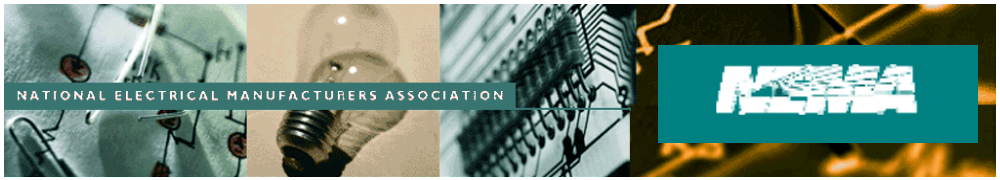


Outdoor Lighting Metrics

Yaser Abdelsamed

Acuity Brands Lighting

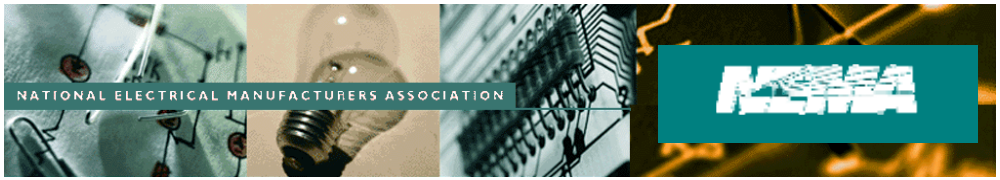
NEMA Task Force – Outdoor Lighting

EnergyStar Partner Meeting

Denver, CO. October 4th, 2010

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

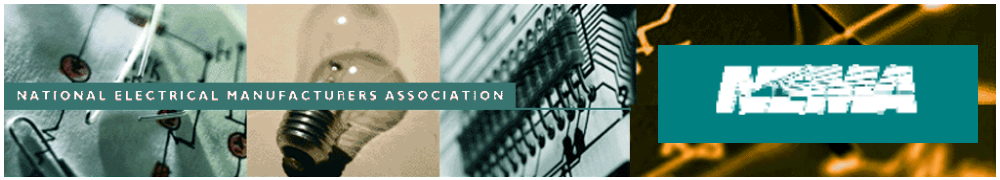
Can it happen?



Energy Star

….save money and protect the environment through energy efficient products and practices.

….products deliver the same or better performance as comparable models while using less energy and saving money.



Energy Star Draft

ENERGY STAR® Program Requirements for Solid State Lighting Luminaires

Proposed Category "A" Additions – Outdoor Area & Parking Garage

Category A: Near-term Applications

Outdoor pole-mounted area and roadway luminaires[1]

Application Requirements		
Minimum Light Output	Luminaire shall deliver a minimum of 1,000 lumens (initial).	
Minimum Fitted Target Efficacy (lm/W)	Fitted Target Efficacy (FTE) evaluates the efficacy with which a luminaire delivers uniform illumination to a rectangular uniform area of coverage (the target area). FTE is calculated using standard absolute luminaire photometry (LM-79-08 test results in LM-63-02 formatted .ies file). Minimum requirements are given in initial lumens per watt of luminaire input power (lm/W). For DOE FTE calculator (beta version) please see http://www.drintl.com/temp/FTE-Calculator.exe. For calculator instructions, please see http://www.drintl.com/htmlemail/FTE_ReadMe.pdf. For supporting materials, please see http://www.drintl.com/htmlemail/FTEoverview01Jul09.pdf and http://www.drintl.com/htmlemail/FTEalgorithm01Jul09.pdf.	
Maximum Luminous Flux in Glare and Uplight Zones[†]	FH (60-80°)	48.0% and 12,000 lumens
	BH (60-80°)	20.0% and 5,000 lumens / 48.0% and 12,000 lumens
	FVH (80-90°)	3.0% and 750 lumens
	BVH (80-90°)	3.0% and 750 lumens
	UL (90-100°)	4.0% and 1000 lumens
	UH (100-180°)	4.0% and 1000 lumens

Shielded (< 1.5 MH house-side)		Unshielded (≥ 1.5 MH house-side)	
Low Output < 9,500 lumens	High Output ≥ 9,500 lumens	Low Output < 13,300 lumens	High Output ≥ 13,300 lumens
37	48	53	70

[†] Both requirements must be met for each BUG secondary solid angle: maximum percent of luminaire lumens in zone and maximum lumens in zone. Secondary solid angles (zones) are per IES TM-15-07. FH-forward high; FH-back; FVH-forward very high; BVH-back very high; UL-up low; UH-up high.

[1] Including but not limited to luminaires intended for lighting streets, parking lots, walkways, and plazas. Includes decorative post-top luminaires. Excludes luminaires intended to be mounted below eye level, e.g. bollards and steplights.

Outdoor wall-mounted area luminaires ("wall packs")

Application Requirements		
Minimum Light Output	Luminaire shall deliver a minimum of 300 lumens (initial).	
Maximum Luminous Flux in Glare and Uplight Zones*	FH (60-80°)	48.0% of total luminaire output
	FVH (80-90°)	3.0% of total luminaire output
	UL (90-100°)	2.0% of total luminaire output
	UH (100-180°)	2.0% of total luminaire output
Minimum Luminaire Efficacy	52 lm/W	

*Secondary solid angles (zones) are per IES TM-15-07. FH-forward high; FVH-forward very high; UL-up low; UH-up high.

