standards for site conditions.

Place & View

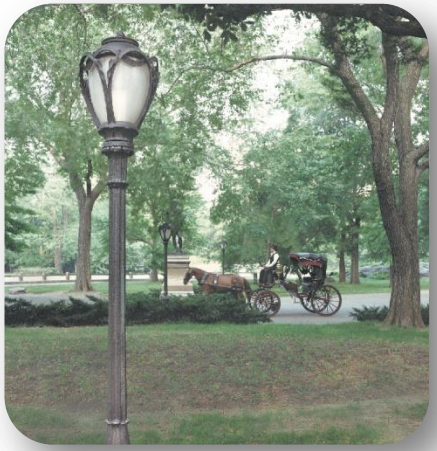
- Historically and stylistically appropriate fixtures
- Design for visual comfort
- Scale fixtures proportional to site and users
- Visual place making
- Dark sky compliant for population density

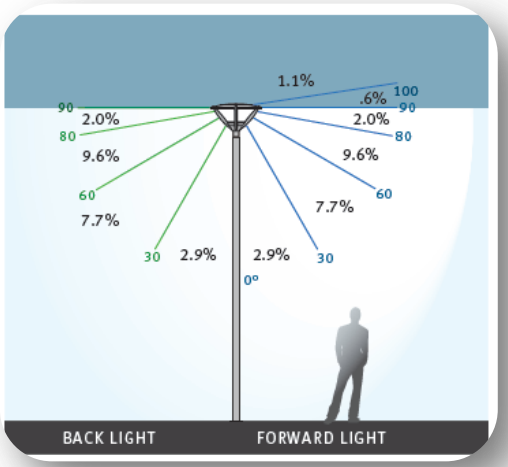
A. **Light fixtures that do not produce discomfort glare or light trespass into adjacent properties.**

B. **(Layered hierarchy) Light vertical surfaces to define the park boundaries and reduce opportunities for visual concealment.**

C. **Fixtures should be attractive and fit the established stylistic and historical character of the place.**

D. **Use color temperature to distinguish private areas from surrounding public areas.**





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Lights impact on Humans

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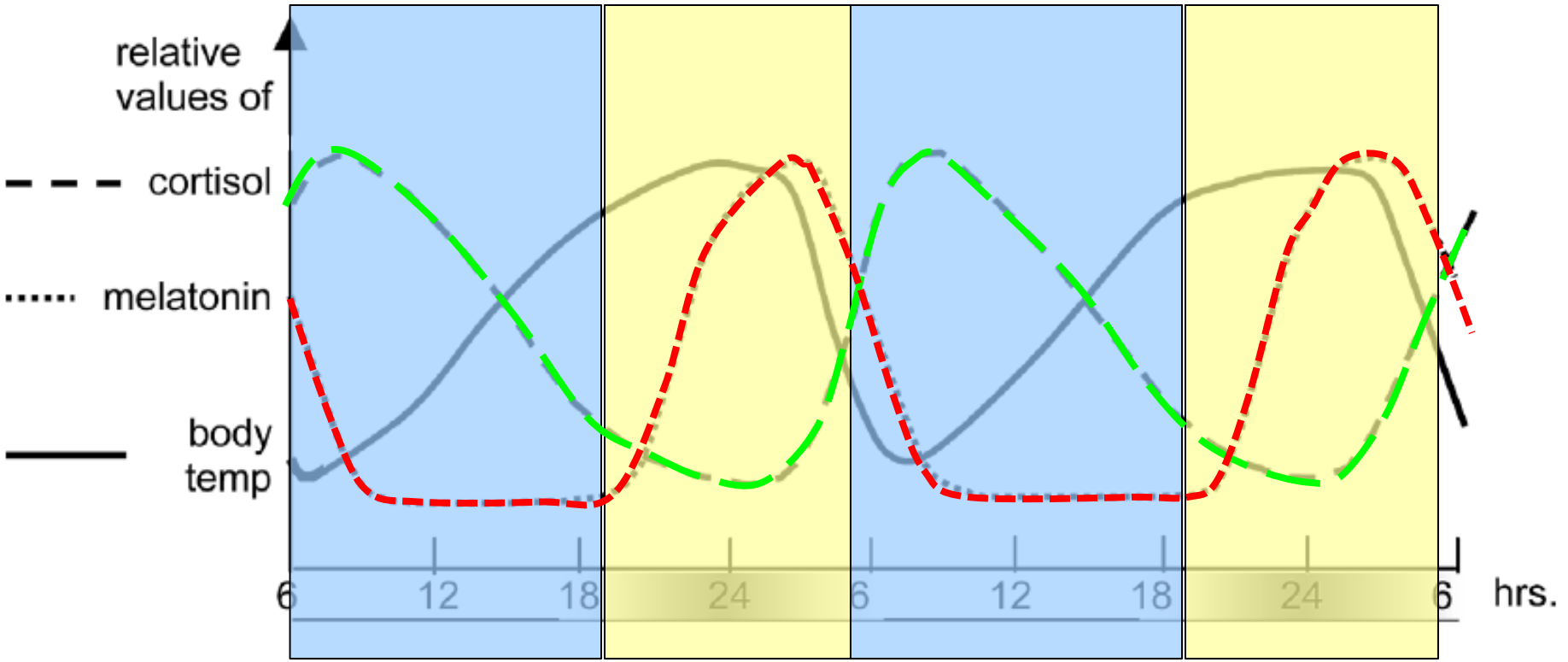
Light (Dark) & Circadian Rhythm



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Light (Dark) & Circadian Rhythm

