El Paso Electric

Energy Efficient Lighting

High Performance T8s, LEDs and Best Practices

Informational Session
March 27, 2012

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Speaker Bio

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Kyle Hemmi, LC, LEED AP, CEM, CDSP
Senior Energy Engineer
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- 16 years in lighting, automation, and controls
  - 9 years working with Utility Energy Efficiency Programs with a focus on Lighting and Measurement & Verification (M&V)
  - 7 years working in Wholesale Electric Distributor, technical sales and management
- Very active in Illuminating Engineering Society (IES)
  - President of the Austin Section
  - Member of the Solid State Lighting Testing Procedures Committee, Energy Management Committee, & Lighting Upgrades Subcommittee
- Technical Steering Committee of the DesignLights Consortium

Lighting Objectives

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Linear Fluorescent Systems

- Understanding High Performance T8 (HPT8) Systems
  - Defining a HPT8 System and the role of the Consortium for Energy Efficiency (CEE) listing
- Key Design and Application Considerations
- Linear Fluorescent Best Practices and Case Studies – Getting the most out of HPT8 and T5HO systems

Solid State Lighting (SSL) - LEDs

- Technology – What do I need to know about LEDs?
- Program Policies for LEDS – How do I know if a particular LED qualifies for incentives?
- Best Practices – Promising and not-so-promising LED applications

Presentations will be available at www.elpasoelectric.com
www.epesaver.com

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Linear Fluorescent Systems

Getting the Most out of your Projects

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Why is High Performance T8 (HPT8) Required?

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Regulatory Changes

July 1, 2010

- T12 magnetic ballasts can no longer be manufactured or imported for sale.

July 14, 2012

- All linear fluorescent lamps manufactured or imported for sale in the U.S. must meet more stringent efficacy standards. Following lamps no longer made:
  - Most 4-ft. linear full-wattage and energy-saving T12 lamps
  - All 2-ft. full-wattage and energy-saving U-shaped T12 lamps
  - All 75W F96T12 and 110W F96T12HO lamps
  - Most 60W F96T12/ES and 95W F96T12/ES/HO lamps
  - All 4-ft. T8 basic-grade 700/SP series lamps rated at 2,800 lumens
  - Some 8-ft. T8 Slimline single-pin 700/SP series; 8-ft. T8 HO RDC-base lamps

What is a High Performance T8 (HPT8)?

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Understanding the CEE Specifications

The Specifications are comprised of various attributes of lighting systems such as lumens, wattage, lamp life, mean lumens per watt, ballast efficacy factor, etc.

http://www.cee1.org/com/com-lt/com-lt-main.php3

Some Technical Lingo:

- **Color Rendering Index (CRI)** – lamp light impact on a lit objects natural color – how 'true' is the color?
- **Lumens** – amount of light produced as seen by the human eye
- **Lamp life** – When 50% of lamps fail
- **Initial Lumens** – measured lumens emitted at 100 hours of lamp operation
- **Mean Lumens** – measured lumens emitted at 40% of rated life of lamp
- **Ballast Efficacy Factor** – used to compare the efficiency of differing ballasts (non-technical definition)
- **Mean lumens per watt** (mean system efficacy) =
  - Mean lumens ÷ system watts (lamp(s)/ballast combination)

High Performance T8 Specification

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Equipment	Specification
High Performance T8 Systems	
Performance Characteristics for Systems	
Mean System Efficacy	90 MLPW for Instant Start Ballasts 88 MLPW for Programmed Rapid Start Ballasts
Performance Characteristics for Lamps	
Color Rendering Index (CRI)	≥ 80
Minimum Initial Lamp Lumens	≥ 3100 Lumens
Lamp Life	≥ 24,000 hrs at three hours per start.
Lumen Maintenance -or- Minimum Mean Lumens	≥ 94% -or- ≥ 2900 Mean Lumens

Reduce Wattage T8 Specification

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Equipment	Specification
28 and 25 Watt Reduced Wattage Systems	
Performance Characteristics for Systems	
Mean System Efficacy	90 MLPW
Performance Characteristics for Lamps	
Color Rendering Index (CRI)	≥ 80
Minimum Initial Lamp Lumens	≥ 2585 Lumens for 28 W ≥ 2400 Lumens for 25 W
Lamp Life	≥ 18,000 hrs at three hours per start.
Lumen Maintenance -or- Minimum Mean Lumens	≥ 94% -or- ≥ 2430 Mean Lumens for 28 W ≥ 2256 Mean Lumens for 25 W

How is Efficacy Calculated?

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- How to calculate Mean Lumens per Watt:
  - Given (from lamp/ballast catalogue):
    - Mean Lumens of lamp per lamp = 2575
    - Ballast Factor = .87
    - 2 lamp system wattage = 48 W
  - For 2 lamp system, calc MLPW:
  - (2 x 2575 x .87) / 48 = 93 MLPW

Where is the approved listing?