Parking garage/canopy luminaires

Application Requirements	
Minimum Light Output	Luminaire shall deliver a minimum of 2,000 lumens (initial).
Zonal Lumen Density Requirement	Luminaire shall deliver a minimum of 20% of total lumens in the 60°-70° zone.
Minimum Luminaire Efficacy	70 lm/W

Shielded (< 1.5 MH house-side)		Unshielded (≥ 1.5 MH house-side)	
Low Output < 9,500 lumens	High Output ≥ 9,500 lumens	Low Output < 13,300 lumens	High Output ≥ 13,300 lumens
37	48	53	70

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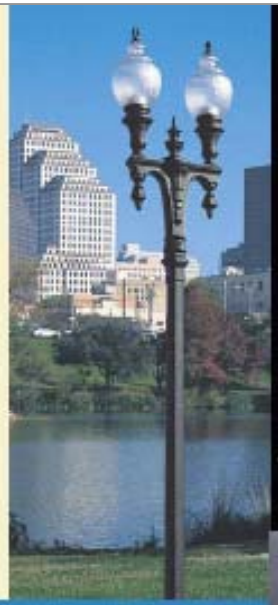
Outdoor Lighting

Area & Parking
Roadway & Street
Flood Lighting
Security
Sports
High-Mast
Building Mounted
Poles & Post
In-grade
Underwater
Accent & Border
Controls








Courtesy Acuity Brands Lighting

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Lighting Quality

Human Needs
- visibility
- task performance
- visual comfort
- social communication
- mood and atmosphere
- Health, safety & well-being
- aesthetic judgment

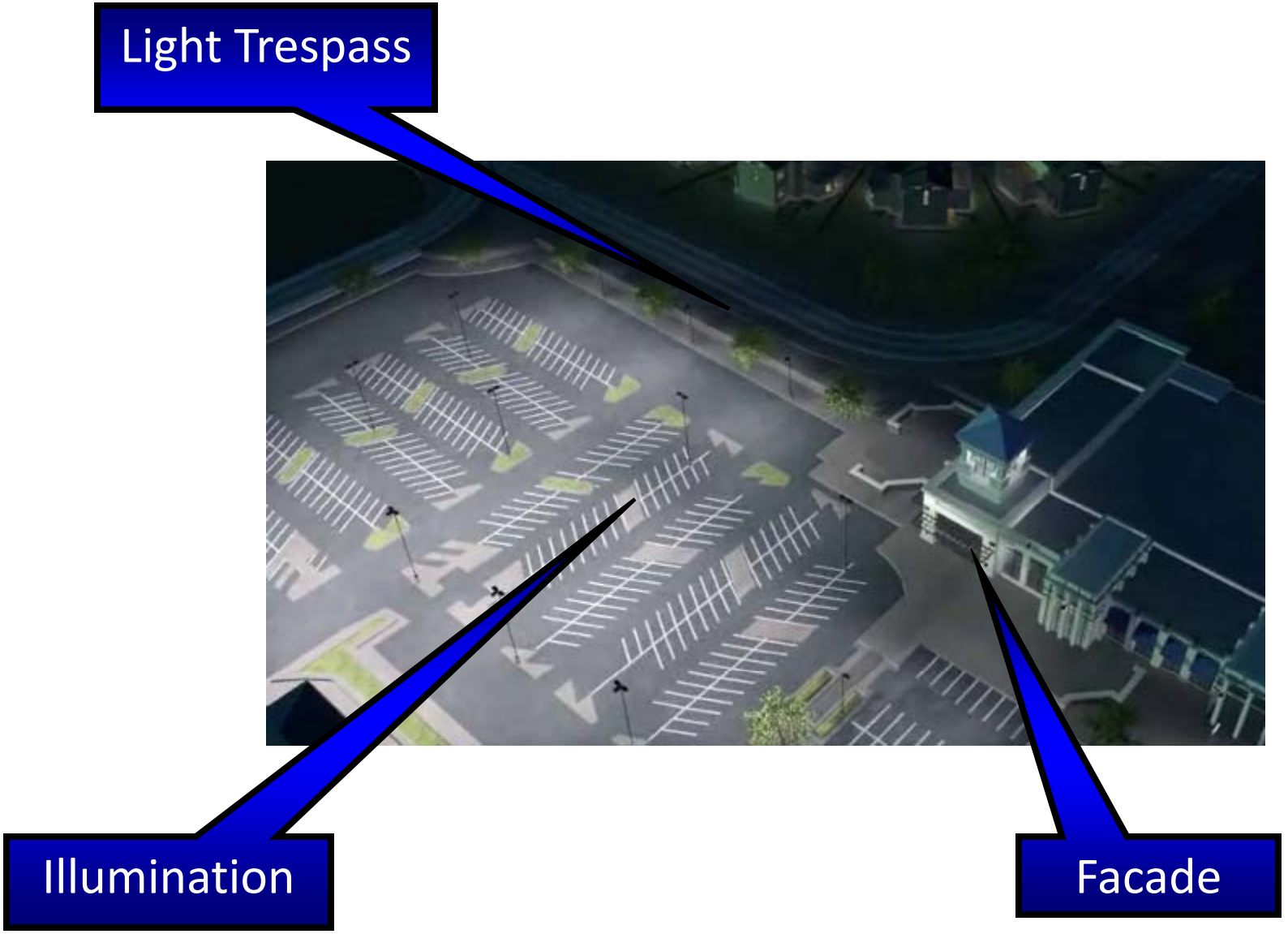
Lighting Quality

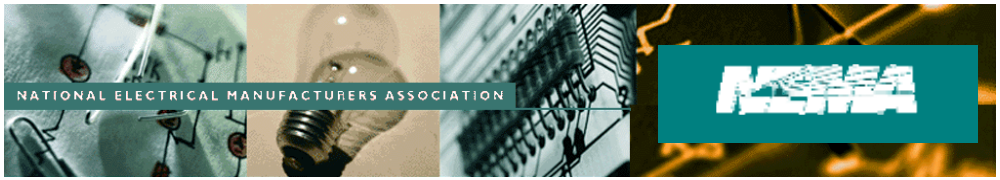
Economics and the Environment
- installation
- maintenance
- operation
- energy
- environment