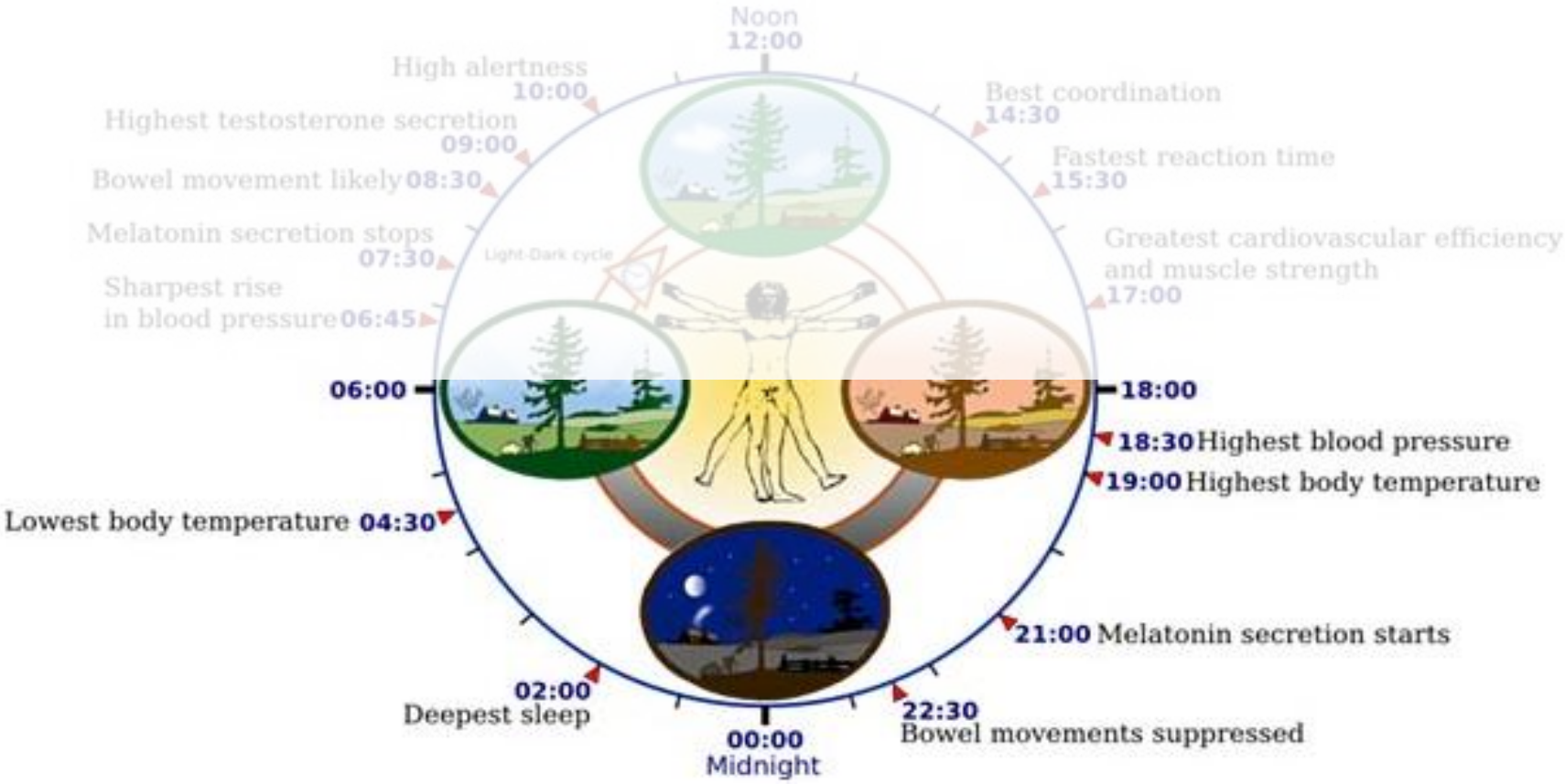

Figure 1. Overview of circadian cycles in humans. This diagram depicts some of the circadian patterns that occur in humans. Note that the clock is on a 24-hour cycle, so that 3:30 p.m., for example, is noted as 15:30. The hormone melatonin, which is a key regulator of the internal circadian clock, peaks in concentration at 21:00 (9:00 p.m.). (Wikipedia, 2008.)

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Non-Visual Effects of Dark (and Light)

News Focus
CIRCADIAN CLOCK:
How the Brain's Clock Gets Daily Enlightenment
Marcia Barinaga

Science 8 February 2002

Researchers have discovered a new class of light-sensing cells in the mammalian retina that send their information to the circadian clock

Like a watch that runs a bit fast or slow, an animal's internal clock must be reset every day. The circadian clock regulates 24-hour patterns of behavior and physiology; it controls body temperature, schedules sleep and activity, and protests when we cross too many time zones at once.

Daylight sets this clock, and researchers have long known that in mammals, circadian photoreceptors--the neurons that detect light and send its signal to the clock--are located in the eyes. But the identities of the photoreceptors and the photopigment chemical within them that reacts to light have remained elusive.

In a burst of papers published in the past 2 months, culminating with two in this week's issue of *Science*, researchers report their discovery of a new class of light-detecting retinal cells that send their signals to the brain's clock; the cells also contain a molecule that may be the long-sought circadian photopigment.

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Light Pollution/ Light Trespass

Light pollution is light shining directly into the sky.

Light trespass is unwanted light shining out of the intended area, usually off the property.

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Dark Sky & Model Lighting Ordinance (MLO)

- The MLO is being adopted in communities across the US as a standard to prevent unwanted light trespass and reduce skyglow
- Permits reasonable use of outdoor lighting
- Help protect the natural environment from the adverse effects of night lighting from man-made sources
- Establishes a standard ordinance format, while allowing municipalities to determine the limits through the establishment of local lighting zones and times of curfews

MLO – Lighting Zones

Most cities are already familiar with classifying different areas into zoning districts for other regulatory purposes and the MLO will recommend Lighting Zones (LZs) that correspond to those districts, typically based on population density and/or use type.

http://www.astro.caltech.edu/observatories/palomar/

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Exterior Lighting Zones

Corresponds with new IESNA RP-33 definition

Zone	Description
0	Undeveloped areas in national parks ***No ambient lighting***
1	Developed areas of national parks, state parks, forest land, and rural areas ***Low ambient lighting***
2	Areas consisting of residential zoning, neighborhood business districts, light industrial and mixed use areas ***Moderate ambient lighting***
3	All other areas ***Moderately high ambient lighting***
4	High-activity commercial districts in major metropolitan areas ***High ambient lighting***

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Exterior Lighting Metrics

AGI32 Computer Rendering

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IES Light Levels

Space/Area	*Average horizontal illuminance	*Vertical Illuminance
Storage yards, industrial equipment areas	0.5 - 2.0	
Building façade		0.5 - 2.0
Facial identification		0.5 - 0.8
Entrances at guarded facilities	10.0	0.5 - 0.8
ATM's	10.0	15.0
Parking garage	6.0	0.5 - 0.8
General parking areas	3.0	0.5 - 0.8
Walkways	0.6	0.5 - 0.8
School - walkways	1.0	0.5 - 0.8
Supermarket/Major retail - close in parking	5.0	0.5 - 0.8
Fast food - drive up window	6.0	0.5 - 0.8

*footcandles

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Light Levels based on IES –RP2

Type of Merchandise	Area to Illuminate	Description	Illuminance in fc			
			Lighting Zone			
			LZ4	LZ3	LZ2	LZ1
Seasonal Outdoor Merchandise	Circulation	Area not used for sales or display, includes approach and parking areas	10	7	5	2.5
	Merchandise	The area of merchandise presentation and sales	30	20	10	5
	Feature Displays	Feature presentation and or single item accent	60	40	20	10
Automotive Sales	Front Row	Feature vehicle lighting of vehicles to create attention to the sales lot	50	40	30	20
	Sales Area	Main sales area for aumotive dealerships, including circulation for customers	40	30	20	10
	Customer Parking	Area not used for sales can include the approach into the sales lot	5	2.5	2	1
	Preparation / Storage Area	Area not used for tsales but used for preperation of vehicles and Service	5	2.5	2	1
Service Stations	Approach	Area not under canopy, and or associated with service functions	15	10	5	2.5
	Gas Islands	Pumps and immediate service area within the canopy	50	30	20	10

