



lighting design lab



efficient nighttime lighting

Presented by Michael Lane, LC



BETTERBRICKS
An initiative of the Northwest Energy Efficiency Alliance.



lighting design lab



"The Lighting Design Lab works to transform the Northwest lighting market by promoting quality design and energy efficient technologies."

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Agenda

- » Sources
- » Vision
- » Light Trespass and Light Pollution
- » MLO
- » LEED
- » Codes



Michael Lane, LC



- » Lead lighting specialist at the Lighting Design Lab and has been with the Lab since its inception in 1989.
- » Received Bachelor of Architecture from Washington State University in 1982, and has specialized in the lighting field for over 24 years.
- » Is a member of the IESNA and was in the first class to be Lighting Certified (LC) by NCQLP.
- » Serves on the IESNA Educational Materials, Sustainable Lighting & Energy Management Committees, the ASHRAE 90.1 Energy Committee and the LEED Sustainable Sites Committee.

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Light sources

- » Electric light sources vary widely in their spectral content, and should be carefully selected for their color characteristics.



- » This is an extreme example – Metal Halide & Low Pressure Sodium - but the spectral composition of any light source will affect our perception of the surfaces around us.



Color quality

» Color Temperature

- » The absolute temperature in Kelvin (K) of a blackbody radiator. The degree of warmth or coolness of the light source.



- 6000K Mercury
- 5000K RE (T8)
- 4300K Metal Halide
- 4200K Cool White
- 4100K RE (T8)
- 3500K RE (T8)
- 3000K RE (T8)
- 2700K Incandescent
- 2200K HPS



Color Rendering Index



- » A measure of the degree of color shift objects undergo when illuminated by a light source compared to a reference source of comparable color temperature.



Efficacy

» Efficacy is the ratio of light output to power input.
(stated as cataloged lamp lumens per watt – not including ballast loss)

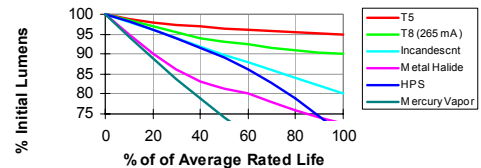
» incandescent	5 – 10 L/W
» fluorescent	60 – 100 L/W
» mercury vapor	25 – 50 L/W
» high pressure sodium	40 – 110 L/W
» metal halide	60 – 100 L/W
» induction	61 – 76 L/W
» low pressure sodium	~ 180 L/W
» LED (white)	30+ L/W



Lamp Lumen Depreciation

» Manufacturers supply data:

- » Initial lumens, which is the light output after 100 hour of "burn in".
- » Maintained lumens, (or design lumens) which is the light output at 40% of lamp life.



Metal Halide



- » Normally neutral to cool color temperature (3500 - 4300K)
- » Noticeable color shift in standard lamps over time
- » Lamp life 10,000 to 20,000 hrs.
- » Cold starting down to -12c
- » Orientation sensitive (V/H/U)
- » 61 mlpw (320W)
- » Acceptable to excellent CRI



Ceramic Metal Halide



- Better CRI: 85+
- Excellent color consistency +/- 200k
- Better lumen maintenance
- 20-400 watts available



Electrodeless Induction Lamps

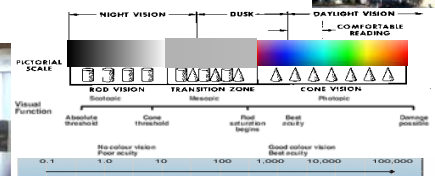
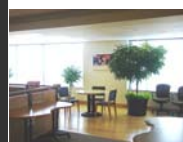
- » 100,000 hour lamp life
- » 57 mlpw (85W)
- » 80+ CRI
- » Cold start to -30 °F
- » instant re-strike
- » low-pressure mercury gas
- » Pedestrian Scale Street Lighting
- » Parking Lot Lighting
- » Use in areas that see little maintenance or are difficult to access.



Photopic Vision

» Defined as vision at relatively high light levels where the cones are fully activated.

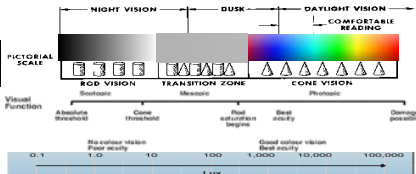
- » It occurs at illumination levels above 3 footcandles.
- » This is commonly called "day vision."