Architecture
- form
- composition
- style
- codes and standards

Source - IES Handbook

The Lighting Task



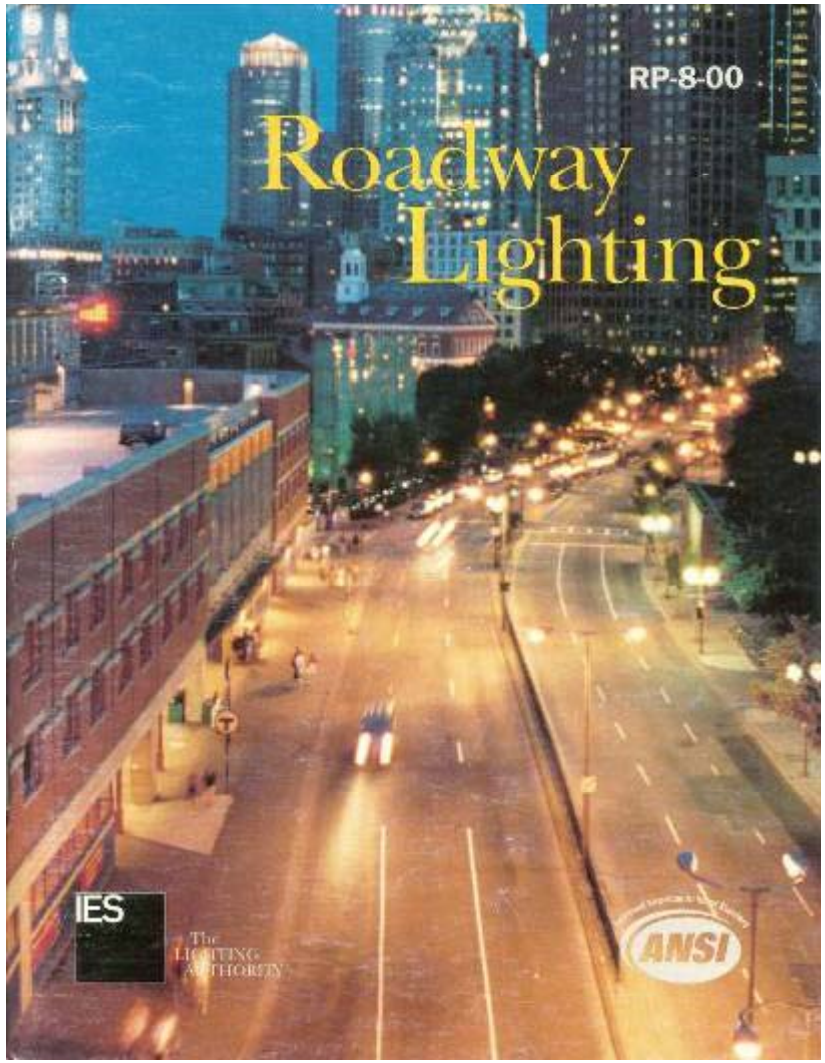


Metric Objectives

An EnergyStar Metric that is…

- ✓ 1. Based on a system of luminaires
- ✓ 2. Founded in illumination metrics
- ✓ 3. Product Specific
- ✓ 4. Correlated to energy savings
- ✓ 5. Technology neutral
- ✓ 6. Easy to Comprehend
- ✓ 7. Useful for energy comparison

IES RP-8… Streets



- Streets, Highways, Sidewalks
- Illumination Metrics
  - Average
  - Ave:Min
  - Veiling Luminance

Table 2: Illuminance Method - Recommended Values

Road and Pedestrian Conflict Area		Pavement Classification (Minimum Maintained Average Values)			Uniformity Ratio	Veiling Luminance Ratio
Road	Pedestrian Conflict Area	R1 lux/fc	R2 & R3 lux/fc	R4 lux/fc	E_{avg}/E_{min}	L_{vmax}/L_{avg}
Freeway Class A		6.0/0.6	9.0/0.9	8.0/0.8	3.0	0.3
Freeway Class B		4.0/0.4	6.0/0.6	5.0/0.5	3.0	0.3
Expressway	High	10.0/1.0	14.0/1.4	13.0/1.3	3.0	0.3
	Medium	8.0/0.8	12.0/1.2	10.0/1.0	3.0	0.3
	Low	6.0/0.6	9.0/0.9	8.0/0.8	3.0	0.3
Major	High	12.0/1.2	17.0/1.7	15.0/1.5	3.0	0.3
	Medium	9.0/0.9	13.0/1.3	11.0/1.1	3.0	0.3
	Low	6.0/0.6	9.0/0.9	8.0/0.8	3.0	0.3
Collector	High	8.0/0.8	12.0/1.2	10.0/1.0	4.0	0.4
	Medium	6.0/0.6	9.0/0.9	8.0/0.8	4.0	0.4
	Low	4.0/0.4	6.0/0.6	5.0/0.5	4.0	0.4
Local	High	6.0/0.6	9.0/0.9	8.0/0.8	6.0	0.4
	Medium	5.0/0.5	7.0/0.7	6.0/0.6	6.0	0.4
	Low	3.0/0.3	4.0/0.4	4.0/0.4	6.0	0.4

(Refer to **Section 3.6** for Intersection Lighting)