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http://www.cee1.org/com/com-lt/com-lt-main.php3

CEE

Commercial Programs

Commercial Lighting

Consortium For Energy Efficiency Home / Contac

About CEE
EE Program Industry
Residential
Commercial
- Buildings
- Clothes Washers
- Data Centers
- HVAC
- Kitchens
- Lighting
- New Construction
- Schools

Industrial
Gas Programs
Multifamily
Government
Evaluation
Resource Library
Consumer information

High Performance (HP) T8 Specifications & Products:
High-performance T8 specifications
Qualifying lamps, 120- and 277-volt ballasts
Qualifying 347-volt ballasts
HPT8 Qualifying List Submission Form

FAQs on CEE's Lightin
Product Lists

Reduced Wattage T8 Specifications & Products:
Reduced-wattage T8 specifications
Reduced-wattage qualifying lamps, ballasts
Reduced Wattage Qualifying List Submission Form

Application Information for HPT8 and Reduced Wattage Systems:
Application Guidance

Other Lighting Resources
Program Summary · Initiative Description · Fact Sheet
SSL Technical Information · SSL Position Paper · Lighting Reports

CEE launched an initiative for Commercial Lighting Systems in November of 2004.

The initial focus of the Commercial Lighting Systems Initiative is national coordination in defining efficient, high-performance lighting products. At the outset, the initiative is addressing higher lumen, 4-foot, 32-watt T8 lighting systems.

In January 2007, a specification for reduced-wattage T8 systems was added to the initiative. Click here for the reduced-wattage T8 system specifications. Future efforts will address other technologies.

What do the listings look like? Lamps Tabs

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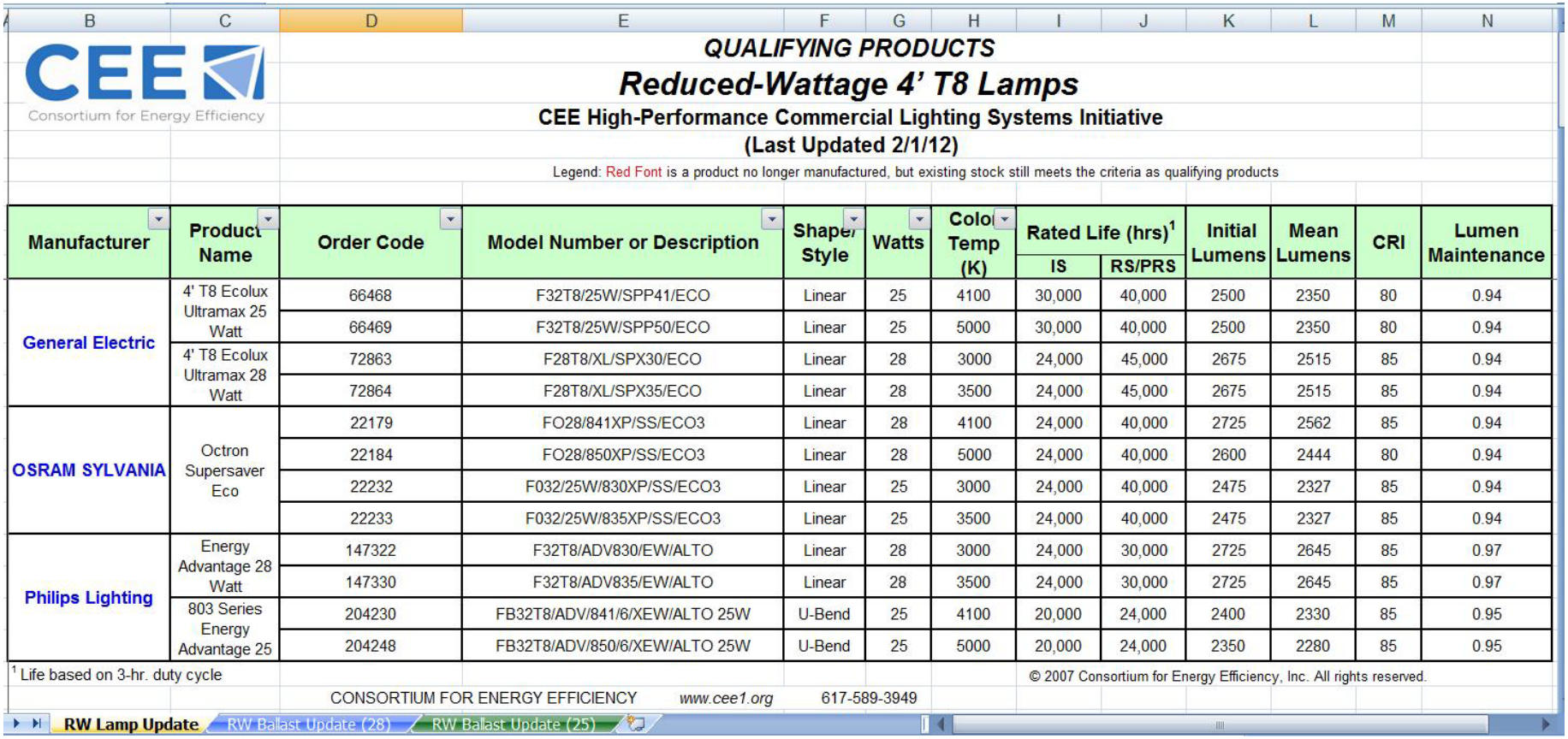