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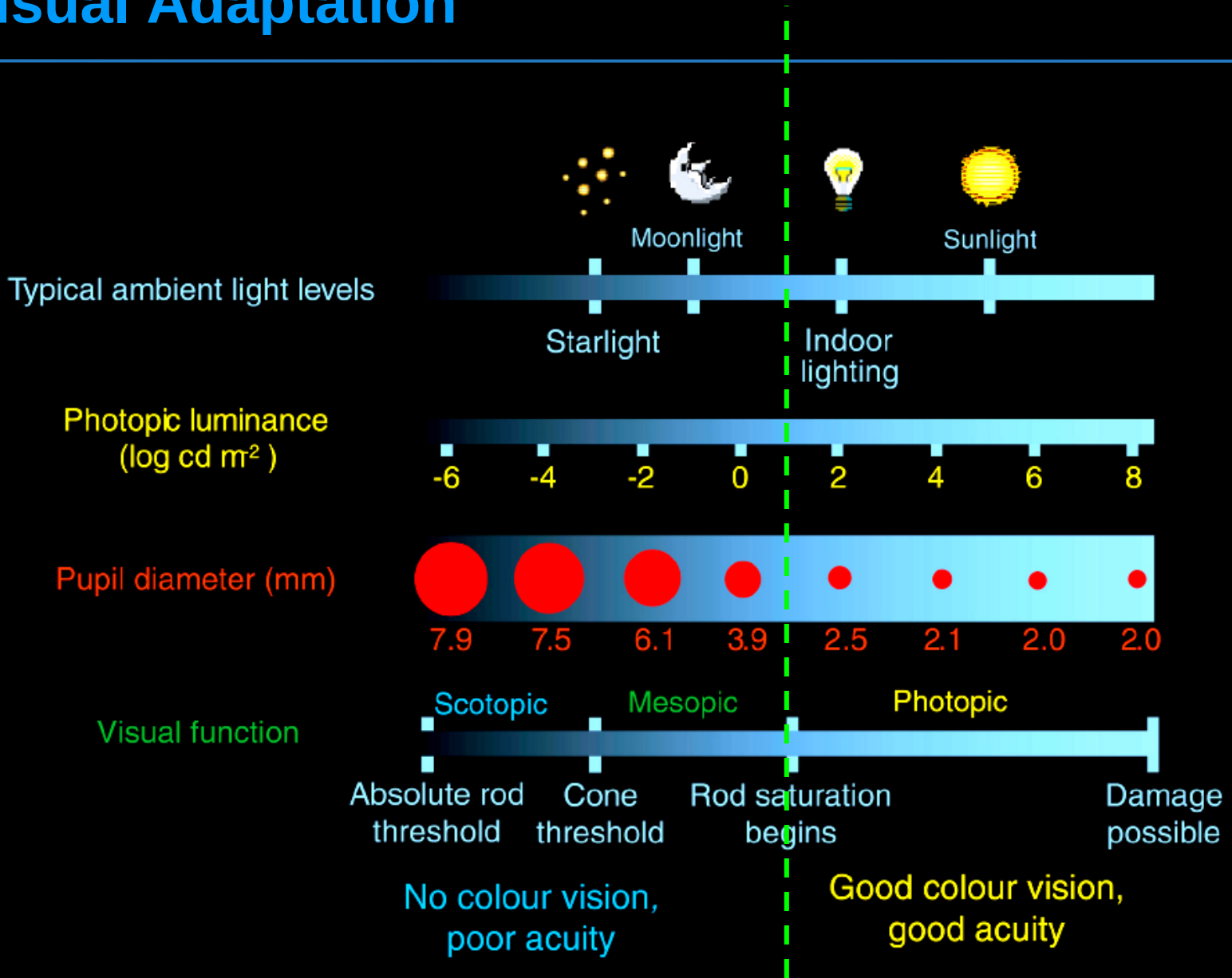
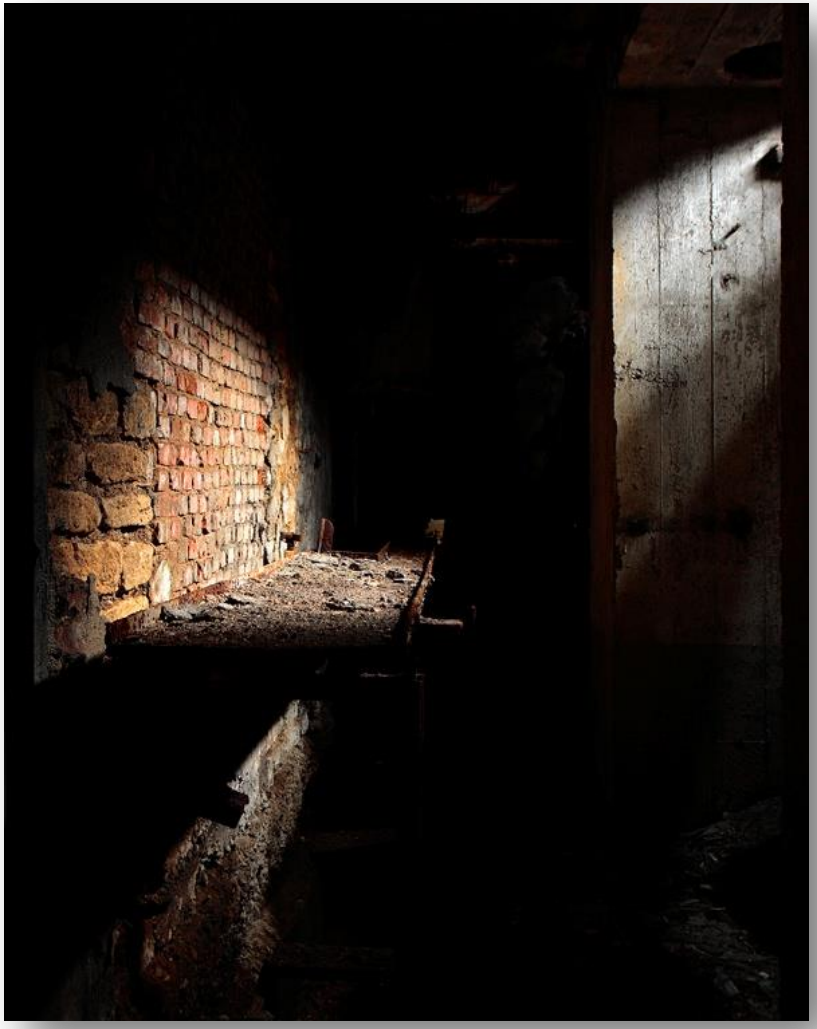
Visual Adaptation



Visual Adaptation

The eye takes approximately 20-30 minutes to fully adapt from bright sunlight to complete darkness and become ten thousand to one million times more sensitive than at full daylight. In this process, the eye's perception of color changes as well.



Glare

- Disability glare is caused by stray light scattered within the eye, which reduces the contrast of the retinal image.
- Streetlights, pedestrian lights, floodlights, and landscape lights, as well as bright reflectors contribute to disability glare.

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Glare

Using well shielded light sources with appropriate optics will help to mitigate unwanted glare

Courtesy: Gardco

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Best Practices

Market Basket
Biddeford, ME

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Outdoor Retail Lighting LED Retrofit

Market Basket – Biddeford, ME

Initial Energy Consumption

- 1000W MH consuming ~1075W each (approx. 70 heads total)
- Mixture of single, double & triple poles in parking lot

Barriers to Project Implementation

- Cost-effective LED solution allowing for one-for-one retrofit
- Performance LED to equal output & distribution of 1000W MH

LED Retrofit Benefits

- Huge Energy Savings = LED heads range from 206W to 309W each
- Reduced Maintenance with 50,000hr Life
- Increased Uniformity with existing aggressive pole spacing

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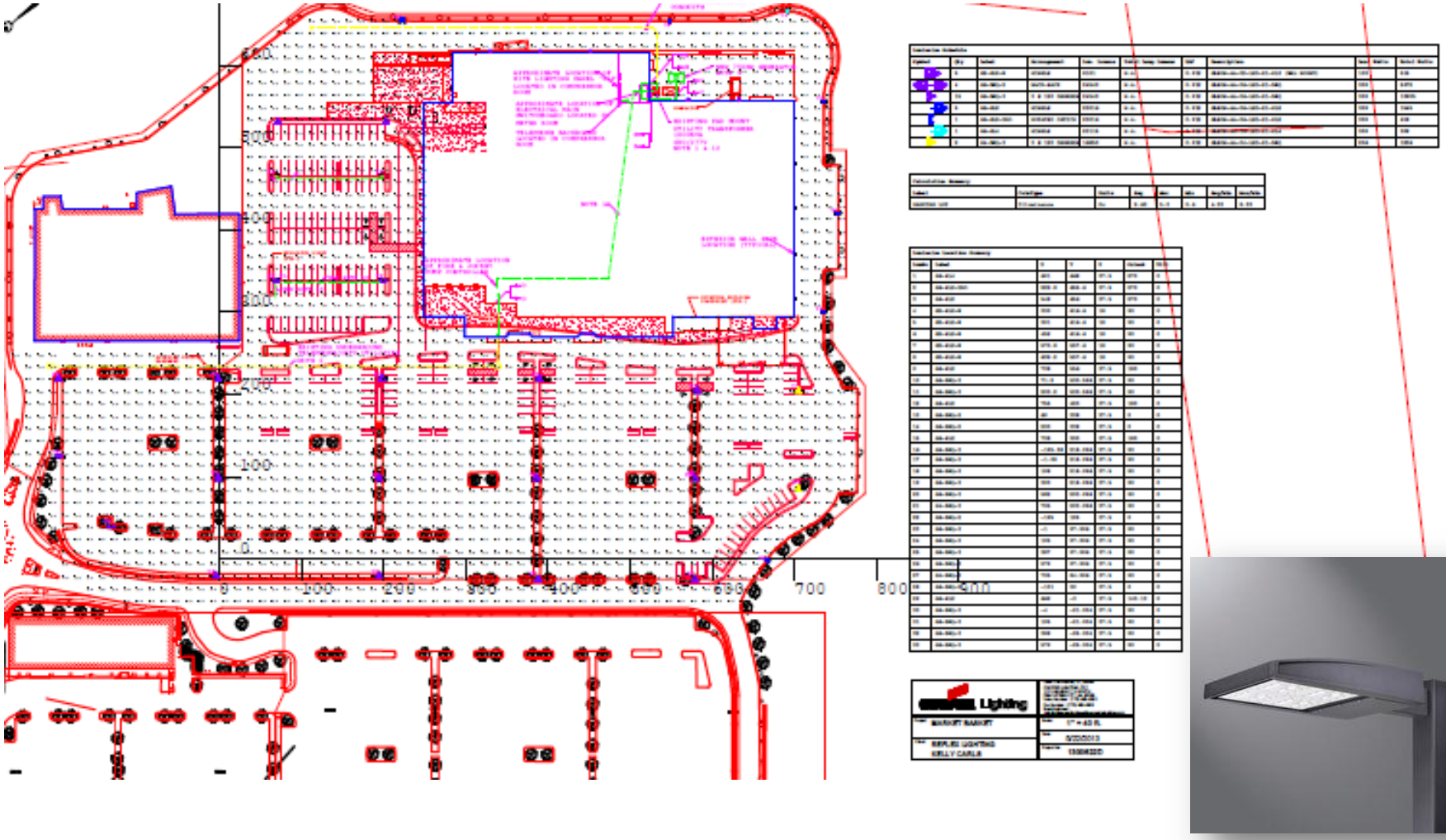
Exterior Lighting & Controls