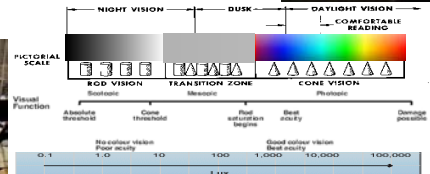
Scotopic vision

- » Occurs at illumination levels under which the cones cease to function
- » substantially less than 1 footcandle, such as those illuminances experienced on a starlit night.
- » It is commonly called "night vision."

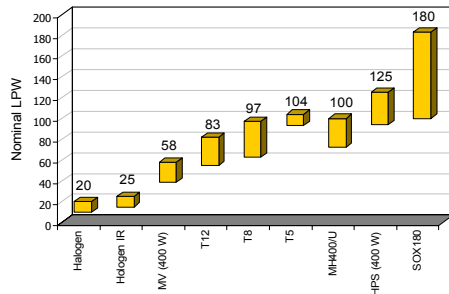


Mesopic vision

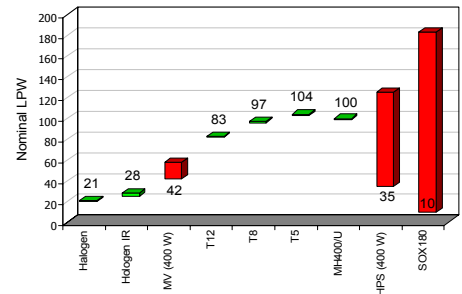
- » Occurs in the state between the photopic and scotopic extremes.
- » In this state both rods and cones are active.
- » It is typically experienced at dusk and under a bright moonlit sky, and includes almost all outdoor electric lighting conditions.



Nominal Lamp Efficacy



Nominal Lamp Efficacy (off axis detection)



Exterior Design Issues

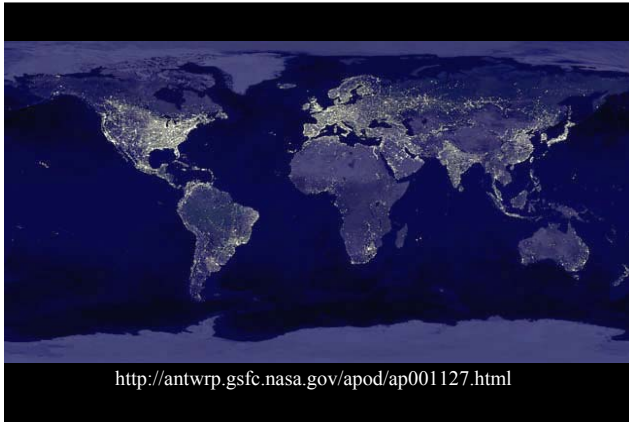
Like all lighting design, successful exterior lighting is found in applying light where it is desired, and keeping it away from where it is not



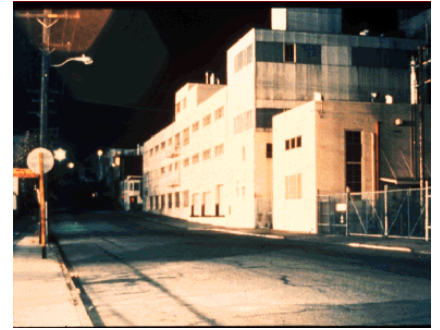
Light Pollution/ Light Trespass

- » Light pollution is light shining directly into the sky
- » Light trespass is unwanted light shining out of the intended area, usually off the property





Light Trespass



IES Light Levels

Recommended average

	Average horizontal illuminance	Vertical Illuminance
Storage yards, industrial equipment areas	0.5 to 2.0	
Building façade		0.5 to 2.0
Facial identification		0.5 to 0.8
Entrances at guarded facilities	10	0.5 to 0.8
ATM's	10	15
Parking garage	6	0.5 to 0.8
General parking areas	3	0.5 to 0.8
Walkways	0.6	0.5 to 0.8
School - walkways	1	0.5 to 0.8
Supermarket/Major retail - close in parking	5	0.5 to 0.8
Fast food - drive up window	6	0.5 to 0.8
Gas station - pump island	5 to 10	0.5 to 0.8
Auto Dealership - general sales area	5 to 20	

Most exterior spaces in the US are over lighted



Adaptation is ...