CEE
Consortium for Energy Efficiency

QUALIFYING PRODUCTS

Reduced-Wattage 4' T8 Lamps

CEE High-Performance Commercial Lighting Systems Initiative

(Last Updated 2/1/12)

Legend: Red Font is a product no longer manufactured, but existing stock still meets the criteria as qualifying products

Manufacturer	Product Name	Order Code	Model Number or Description	Shape/ Style	Watts	Color Temp (K)	Rated Life (hrs)[1]		Initial Lumens	Mean Lumens	CRI	Lumen Maintenance
							IS	RS/PRS				
General Electric	4' T8 Ecolux Ultramax 25 Watt	66468	F32T8/25W/SPP41/ECO	Linear	25	4100	30,000	40,000	2500	2350	80	0.94
		66469	F32T8/25W/SPP50/ECO	Linear	25	5000	30,000	40,000	2500	2350	80	0.94
	4' T8 Ecolux Ultramax 28 Watt	72863	F28T8/XL/SPX30/ECO	Linear	28	3000	24,000	45,000	2675	2515	85	0.94
		72864	F28T8/XL/SPX35/ECO	Linear	28	3500	24,000	45,000	2675	2515	85	0.94
OSRAM SYLVANIA	Octron Supersaver Eco	22179	FO28/841XP/SS/ECO3	Linear	28	4100	24,000	40,000	2725	2562	85	0.94
		22184	FO28/850XP/SS/ECO3	Linear	28	5000	24,000	40,000	2600	2444	80	0.94
		22232	F032/25W/830XP/SS/ECO3	Linear	25	3000	24,000	40,000	2475	2327	85	0.94
		22233	F032/25W/835XP/SS/ECO3	Linear	25	3500	24,000	40,000	2475	2327	85	0.94
Philips Lighting	Energy Advantage 28 Watt	147322	F32T8/ADV830/EW/ALTO	Linear	28	3000	24,000	30,000	2725	2645	85	0.97
		147330	F32T8/ADV835/EW/ALTO	Linear	28	3500	24,000	30,000	2725	2645	85	0.97
	803 Series Energy Advantage 25	204230	FB32T8/ADV/841/6/XEW/ALTO 25W	U-Bend	25	4100	20,000	24,000	2400	2330	85	0.95
		204248	FB32T8/ADV/850/6/XEW/ALTO 25W	U-Bend	25	5000	20,000	24,000	2350	2280	85	0.95

[1] Life based on 3-hr. duty cycle

CONSORTIUM FOR ENERGY EFFICIENCY www.cee1.org 617-589-3949

RW Lamp Update | RW Ballast Update (28) | RW Ballast Update (25)

What the CEE Listing Looks Like? Ballasts Tabs

Why is HPT8 a Good Thing?

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Imagine you are doing a 3 or 4-lamp T12 Upgrade: What are your primary options?

System Type	LSF Fixture Codes	Incremental Cost ($)	Watts	Payback (Years)	Mean Lumens of Fixture	Maintained Efficacy (lm/W)	CRI	Rated Lamp Life (hrs)
Standard Electronic Ballast - 32W Lamps **(Baseline in this Scenario)**	F42ILL	NA	58	**NA**	3,508	60.5	75	20,000
High Performance (HP) Ballast - 28W Lamps **(HPT8 Option 1)**	F42IRLU	$4 - $6	48	**< 1yr**	3,605	75.1	85	> 24,000
High Performance (HP) Ballast - 25W Lamps **(HPT8 Option 2)**	F42INLU	$5 - $7	43	**< 1yr**	3,271	76.1	85	> 24,000

2012 Updates Lighting Survey Form (LSF)

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- New Deemed Building Types and updated Operating Hours and Coincidence Factors
- Additional Interactive Effect savings for lighting put in Refrigerated spaces/buildings
- Updated Lighting Power Densities (LPDs) for IECC 2009 State Energy Code Standards (90.1-2007 equivalent)
  - LPDs are the code limits (watts/SqFt) that are used to calculate savings in New Construction projects