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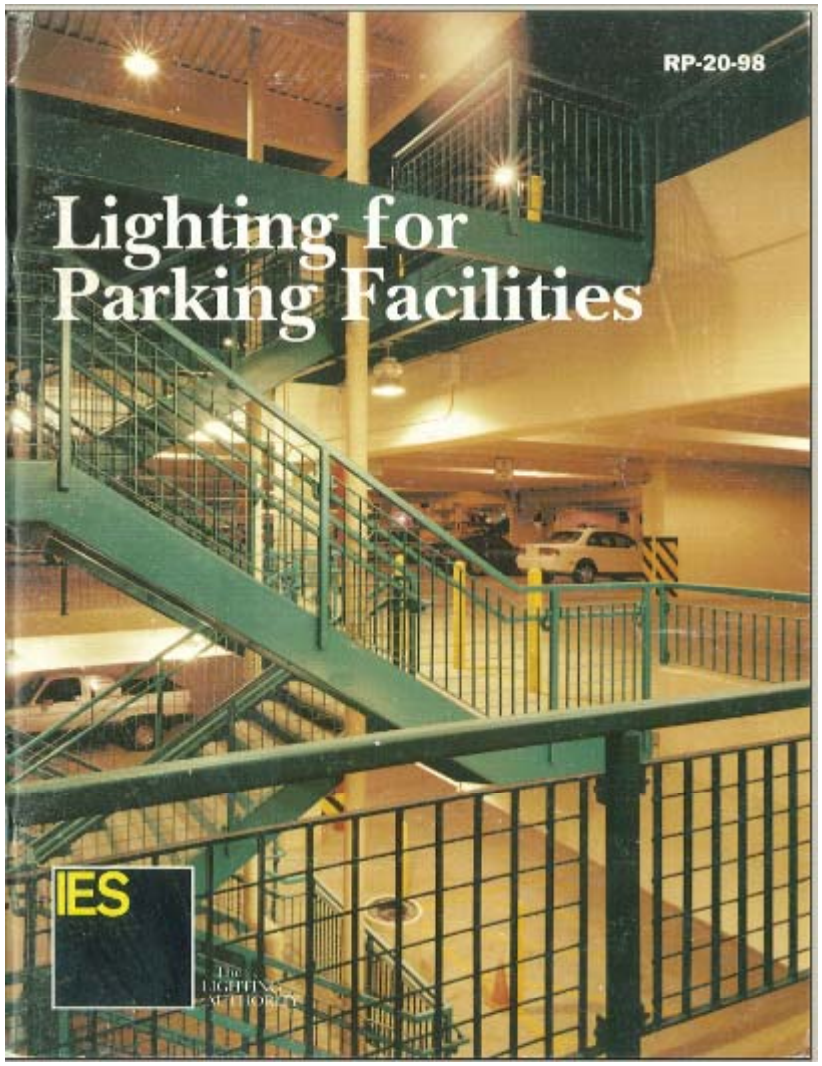
IES RP-20… Area



- Covers Area, Wall, Garage
- Illumination Metrics
  - Minimum
  - Max:Min
  - Vertical illumination

Table 1: Recommended Maintained Illuminance Values for Parking Lots

		Basic[1]	Enhanced Security[2]
Minimum Horizontal Illuminance[3]	lux[4]	2	5
	fc[5]	0.2	0.5
Uniformity Ratio, Maximum to Minimum[6]		20:1	15:1
Minimum Vertical Illuminance[7]	lux[4]	1	2.5
	fc[5]	0.1	0.25

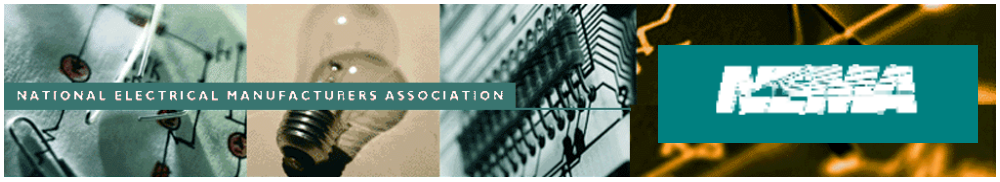
[1] For typical conditions. During periods of non-use, the illuminance of certain parking facilities may be turned off or reduced to conserve energy. If reduced lighting is to be used only for the purpose of property security, it is desirable that the minimum (low point) value not be less than 1.0 horizontal lux (0.1 hfc). Reductions should not be applied to facilities subject to intermittent night use, such as at apartments, hospitals, and transportation terminals.

[2] If personal security or vandalism is a likely and/or severe problem, a significant increase of the Basic level may be appropriate (see **Section 4.3**). Many retailers prefer even higher levels, with a specification of 10 lux (1 fc) as the minimum value.

[3] For **preliminary design**, an *average* value of 10 horizontal lux (1 hfc) for basic, or 25 horizontal lux (2.5 hfc) for enhanced illuminance may be calculated. The minimum points (or areas) and maximum point are then calculated and the uniformity ratio checked for compliance with the **Table 1** values (see **Section 5.3**). *Note:* The 5:1 average-to-minimum ratio is the first step toward directing the design to achieve the maximum to minimum ratios presented in **Table 1**.

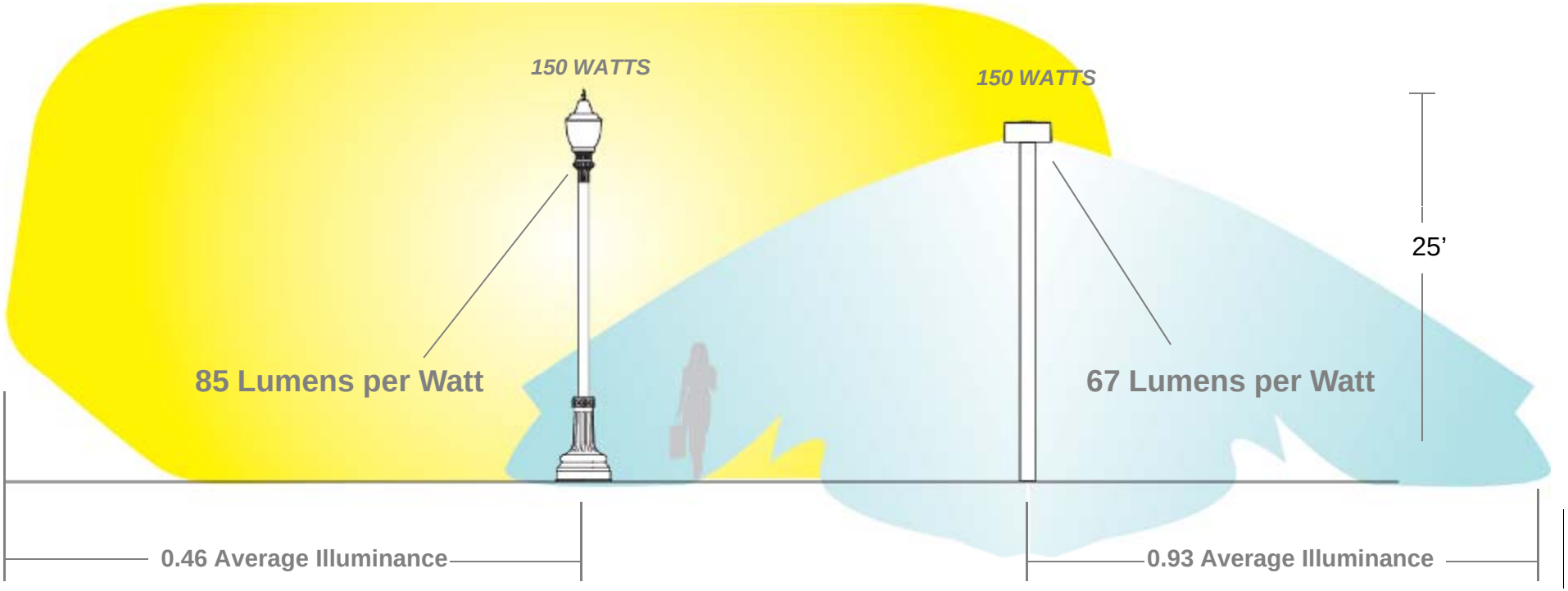
[4] Measured on the parking surface, without any shadowing effect from parked vehicles or trees at points of measurement.