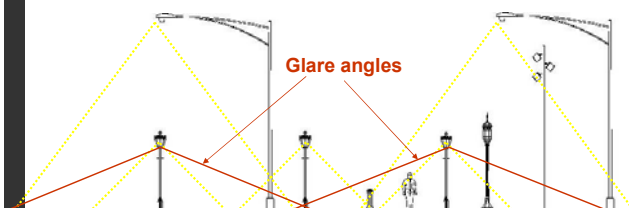
important at night when moving from dark to bright or bright to dark areas

Of particular concern, as our eyes age, they are slower to adapt and thus even more sensitive to changes in light levels



Glare and lighting angles

» The higher the luminaire, the farther apart they can be w/out glare. Lower, 'human scale' pedestrian lights require greater frequency.



Luminaire optics

» Note that the fixture w/ superior optics not only minimizes glare, but delivers useful light further



1A



Figure 1A. Person in negative contrast with background. Figure 1B. Person in positive contrast with background. Positive contrast allows features to be recognized and makes it possible to decide whether a threat exists while there is time to avoid the approaching person.

LD+A April 2006



Renderings of street lit with cutoff luminaires (Figure 9A) and with semi-cutoff luminaires (Figure 9B).

LD+A April 2006



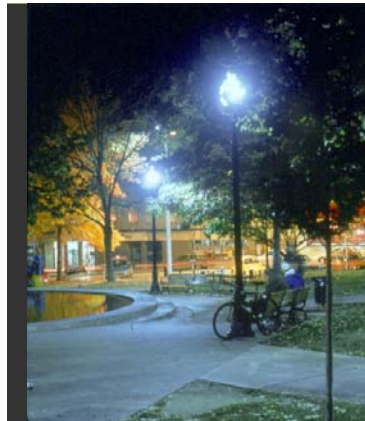
Pole Height

- » Using more luminaires with lower pole height and lower brightness lamps can significantly reduce glare and light trespass while improving uniformity



Uniform lighting

- » Helps control glare
- » Requires less light
- » Uses less power



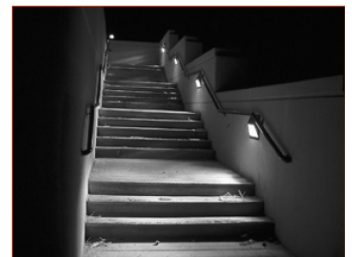
Safety and Security

- » Hazards – Stairs, low hanging objects, etc
- » Criminal activity – Lighting is only a deterrent if criminals think they will be observed
- » Security – Sense of wellbeing, clearly defined area



Security

- » In general, comfortable, well-defined exterior environments with clear zones of recognition are perceived as secure.





Security Lighting

People often associate higher illuminance or greater luminance with safer surrounds, but poorly directed light can reduce visibility and thereby reduce both safety and security



MLO

- » The MLO is intended for use by cities and municipalities that want to provide a regulatory strategy for outdoor lighting, to require outdoor lighting appropriate to communities, the environment, and natural habitat. IDA will take the lead in the development of the MLO. Design Guidelines will be developed under the lead of IESNA to provide technical background on the provisions of the MLO for design professionals to determine how to give appropriate design guidance about the MLO.
- » The MLO is still under development by a joint task force of both organizations. While the final Ordinance will not be available for another few months, the following information indicates the initial intent of the Ordinance.



MLO

- » 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 and/or use type
- » Each LZ (from 0 to 4) will provide a recommended upper limit on the amount of light. A community could choose to assign a different LZ to the area, preferably lower, to align with its existing districts



LEED
LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

- » Exterior lighting requirements in LEED™ Rating System Version 2.1 (SSc8)
- » Published by US Green Building Council

- » Version 2.2
 - » *minimize* light trespass from the building and site
 - » *reduce sky-glow to increase* night sky access
 - » *improve nighttime visibility through glare reduction*
 - » *reduce development impact on nocturnal environments*



Exterior lighting

- » Only light areas as required for safety and comfort
- » Do not exceed 80% of the lighting power densities for exterior areas and 50% for building facades and landscape features as defined in ASHRAE/IESNA Standard 90.1-2004, Exterior Lighting Section, without amendments
- » All projects shall be classified under one of the following zones, as defined in IESNA RP-33, and shall follow all of the requirements for that specific zone