Key Design and Application Considerations

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- Improve not just efficiency by minimizing the energy consumed, but also improve the quality of lighting by provide adequate light levels for the task performed.
- A designer should also consider the following characteristics when designing a lighting system:
  - Color rendering index (CRI)
  - Correlated Color Temperature (CCT)
  - Luminous efficacy (lm/W)
  - Lighting power density (LPD)
  - Lumen maintenance (%)
  - Lamp life (hrs)

Illuminating Engineering Society (IES) Resources

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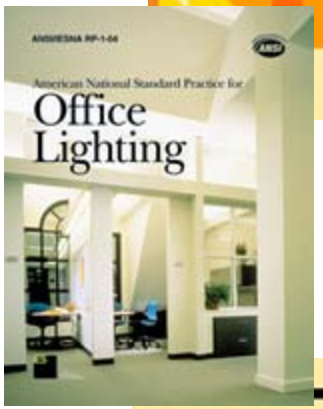
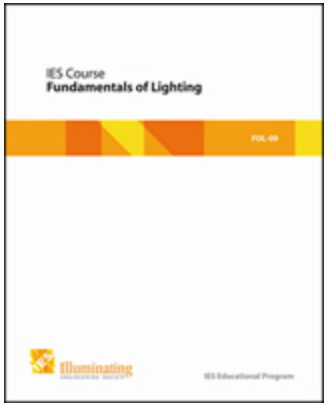
- 10th Edition of Handbook (HB-10-11)
- Recommended Practices for Office Lighting (RP-1-04; RP-1-12 coming!) ~ 18 others
- Fundamentals of Lighting –
  - 7-module course (FOL-09)
- Guidelines for Applying LEDs (G-2-10)
- Design Guides – Commissioning Lighting Controls (DG-29-11)
- Guidelines for upgrading Lighting Systems in Commercial Buildings (LEM-03-07; LEM-3-12 coming!)





Illuminance (Footcandle - fc) Recommendations

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A footcandle is a unit of illumination equivalent to the light produced by one candle at a distance of one foot and equal to one lumen incident per square foot.

- Shows you how much light you are getting at the workplane - what your light meter will give you

Recommendation: To meet or fall below the code required Lighting Power Densities (LPDs) above and the light level recommendations outlined in applicable IES standards

- **Lighting Handbook (10th ed.) – newest recommendations for all Building Types**
- Schools (ANSI/IESNA RP-3-00, Lighting for Education Facilities – updated 2006) – Example - Standard Classroom: **20 to 30 fc**
- Offices (ANSI/IESNA RP-1-04, American National Standard Practice for Office Lighting) – Example – Typical Office: **20 to 30 fc**
- Outdoor Areas (ANSI/IESNA RP-33-99, Lighting for Exterior Environments) – Example – Retail Parking Lot: **0.8 to 1.5 fc; Gas Station Canopy: 5 to 15 fc**
- Warehouses (ANSI/IESNA RP-7-01, Lighting Industrial Facilities) – Example – Warehousing/Storage/Material Handling: **5 to 30 fc**; Maintenance: **50 fc**

Spectrally Enhanced Lighting (SEL)

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SEL is Design method for interior lighting applications where visual acuity is important

- Relies on use of high color temperature lighting (≥ 5000K) to increase perceived light between 10-30% - adding "cooler" blue light to lamp's color spectrum
- It works because it puts additional peripheral parts of your eye to work - stimulated by the blue light
- **Use to improve acuity without impacting savings or increase savings while maintaining same acuity is applications like offices, schools, hospitals, prisons, or warehouses**
- S/P Ratios tell us how effective a source can be in SEL (HPS = 0.62; Incandescent = 1.41; Fluorescent 5000K=1.95: "Cool" LEDs=2.15); Ratios are applied to an SEL calculation (formula) to determine equivalency
- Should still design to IES Recommendations

Additional SEL Resources:

- www1.eere.energy.gov/buildings/spectrally_enhanced.html
- www1.eere.energy.gov/femp/technologies/eut_spectral_lighting.html

Color Requirements: Correlated Color Temperature (CCT)