Large New Retail Development



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Exterior Lighting & Controls

Large New Retail Development

- **LED Parking Lot & Sidewalk Post-top Fixtures**
- **Wireless Control Platform throughout**
- **$30,000 Mass Save Incentive**

Qty	Fixture Type	Description	Wattage	Annual Burn Hours
62	Type A	Ventus #VTS-B09-LED-E1-5MQ-BK-7-YR-FINISH	219	1,825
52	Type B	Ventus #VTS-B09-LED-E1-SL4-BK-7-YR-FINISH	219	1,825
75	Type D	Mesa #MSA-B01-LED-E1-T2-BK-7-YR-FINISH	27	4,380
21	Type E	Ventus #VTS-B09-LED-E1-5MQ-BK-7-YR-FINISH	219	1,825

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Exterior Lighting Codes

© California Lighting Technology Center, UC Davis
credit. Kathreen Fontecha

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Exterior Lighting Codes

NFPA Life Safety

Life Safety Code (NFPA 101) Section 3.3.151 Means of Egress:
A continuous and unobstructed way of travel from any point in a building or structure to a **public way** consisting of three separate and distinct parts: (1) the exit access, (2) the exit, and (3) the exit discharge.

Section 3.3.193 Public Way:
A street, alley, or other similar parcel of land essentially open to the outside air deeded, dedicated, or otherwise permanently appropriated to the public for public use and having a clear width and height of not less than 10 ft (3050 mm).

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Exterior Lighting Codes

IECC 2012

Connected Exterior Lighting Power must not exceed the **Exterior Lighting Power Allowance**

1. Calculated exterior lighting power allowance -LPD

   Lighting power densities (LPD) are determined by exterior function and by applicable lighting zone

2. Calculated proposed LPD follow wattage calculation “rules”

   Exempted lighting is omitted

3. Compare values: proposed wattage must be less than or equal to allowed wattage

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Exterior Lighting Codes

IECC 2012

Tradable surfaces

Common exterior lighted needs that can be traded for other needs.

For example, wattage allowed for parking lot lighting can be "traded" and used for canopy lighting.

Non-tradable surfaces

Less common exterior lighted needs that cannot be traded for other needs.

These applications have more specific security or task illuminance needs.

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Exterior Lighting Codes

IECC 2012 –Lighting Zones

Lighting Zone	Description
0	Undeveloped areas in national parks
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas consisting of residential zoning, neighborhood business districts, light industrial and mixed use areas
3	All other areas
4	High-activity commercial districts in major metropolitan areas

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Exterior Lighting Codes

IECC 2012 –Lighting Zones

		Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance		500 W	600 W	750 W	1300 W
Tradable Surfaces	**Uncovered Parking Areas**				
	Parking areas and drives	0.04 W/ft^2	0.06 W/ft^2	0.10 W/ft^2	0.13 W/ft^2
	Building Grounds				
	Walkways less than 10 feet wide	0.7 W/linear foot	0.7 W/linear foot	0.8 W/linear foot	1.0 W/linear foot
	Walkways 10 feet wide or greater Plaza areas Special Feature Areas	0.14 W/ft^2	0.14 W/ft^2	0.16 W/ft^2	0.2 W/ft^2
	Stairways	0.75 W/ft^2	1.0 W/ft^2	1.0 W/ft^2	1.0 W/ft^2
	Pedestrian Tunnels	0.15 W/ft^2	0.15 W/ft^2	0.2 W/ft^2	0.3 W/ft^2

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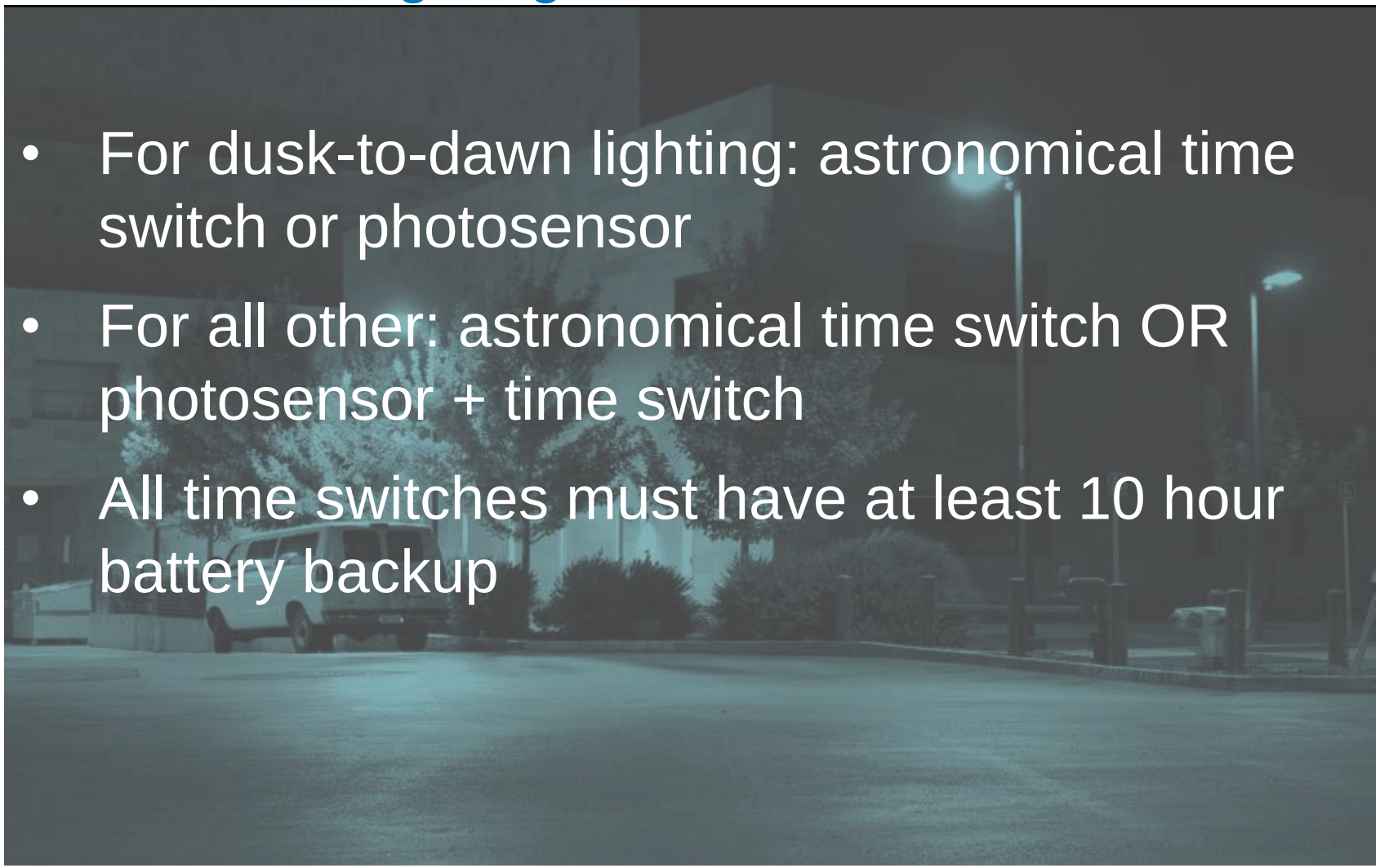
Exterior Lighting Codes

IECC 2012 –Lighting Controls



- For dusk-to-dawn lighting: astronomical time switch or photosensor
- For all other: astronomical time switch OR photosensor + time switch
- All time switches must have at least 10 hour battery backup

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Best Practices

Stony Brook Office Park
Waltham, MA

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Stony Brook Office Park Site Lighting

Commercial Office Complex with 3 Buildings (Waltham, MA)

- Campus managed by CB Richard Ellis
- Various interlocking parking lots with Multiple Drive Lanes
- Covered Parking Garage Structure

Existing Conditions

- Poor Uniformity & Light Levels below IESNA recommendations
- Concern for Safety & Security throughout campus
- Prioritized for Capital investment to address these issues for tenants