[5] Rounded conversion of lux to footcandles (see **Annex E**).



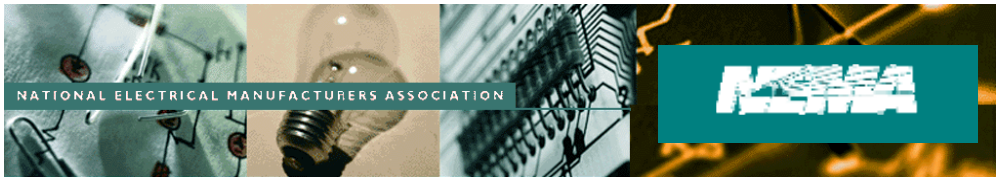
Lumens Per Watt

LPW = Lumens / Power



Although the luminaire on the left is 27% higher in fixture LPW, it produces less than half the average illumination on the ground

Courtesy Cooper Lighting



What's your type?

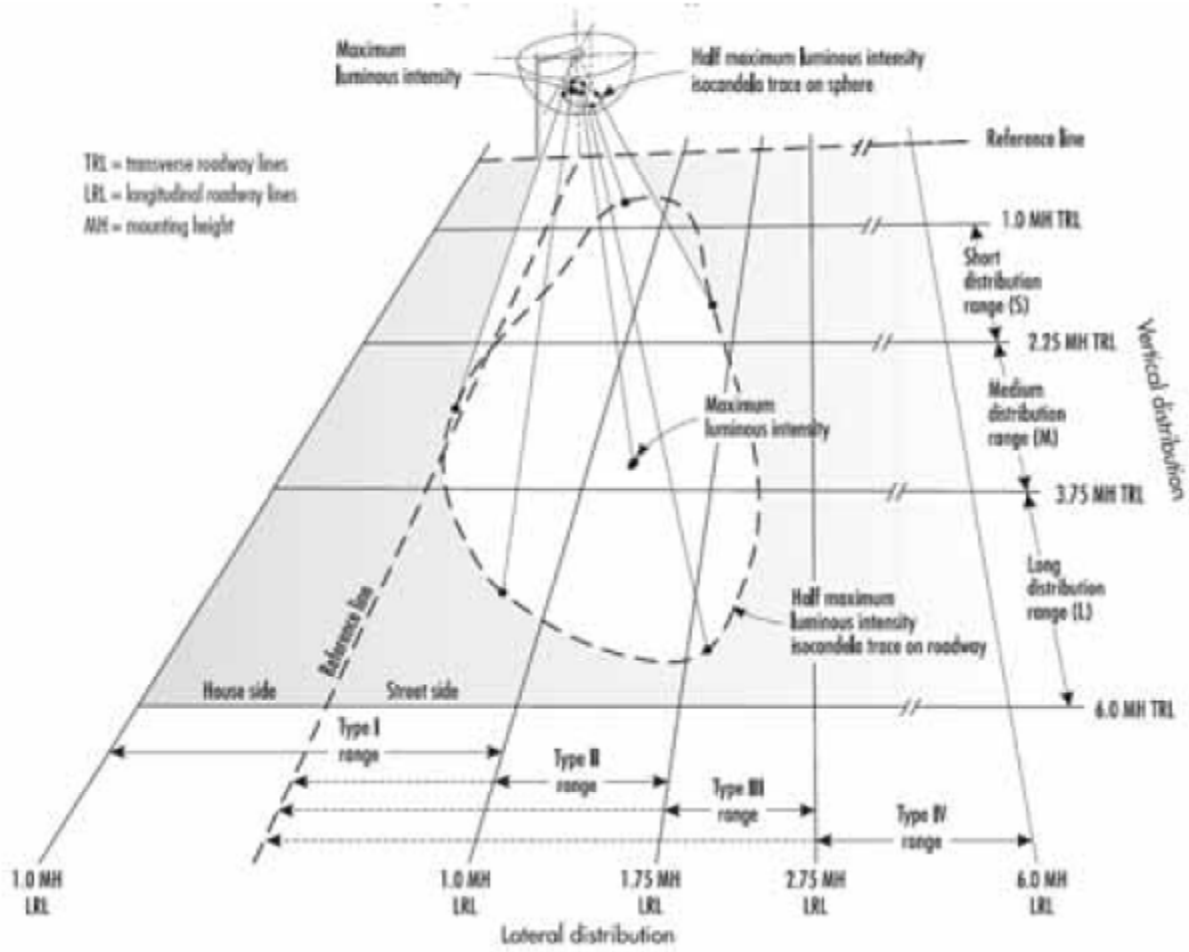
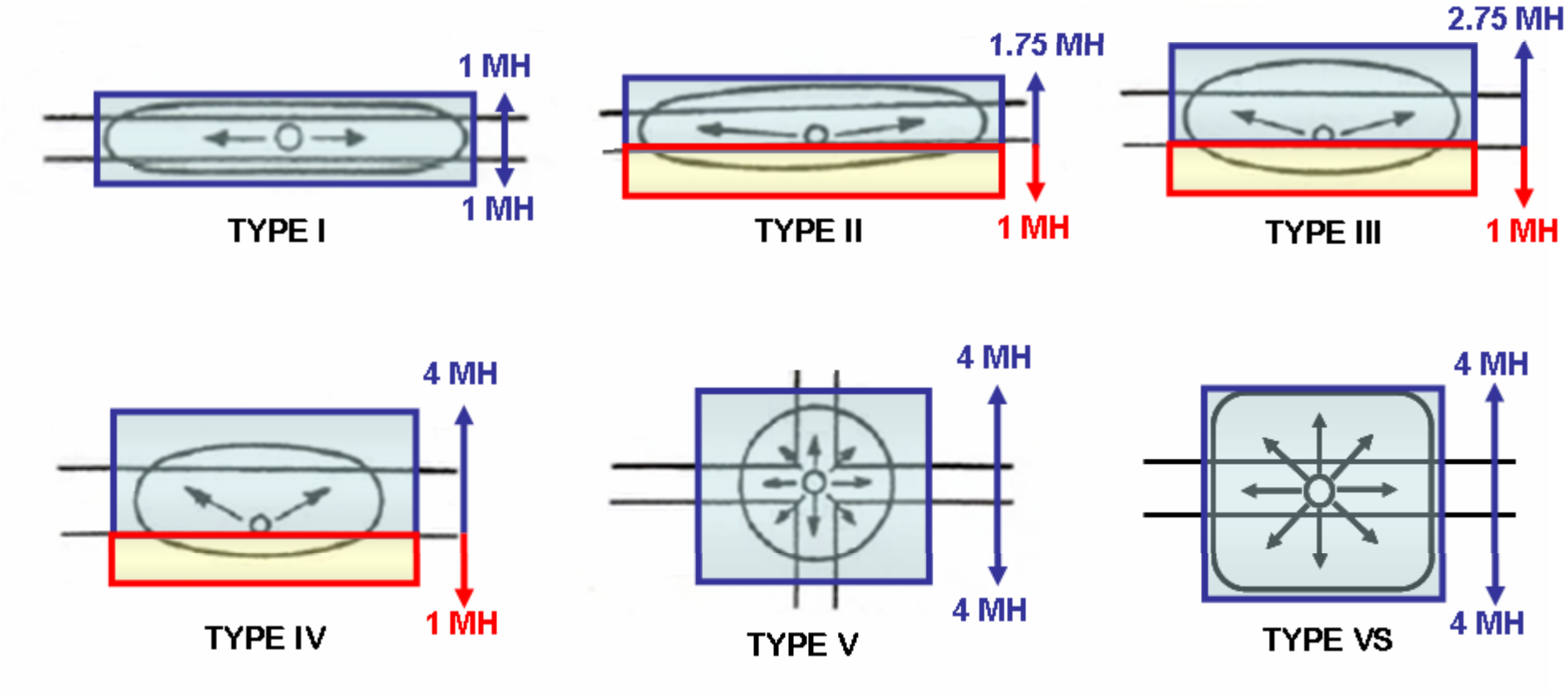