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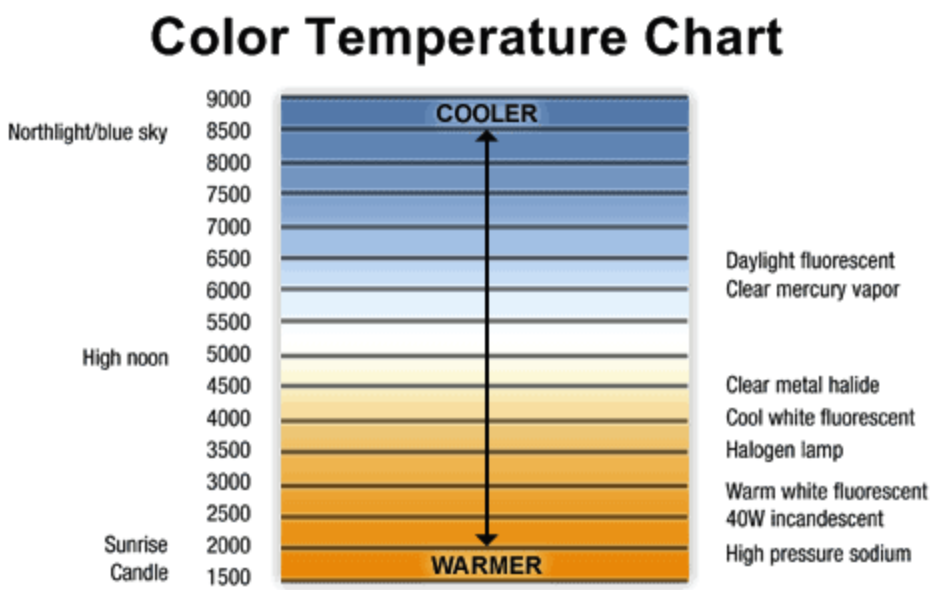
Correlated Color Temperature (CCT) is a measure of warmth or coolness of a light source's appearance. It is measured in degrees Kelvin, expressed in Kelvin (K) and is the closest possible match to Color Temperature



Color Requirements: Color Rendering Index (CRI)

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Color Rendering Index (CRI) is a unit of measure that defines how well colors are rendered by different illumination conditions in comparison to a standard.

The higher the number, the more likely the light source will render objects "naturally."

Ballast: Things to Consider

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- Fluorescent lamps need a ballast to control the amount of electrical current flowing into the lamp such that the right amount of light is emitted and the lamp does not burn out prematurely.
  - Main Types are Instant Start/Programmable Start (also different ballast factors)
  - A qualified list for our programs can be found at the Consortium for Energy Efficiency's website (http://www.cee1.org/com/com-lt/com-lt-main.php3).
- **Recommendation:** CLEAResult generally recommends the use of instant start ballasts in all but the most demanding control applications due to their quicker paybacks (lower initial cost/wattage consumption) and maintenance/stocking benefits that typically exceed any lamps replacement costs.

Typical Existing Open Office or Classroom: Example

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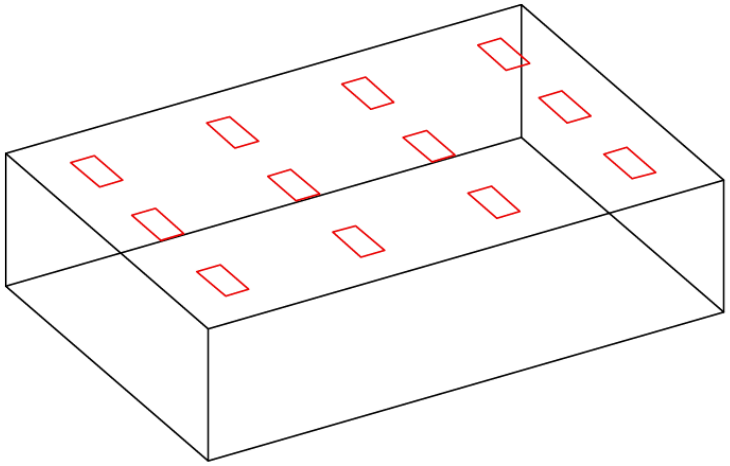
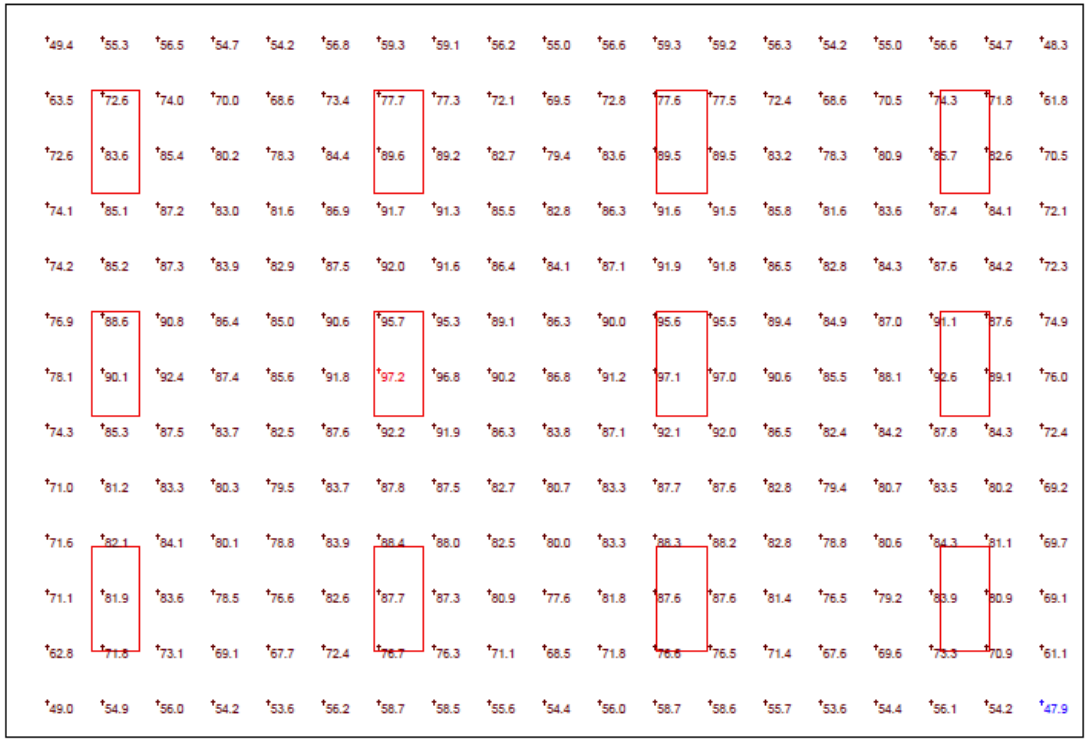
- Office/Classroom w/12 fixtures
- Code allowed Power Density =
  - 1.0 W/SqFt for an office
  - 1.2 W/SqFt for a School
  - 1344W; 1.3 W/SqFt a Waste
- IES Recommended footcandle levels, between 20 and 30 fc
  - 97 fc Maximum; 78 fc Average
  - Creates Eye Strain and Glare