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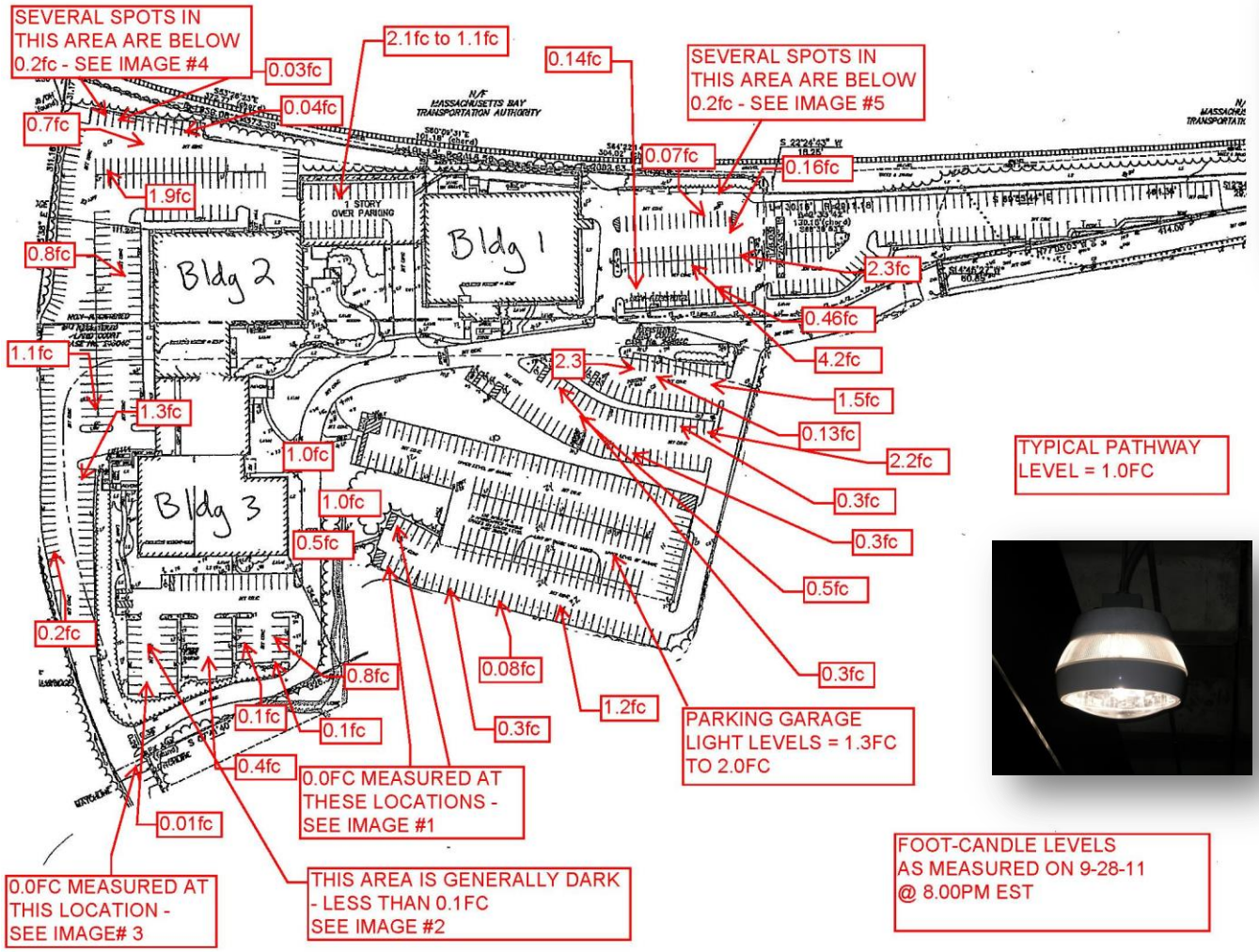
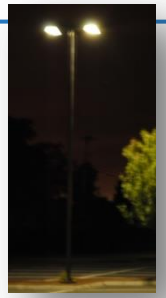
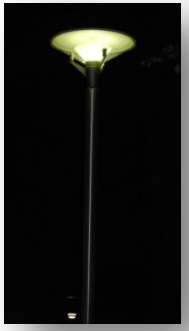
Stony Brook Site Audit Analysis







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Stony Brook Project Scope Analysis

Initial Energy Consumption

(32) 250W Metal Halide Garage Canopy Fixtures = **295 Input Watts**

(37) 400W Metal Halide Shoebox Fixtures (30') = **455 Input Watts**

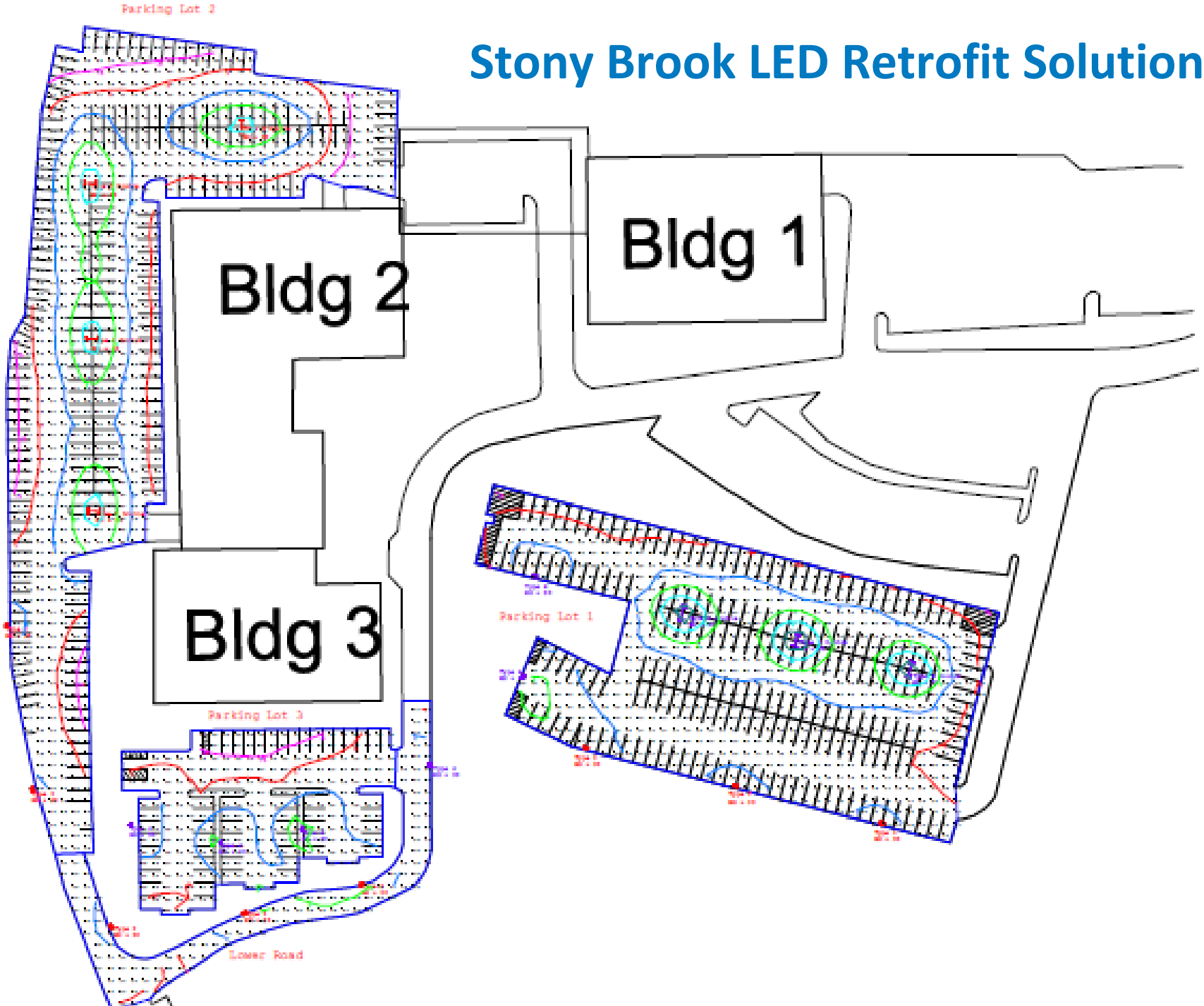
(11) 250W Metal Halide Shoebox Fixtures (20') = **295 Input Watts**

Capital Expense Budget for Project = $130K Material & Labor

Barriers to Project Implementation

- Cost-effective LED solution allowing for one-for-one retrofit
- Utilize fixtures that qualify for custom NSTAR incentive
- Leverage incentive & energy savings to improve payback

Stony Brook LED Retrofit Solution



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Stony Brook LED Retrofit Solution

Proposed LED Retrofit Solution

(32) 51W LED Garage Canopy Fixtures = 244W Saved per Fixture

(7) 219W LED Ventus Fixtures (30') = 236W Saved per Fixture

(30) 168W LED Ventus Fixtures (30') = 287W Saved per Fixture

(11) 124W LED Ventus Fixtures (20') = 171W Saved per Fixture

*Simplified labor with one-for-one retrofit solution

*Minimized Cost re-using existing poles/mounting locations

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Stony Brook LED Retrofit Financial Summary

Annual Burn Hours = 5,110 hrs

NSTAR Custom Incentive = **$19,371**

Realized Energy Savings = **$150-$175 per DAY**

Improved Light Levels throughout the site to increase safety & security for tenants, with additional benefits...