LEED lighting zones

- » LZ1 - Dark (Park and Rural Settings)
- » LZ2 – Low (Residential areas)
- » LZ3 – Medium
(Commercial/Industrial, High-Density Residential)
- » LZ4 – High (Major City Centers, Entertainment Districts)



Light Trespass

LEED-NC
Version 2.2

- » Design exterior lighting so that all site and building mounted luminaires produce a maximum initial illuminance value no greater than (LZ1=0.01, LZ2=0.10, LZ3=0.20, LZ4=0.6) horizontal and vertical footcandles at the site boundary and no greater than 0.01 horizontal footcandles 10 (15 for LZ3 & LZ4) feet beyond the site boundary



Light Pollution

LEED-NC
Version 2.2

- » Document that (LZ1=0%, LZ2=2%, LZ3=5%, LZ4=10%) of the total initial designed fixture lumens are emitted at an angle of 90 degrees or higher from nadir (straight down)



LZ2, LZ3 & LZ4

LEED-NC
Version 2.2

- » For site boundaries that abut public rights-of-way, light trespass requirements may be met relative to the curb line instead of the site boundary



Table 9.4.5

Lighting Power Densities for Building Exteriors

Applications

Lighting Power Densities

Tradable Surfaces (Lighting Power Densities for open parking areas, building grounds, building entrances and exits, canopies and overhangs, and outdoor sales areas may be traded)

Uncovered Parking Areas	
Parking Lots and drives	0.15 W/ft ²
Building Grounds	
Walkways less than 10 feet wide	1.0 Watts/linear foot
Walkways 10 feet wide or greater, Plaza areas and Special feature areas	0.2 W/ft ²
Stairways	1.0 W/ft ²
Building Entrances and Exits	
Main Entries	30 Watts/linear foot of door width
Other doors	20 Watts/linear foot of door width



Table 9.4.5

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Lighting Power Densities

Tradable Surfaces (Lighting Power Densities for open parking areas, building grounds, building entrances and exits, canopies and overhangs, and outdoor sales areas may be traded)

Canopies and Overhangs	
Canopies (free standing & attached) and overhangs	1.25 W/ft ²
Outdoor Sales	
Open areas (including vehicle sales lots)	0.5 W/ft ²
Street Frontage for vehicle sales lots in addition to "open area" allowance	20 Watts/linear foot



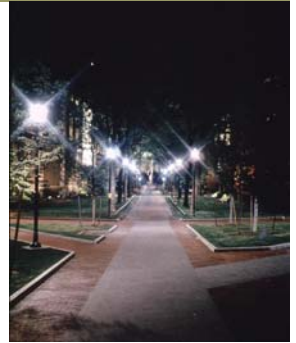
Uncovered Parking Areas

- » A requirement of 0.15 W/sf was developed for **Parking Lots and Drives**
- » Criteria used was:
 - » 1.0 minimum horizontal FC
 - » 3.0 average horizontal FC
 - » 0.5 minimum vertical FC
- » Models met the criteria at 0.122 W/sf



Building Grounds

- » A requirement of 1.0 W/lf was developed for **Walkways**
- » Criteria used was:
 - » 0.5 minimum horizontal FC
 - » 0.5 minimum vertical footcandles
- » Models met the criteria at 0.875 W/lf



Building Grounds

- » A requirement of 0.2 W/sf was developed for **Plazas and walkways 10 and wider**
- » Criteria used was:
 - » 0.5 minimum horizontal FC
 - » 0.5 minimum vertical footcandles
- » Models met the criteria at 0.175 W/sf



Building Grounds

- » A requirement of 1.0 W/sf was developed for **Stairs**
- » Criteria used was:
 - » 0.5 minimum horizontal FC
 - » 1.0 minimum vertical footcandles
- » Model was developed using physical constraints of stair design (one 50 watt fixture every for every 12 feet of stair)



Canopies and overhangs

- » A requirement of 1.25 W/sf was developed for **Canopies** (free standing & attached) and overhangs
- » Criteria used was:
 - » 5 to 20 average horizontal FC
 - » 0.5 minimum vertical footcandles
- » Models met the criteria at 0.8 to 1.2 W/sf



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To reach me



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Questions?

Thank You

Let Us Know How We Can Help....