Area	# of Fixtures	Fixture Type	Total Watts (W)	Area (SqFt)	Power Density (W/SqFt)	Avg FC Avg/Min	Max FC Max/Min
Open Office/Class	12	4 lamp, 32W T8 Lensed	1344	1034	1.3	**78.0** 1.6:1	**97.2** 2:1





Typical Existing Open Office or Classroom: Recommendation

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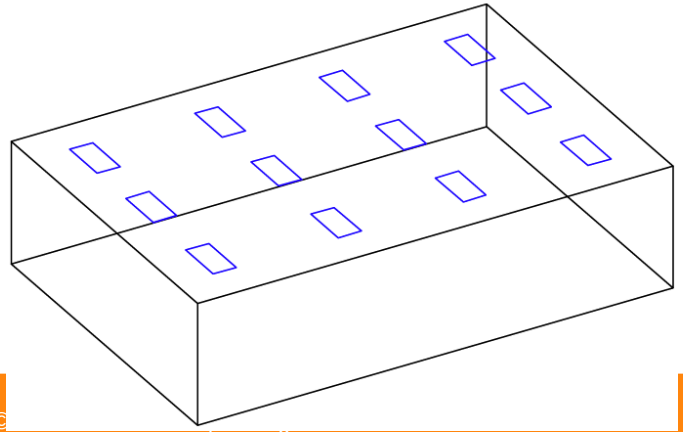
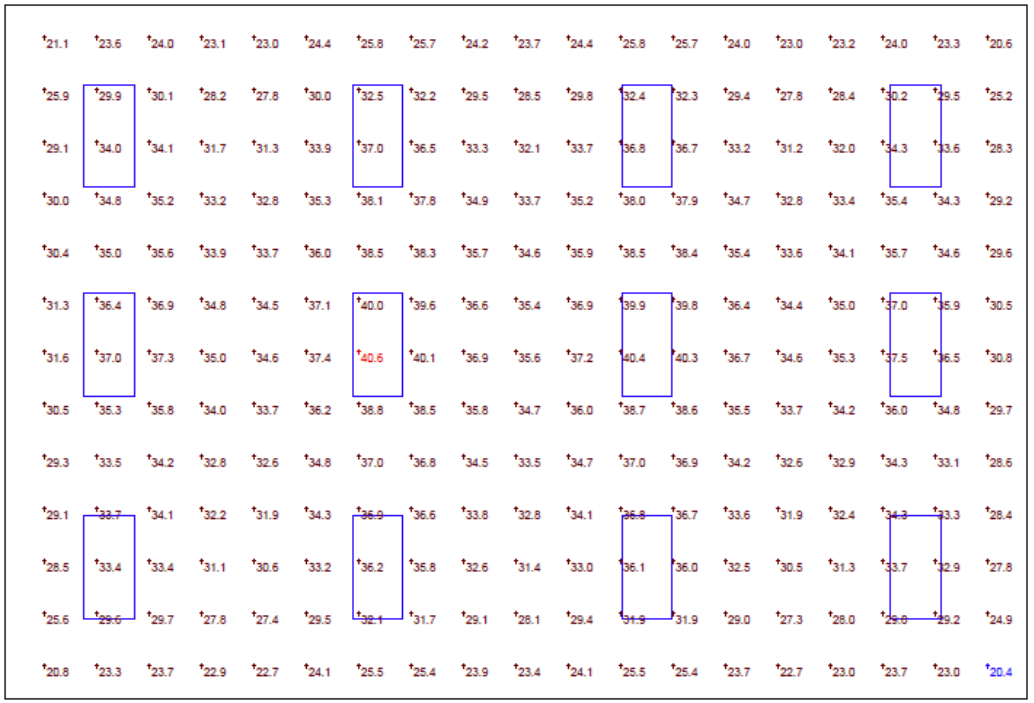
- Same Office/Classroom w/12 2-lamp, 28W HPT8 w/ low ballast factor ballast
- New Power Density =
  - 1.0 W/SqFt for an office
  - 1.2 W/SqFt for a School
  - 516W; **0.50 W/SqFt** = $$$
- IES Recommended footcandle levels, between 20 and 30 fc
  - 40.6 fc Maximum; 32.1 fc Average
  - Adequate for even the most demanding classroom or office settings
  - Windows would provide even more light
  - Greatly reduced eye strain and glare