Figure 2. Diagram showing vertical and lateral IESNA distributions (NLPIP 2004; adapted from Fig. 22-7 in IESNA Lighting Handbook, 9th Edition [Rea 2000]).

Target Efficacy Rating

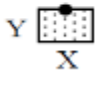
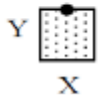
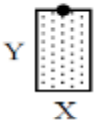
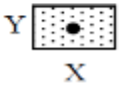
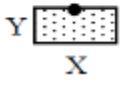
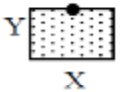
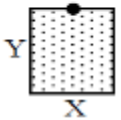
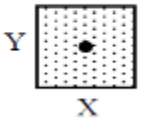
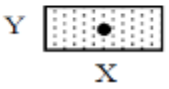
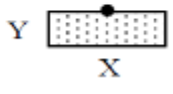
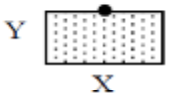
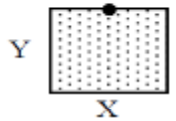
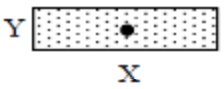
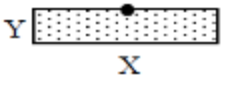
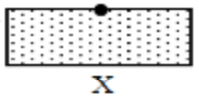
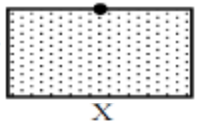
TER = Lumens in Area / Power



NEMA LE-6 is based only on averages and is prescriptive by type.

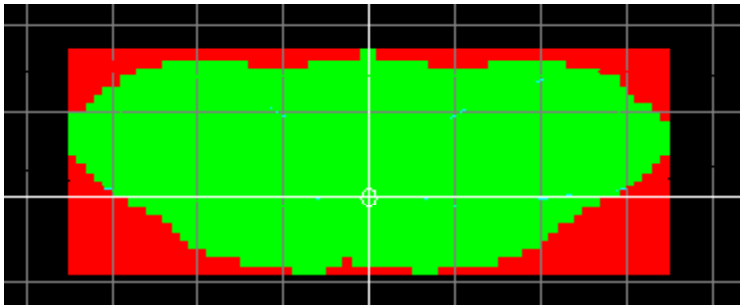
Luminaire System Application Efficacy

$$LSAE = (\Phi_{task\text{-}conforming} \times (N_{conforming} \div N)) \div P$$

	Type I	Type II	Type III	Type IV	Type V[2]
Very Short	 X= 2.00×MH Y= 2.00×MH	 X= 2.00×MH Y= 1.75×MH	 X= 2.00×MH Y= 2.75×MH	 X= 2.00×MH Y= 6.00×MH	
Short	 X= 4.50×MH Y= 2.00×MH	 X= 4.50×MH Y= 1.75×MH	 X= 4.50×MH Y= 2.75×MH	 X= 4.50×MH Y= 6.00×MH	 X= 3.50×MH Y= 3.50×MH
Medium	 X= 7.50×MH Y= 2.00×MH	 X= 7.50×MH Y= 1.75×MH	 X= 7.50×MH Y= 2.75×MH	 X= 7.50×MH Y= 6.00×MH	
Long	 X= 12.00×MH Y= 2.00×MH	 X= 12.00×MH Y= 1.75×MH	 X= 12.00×MH Y= 2.75×MH	 X= 12.00×MH Y= 6.00×MH	