- Reduced Maintenance
- Daily Energy Savings

Solid State Lighting –LED's

New York Times –New Technology in Lighting
April 24, 2013

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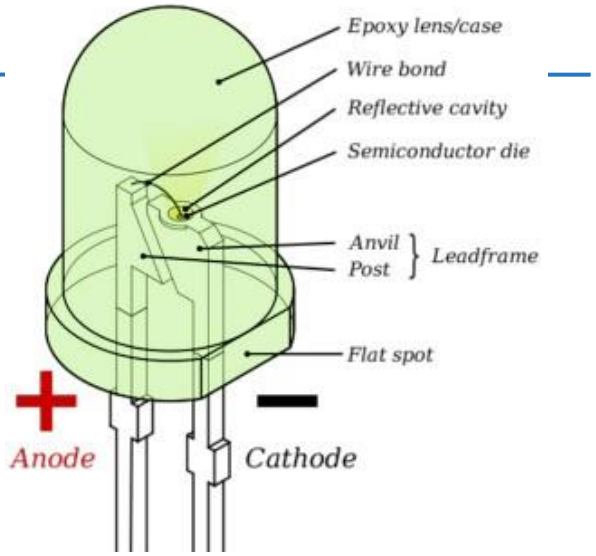
Solid State Lighting –LED's

Light-Emitting Diodes (LEDs) are solid-state electronic devices that generate light via the transformation of electric energy to radiant energy within the crystalline structure of a semiconductor chip.

- **No heated filaments or gases**
- **Can be reliable, durable, efficacious, long-lived, flexible, and very efficient with improved heat sinking and proper care**
- **White LED's have a chromaticity closest to natural daylight**
- **Performance of LED's decreases with increasing temperature**



Characteristics Effecting LED Performance

	Light Output	Junction Temp Tj	Efficacy	Lifetime	Cost ($/lumen)	CCT
Increase LED Input Current	Higher ↑	Hotter ↑	Worse ↓	Shorter ↓	Lower ↓	Larger shift (Typically cooler)
Decrease LED Input Current	Lower ↓	Cooler ↓	Better ↑	Longer ↑	Higher ↑	Smaller shift
Improve Heat Sinking	Higher ↑	Cooler ↓	Better ↑	Longer ↑	Depends on design	Smaller shift

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Solid State Lighting –LED's

The primary difference between LED technologies and traditional lighting technologies is in the thermal management.

The heat generated in an LED chip during operation is detrimental to the efficacy, light output, chromaticity, and lifetime of the device.

LEDs can produce light for 50,000-100,000 hours with proper thermal management

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Light Source Analysis

	LED		LED		CMH		Induction	
	MicroEmitter LED		LifeLED 65W49LED		Philips CDM70/U/PS/4K ALTO		Philips QL 85W	
Lamp Life	70,000	hrs	70,000	hrs	24,000	hrs	100,000	hrs
Yrs (12hr Use)	**16.0**	**yrs**	**16.0**	**yrs**	**5.5**	**yrs**	**22.8**	**yrs**
CRI			70 CRI		85 CRI		80 CRI	
Efficacy	49.8	lm/W	69.4	lm/W	59.3	lm/W	70.6	lm/W
Design Lumens	1629	lm	5000	lm	4150	lm	6000	lm
Wattage	32.7	W	72	W	70	W	85	W
Color Temp Range	5100 K		4000 K		4000 K		4000 K	
Dimmable?	0% - 100%							

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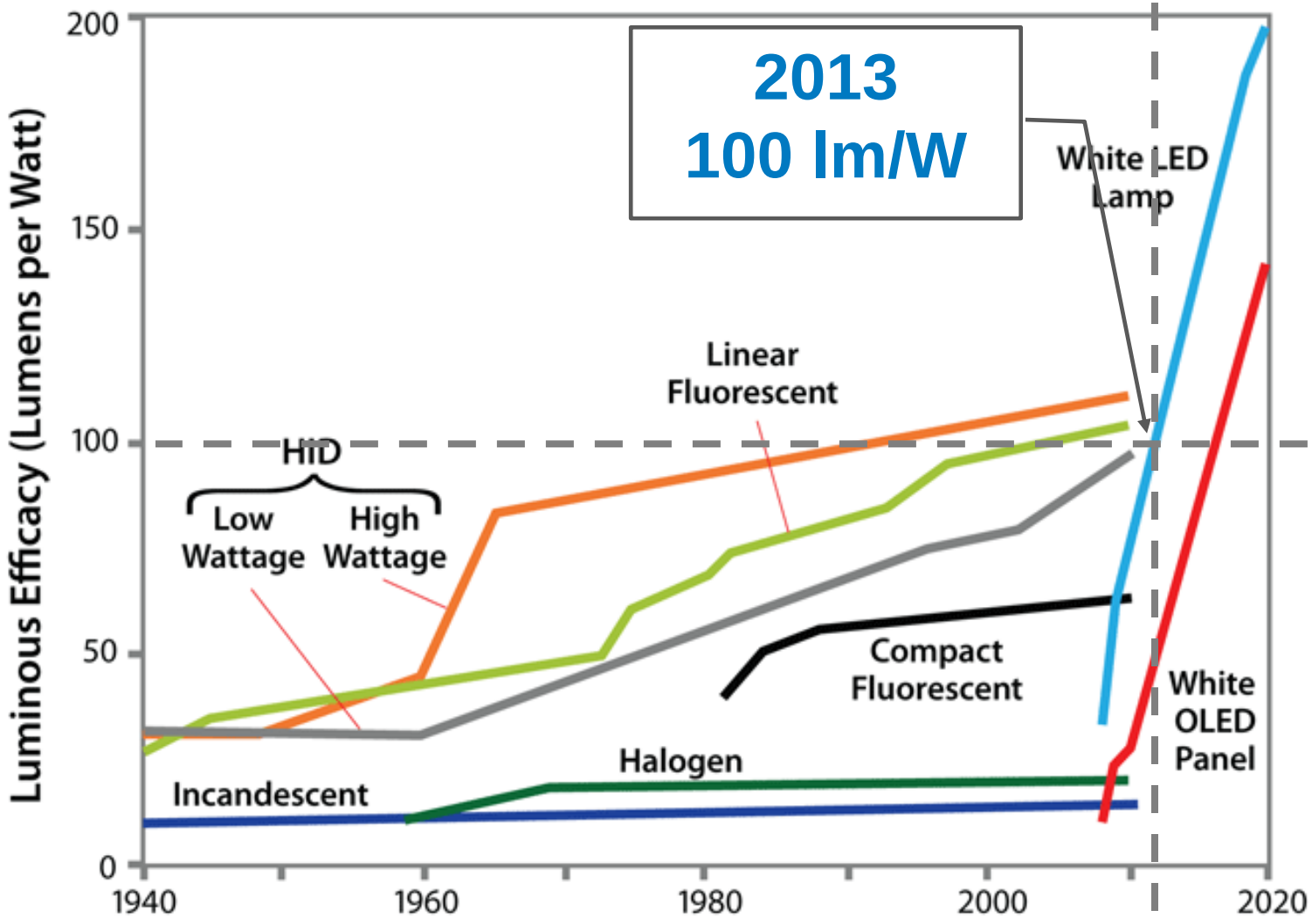
Advancement of LED's