Area	# of Fixtures	Fixture Type	Total Watts (W)	Area (SqFt)	Power Density (W/SqFt)	Avg FC Avg/Min	Max FC Max/Min
Open Office/Class	12	2-lamp, 28W T8, Low BF	516	1034	0.50	**32.1** 1.6:1	**40.6** 2:1





Cost Analysis

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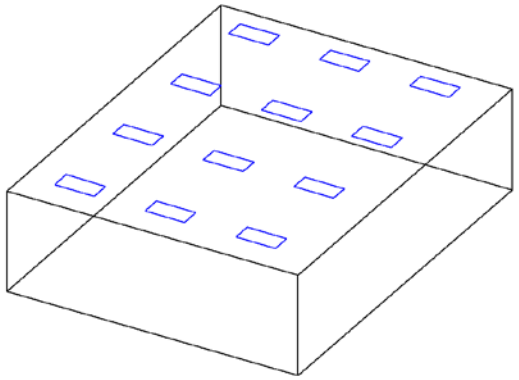
- Simple Payback if:
  - Retrofitting One System to another
  - Comparing the Two Alternatives in a New Construction scenario

Fixture Information	Proposed # of Fixtures	Proposed Fixture Type	Proposed Total Watts	Rec. # of Fixtures	Rec. Fixture Type	Rec. Total Watts	Annual Op Hours
Retrofit	12	4 lamp, 32W Standard T8	112 W	12	2 lamp, 28W HPT8, Low BF	43 W	3737
New Construction	12	4 lamp, 32W Standard T8	112 W	12	2 lamp, 28W HPT8, Low BF	43 W	3737

$$$ Payback	Incremental Cost	Annual kWh Savings	Electric Cost Savings at $0.08/kWh	Maintenance Savings per yr	Utility Incentive	Simple Payback
Retrofit	$600	3094	$248	$6	$217	**1.5**
New Construction	($24)	2082	$167	$6	$146	**-1.0**



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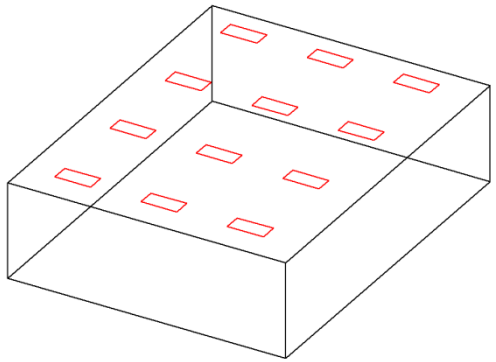