Fitted Target Efficacy (FTE)

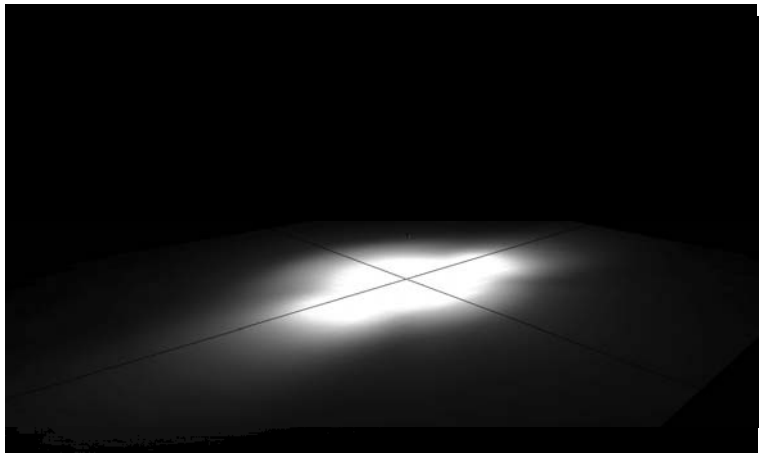
- New Project-Independent Metric
  1. Determines the Uniform Pool of illumination unique to each luminaire and sums the luminous flux landing therein
  2. Fits a Rectangular Target to surround the Uniform Pool and finds the % of Rectangular Target covered by the Uniform Pool
  3. The summed lumens are scaled (down) by the weighted % coverage and then divided by input wattage (for units of lm/W)



Fitted Target Efficacy (FTE)

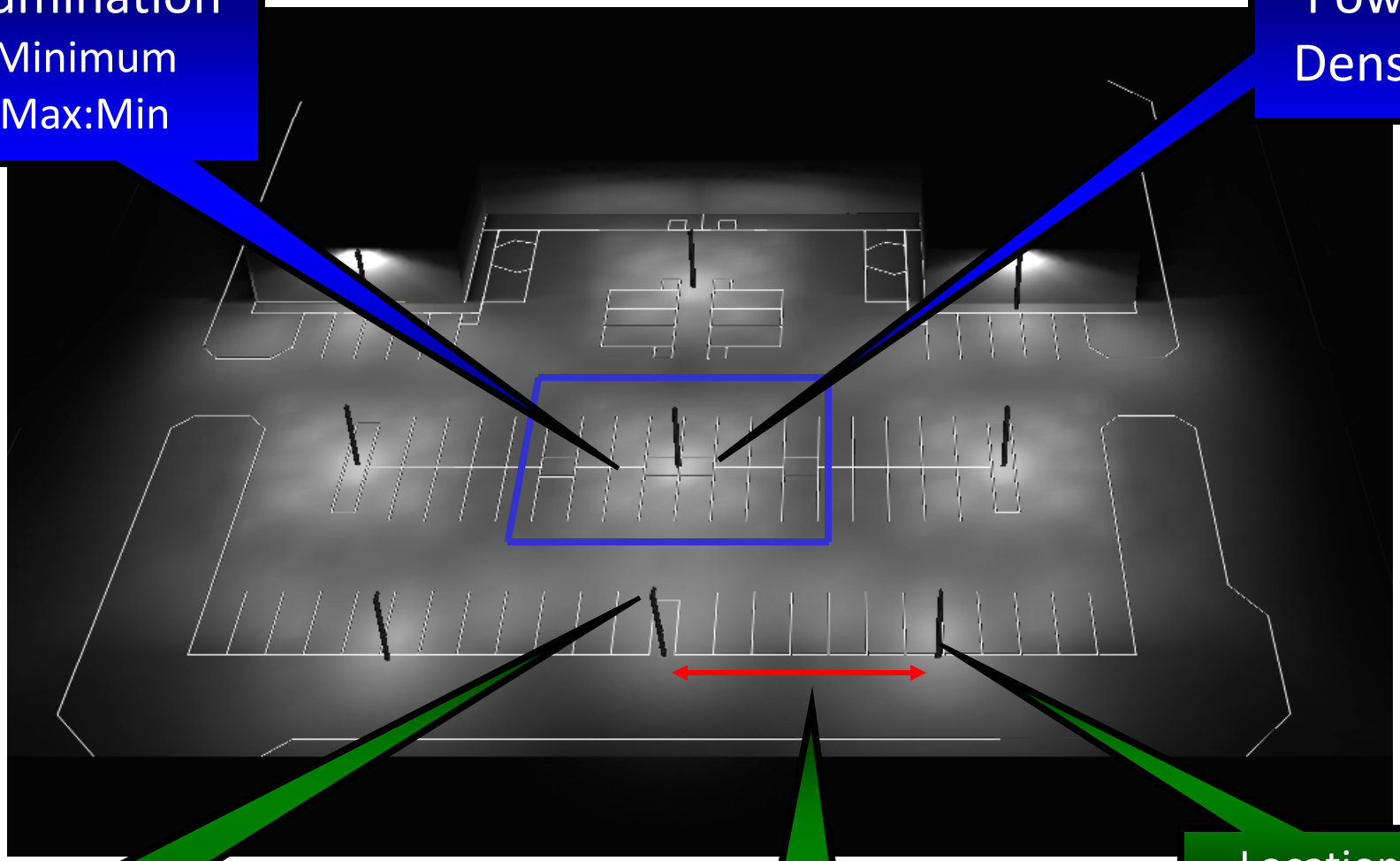
- Primary benefits:

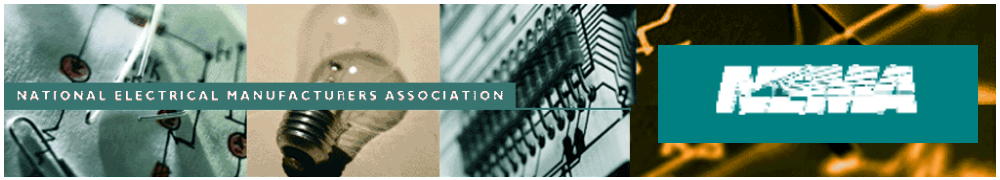
✓	Application Independent
✓	Evaluation of Efficacy (lm/W)
✓	Effectiveness of HS Shielding
✓	Utility of Distribution Shape
✓	No Arbitrary Proportions



- Flexibility for designers and manufacturers
- Effective HS shielding is rewarded, *not required*
- Area of coverage is described, *not prescribed*
- Apples-to-apples comparison *for similar distributions*, independent of mounting height, illuminance, etc.

Power Density





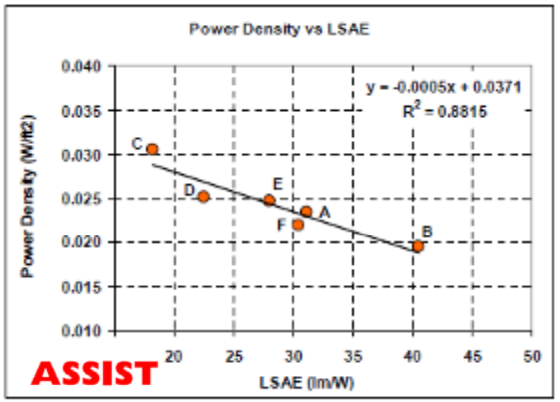
Current Results

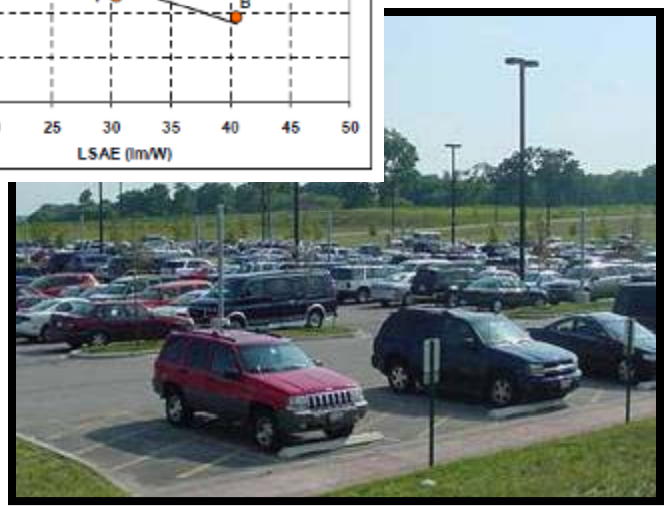
- Over 700 photometric files analyzed (FTE dataset)
  - Agreed upon in collaboration with DOE
  - All lumens and input watts were corrected to energy legislation
- Application Space - Area Lighting selected to test the method
  - Lighting to **INITIAL RP-20 Enhanced Levels**
  - Several arrays of poles were analyzed
  - **4x4** was selected to ensure contribution from adjacent poles
  - **Two fixtures per pole** in a back to back configuration
- LPW, TER, FTE, LSAE, as well as 4 methods of Power Density
  - Various power density calcs based on key practical limitations
    - Parking lot geometry, pole heights, and calculation method

Next Steps - Area

- ENERGY CORRELATION STUDY
  - NEMA to provide appropriate number of installations within dataset
  - DOE will establish correlation between metrics and actual energy used
  - The best correlation will be the metric selected for next phase

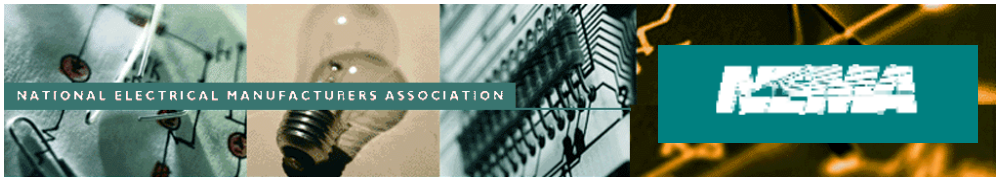
- If Power Density is selected, NEMA will work with EPA to make both the calculation method and tool available
- Threshold settings
  - Percentile cuts for EnergyStar
  - Technology Neutral





Next Steps - Overall

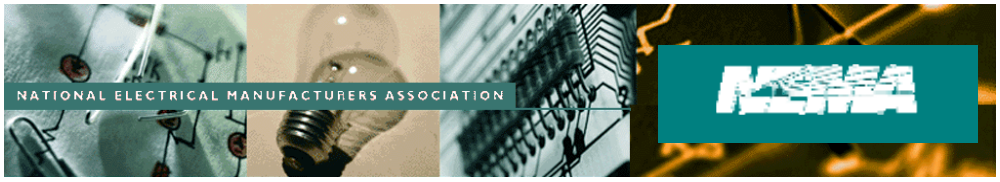
- Application of selection procedure to other applications
  - Streets, Roadways, Sidewalks (RP-8)
  - Parking Garage (RP-20)
  - Lanes, Perimeter (RP-20)
- Selection of final classifications
  - Types of applications
  - DOE / NEMA review
- DOE will review NEMA's final proposed revisions to the overall draft criteria.
- DOE will make the final recommendation to EPA on how to proceed with criteria.



Summary

An EnergyStar Metric that is…

1. ✓ Based on a system of luminaires
2. ✓ Founded in illumination metrics
3. ✓ Product Specific
4. ✓ Correlated to energy savings
5. ✓ Technology neutral
6. ✓ Easy to Comprehend
7. ✓ Useful for energy comparison



QUESTIONS?