US DOE SSL Multi Year Program Plan 2012

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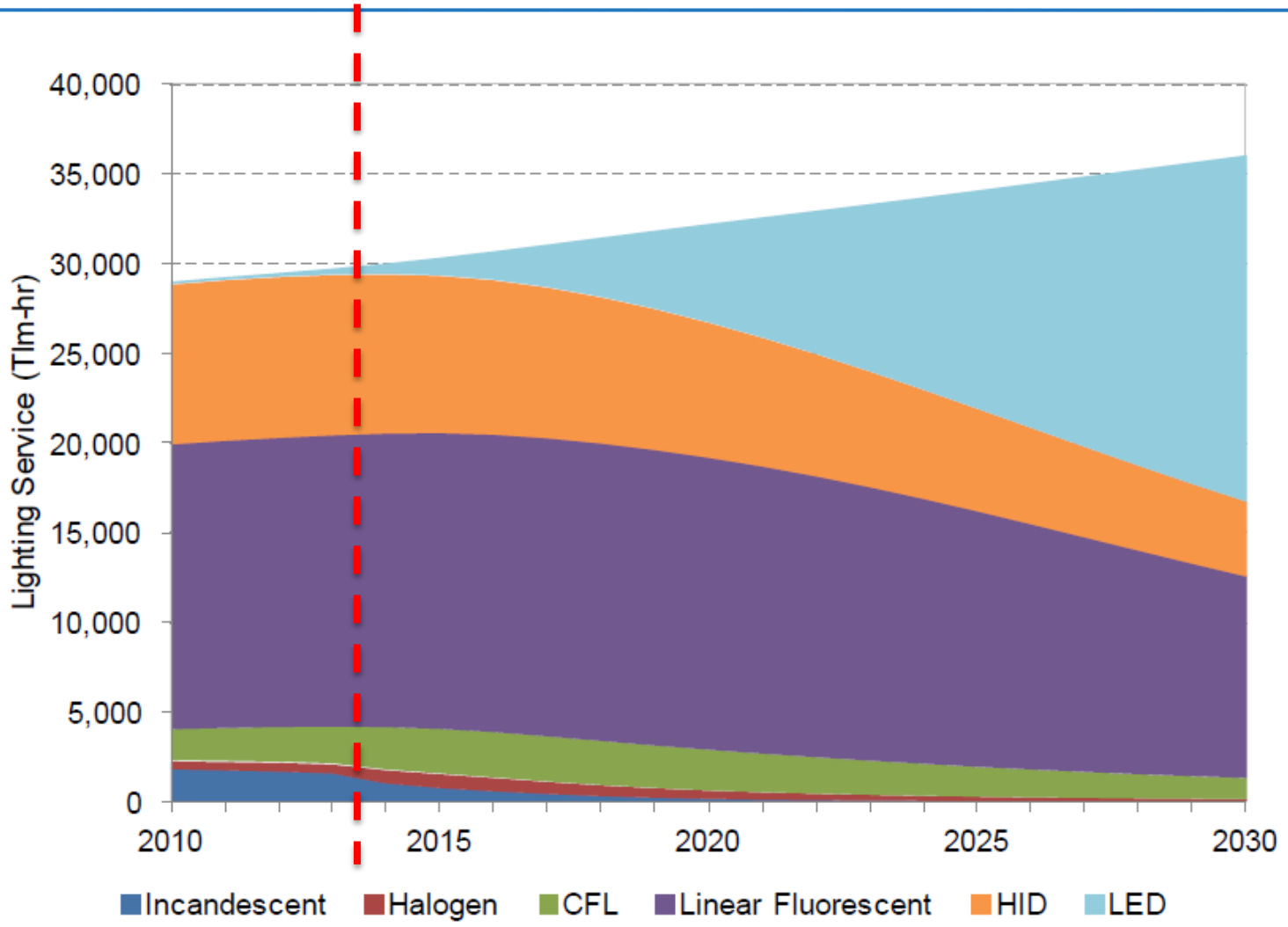
Lighting Market Trends 2010 - 2030



DOE: Total U.S. Lighting Service Forecast, 2010 to 2030

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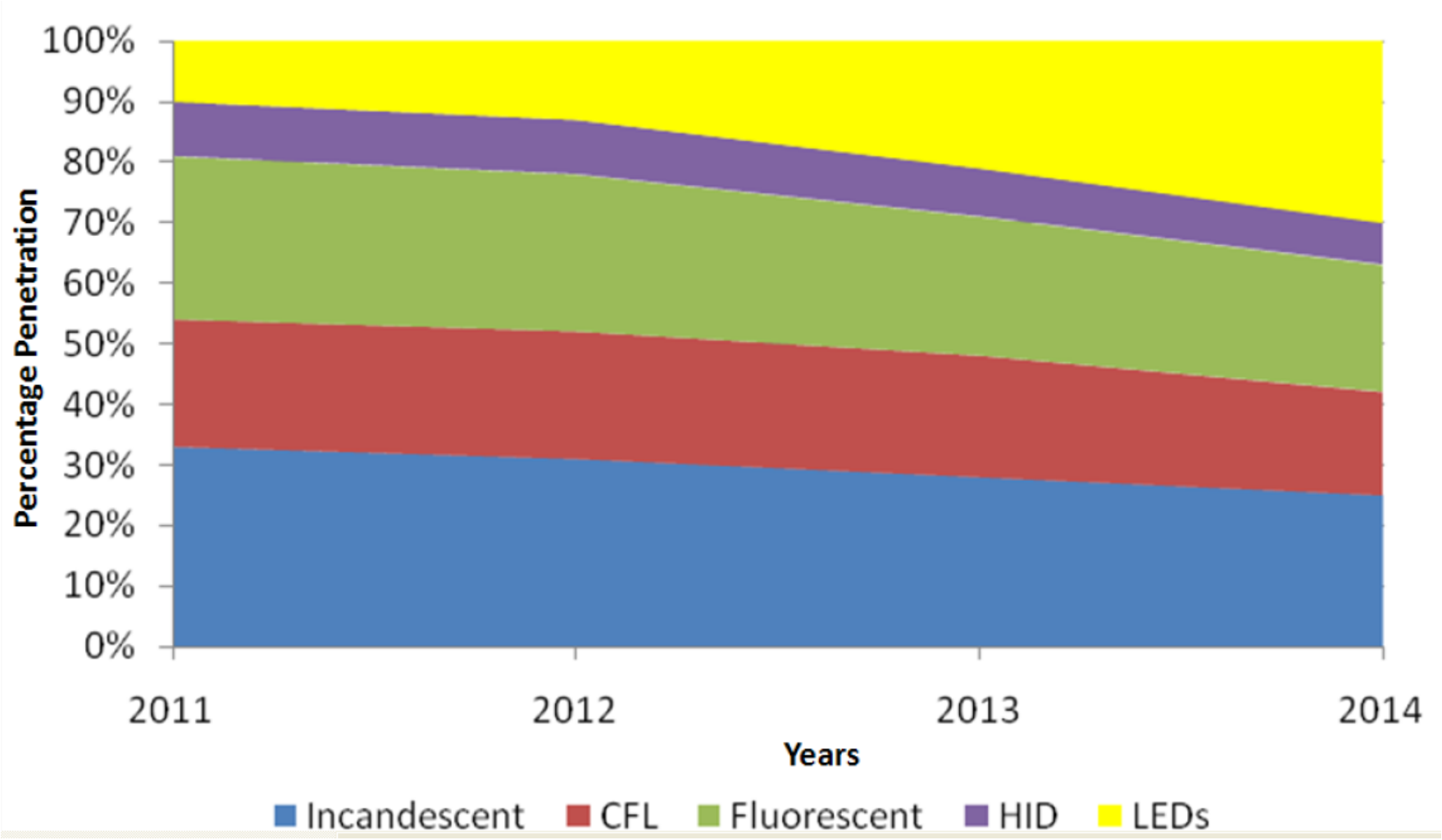
Lighting Market Trends 2011 - 2014



US DOE SSL Multi Year Program Plan 2012

Next Generation
LUMINAIRES

OUTDOOR SHOWCASE 2012

Recognizing and promoting excellence in the design of energy-efficient LED commercial lighting luminaires

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2012 Next Generation –Exterior Award Winner

Best in Class –Roadway Lighting

Light Output: **6289.4 lumens**

Input Power: **80.3 watts**

Efficacy: **78.3 lm/W**

Power Factor: **100%**

CCT: **3900K**, CRI: **72**

GE Lighting -**The Evolve™** LED Scalable Cobrahead, with its unique, advanced optical design using reflective technology, offers hundreds of photometric combinations.

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2012 Next Generation –Exterior Award Winner

Best in Class –Streetscape Lighting

Light Output: **2830.5 lumens**

Input Power: **58.0 watts**

Efficacy: **48.7 lm/W**

Power Factor: **99%**

CCT: **4526K**, CRI: **75**

The Relume **OXFORD** is an innovative decorative acorn luminaire that provides uniform lighting while offering a pleasing low brightness appearance, with the elimination of the LED points of light, and an adjustable uplight feature.

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2012 Next Generation –Exterior Award Winner

Best in Class –Façade Lighting

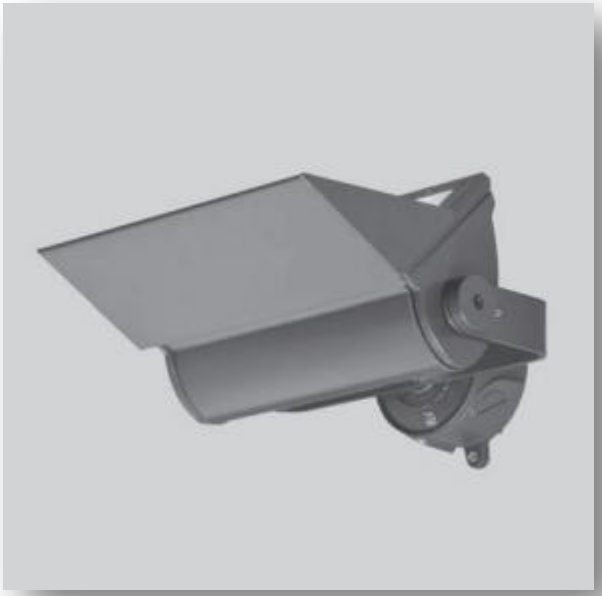
Light Output: **751.0 lumens**

Input Power: **18.1 watts**

Efficacy: **41.5 lm/W**

Power Factor: **99%**

CCT: **3108K**, CRI: **86**



The Lighting Quotient **fraqtir™ S170** is an IP66 outdoor rated luminaire with integral driver and precision optics designed to evenly illuminate surfaces from one edge..

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Best Practices

Landmark Center
Boston, MA

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Façade Lighting Upgrade

Landmark Center

Existing Images of Façade Lighting

Landmark Center

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Façade Lighting Upgrade

Proposed Rendering for RGB LED to upgrade Façade Lighting

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Best Practices

Park Lighting – Case Study

Othello Park
Seattle, WA

Othello Park
Site Lighting Analysis

General flood lighting strategy to cover the general park area for surveillance:

A. Existing lighting was installed and supplemented in the mid 90's:
   (4) 250W HPS Post top pole area lights
   (9) multi-head 400W HPS flood light fixtures mounted on SCL power poles along the perimeter for maximum area coverage
   (4) interior poles with 2-400W HPS flood light fixtures angled for maximum coverage.
B. Poor quality of light (CRI) reduces the ability to identify people.
C. Fixtures cause glare which diminishes visibility
D. Lighting uses 6200W of power, mostly to light air.

"Floodlights in the middle of the park (on pole #4306E) shine dangerously in the eyes of oncoming pedestrians and make identification of others on the path impossible. There is less than 2-foot visibility of oncoming pedestrians.
The same flood lights shine in the eyes of cars passing by on Othello if drivers look into the park to identify activities taking place after dark. These lights may help identify that something is happening, and at the same time work against anyone trying to get accurate I'd. on who the actors are in the park."

-2003 Othello CPTED Report, Seattle Neighborhood Group

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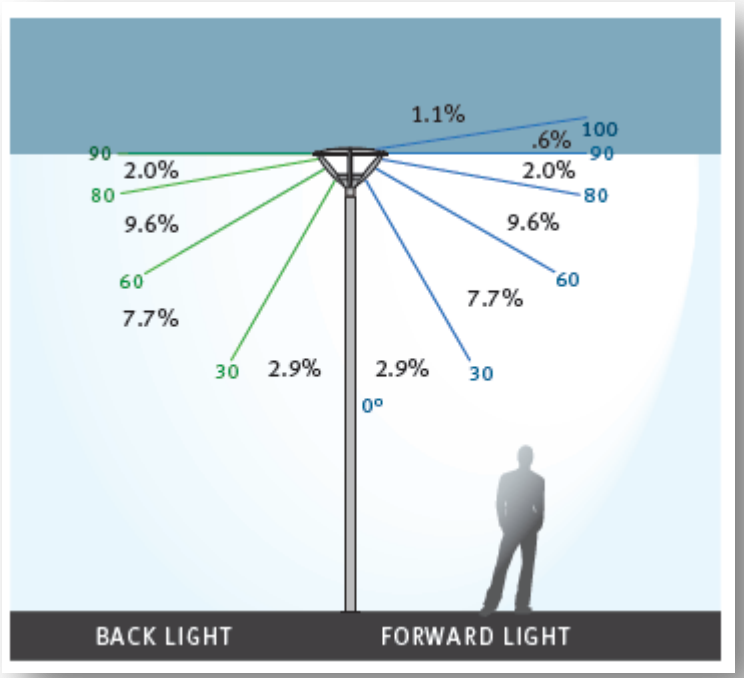
Othello Park –Schematic Design

Lighting Issues

Dark Sky Strategy

Based on the 2000 census Othello Park is in an area designated as Lighting Zone 3 – Urban. All lighting to conform to this designation:

a. All pole light fixtures to be specified as shielded
b. All building mounted fixtures to be shielded
c. All landscape uplights to be aimed toward trunk of tree to reduce skyward illumination.



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Othello Park –Schematic Design

Lighting Notes & Legend

A. **Eliminate all existing 400W HPS flood lights from perimeter street light poles. Remove (4) existing poles with 400W HPS flood lighting.**
B. **Replace (4) existing 250W HPS post top area light fixtures and poles.**
C. **Lighting to use power from existing facility service panel**
D. **Lighting power to be below grade**
E. **Replace, add and refurbish lighting at Comfort Station**

LEGEND			
Sym	Qty	Description	Watts
	13	Pedestrian scale pole lights	100W
	7	Line voltage power feed for ground mounted, tree uplights (3) 12W LED accent lights per feed	36W
		120V Exterior Outlet Box for Performances (2) per Stage Area	


Othello Park
LIGHTING
OPTION A
For Budgetary Purposes Only
Notes:
A. Eliminate all existing 400W HPS flood lights from perimeter street light poles. Remove (4) existing poles with 400W HPS flood lighting.
B. Replace (4) existing 250W HPS post top area light fixtures and poles.
C. Lighting to use power from existing facility service panel
D. Lighting power to be below grade
E. Replace, add and refurbish lighting at Comfort Station

Othello Park
LIGHTING
OPTION A

For Budgetary Purposes Only

Notes:

A. Eliminate all existing 400W HPS flood lights from perimeter street light poles. Remove (4) existing poles with 400W HPS flood lighting.

B. Replace (4) existing 250W HPS post top area light fixtures and poles.

C. Lighting to use power from existing facility service panel

D. Lighting power to be below grade

E. Replace, add and refurbish lighting at Comfort Station

Othello Park
Schematic Lighting Plan

a. **Well shielded pole lighting at park entrances and pathway nodes to promote wayfinding and highlight activity areas.**

b. **Uplighting of specific trees to define the boundaries of the park while highlighting the natural features and removing areas of concealment.**

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Exterior Lighting Criteria for Public Areas

- Deter Crime
- Decrease Fear
- Natural Surveillance
- Access Control
- Ownership

- Encourage Positive Activities and Use
- Activate Significant or Ignored Space
- Accommodate community activities
- Provide visual guidance for access and egress
- Signify important features

- Durable, Vandal Resistant Fixtures
- Low Life Cycle Costs
- Energy Effective Lighting
- Meets Specified Lighting Quantity and Distribution

- Historically and stylistically appropriate fixtures
- Design for visual comfort
- Scale fixtures proportional to site and users
- Visual place making
- Dark sky compliant for population density

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Advances in Exterior Lighting and Design

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