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Warehouse/Gym Application

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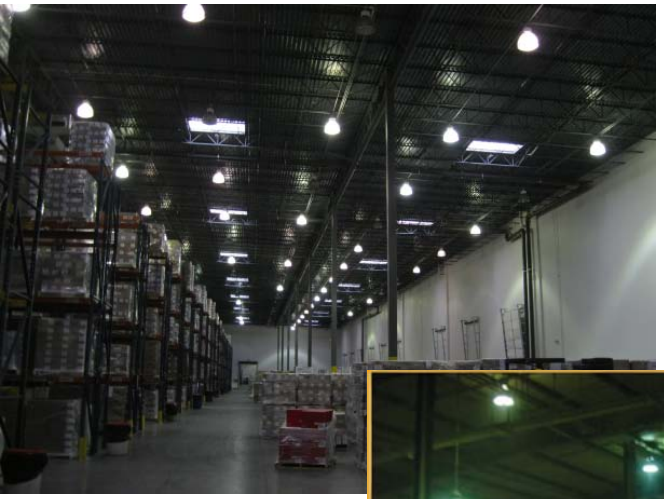
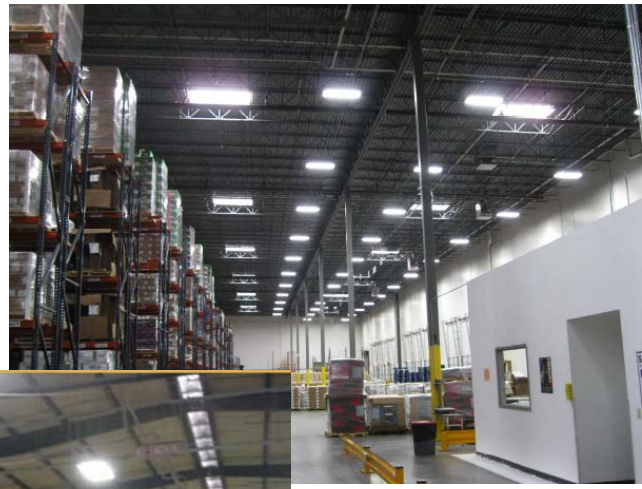
We encounter many warehouse, gym and other high bay applications in our programs. Two lighting systems work well with the varying ceiling heights.

- Recommendation: Use either T5HO (w/ reduced-wattage lamps) or High Performance T8 (HPT8) lamping systems. The choice between the two systems depends on ceiling height and required footcandle levels based on activity.





Highbay HPT8 and T5HO Options

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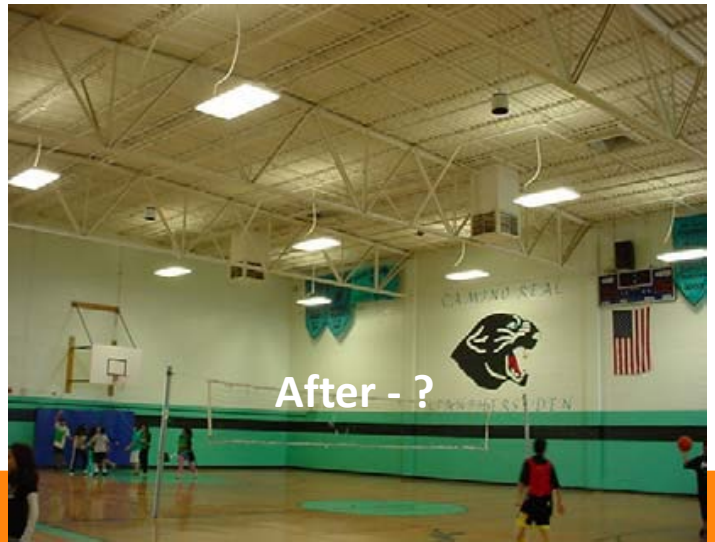
Model	Mean Lumens per lamp	Avg. Life 3hr Starts	Watt per Lamp	Standard Wattage Lamps	RW-System Wattage Lamp	Saving vs. Std. Wattage Lamp	Savings vs. 400MH
4-Lamp and 6-Lamp T5HO Systems							
F54T5HO 47W (4-lamp)	4,400	30,000	47W	234W	**204W**	30W	249W
F54T5HO 49W (4-lamp)	4,400	25,000	49W	234W	**214W**	20W	239W
F54T5HO 47W (6-lamp)	4,400	30,000	47W	351W	**306W**	45W	147W
6-Lamp T8 Systems							
High Lumen (HPT8) F32T8	3,100	25,000	32W	**162W**	NA	NA	286W
HPT8 Reduced-wattage 28W	2,850	24,000	28W	142W	**142W**	19W	305W



Existing Warehouse Design

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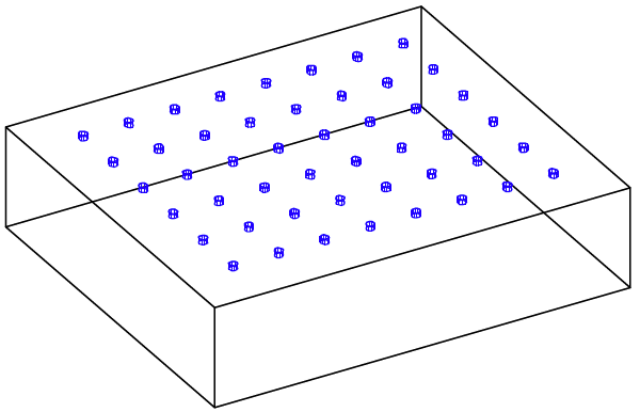
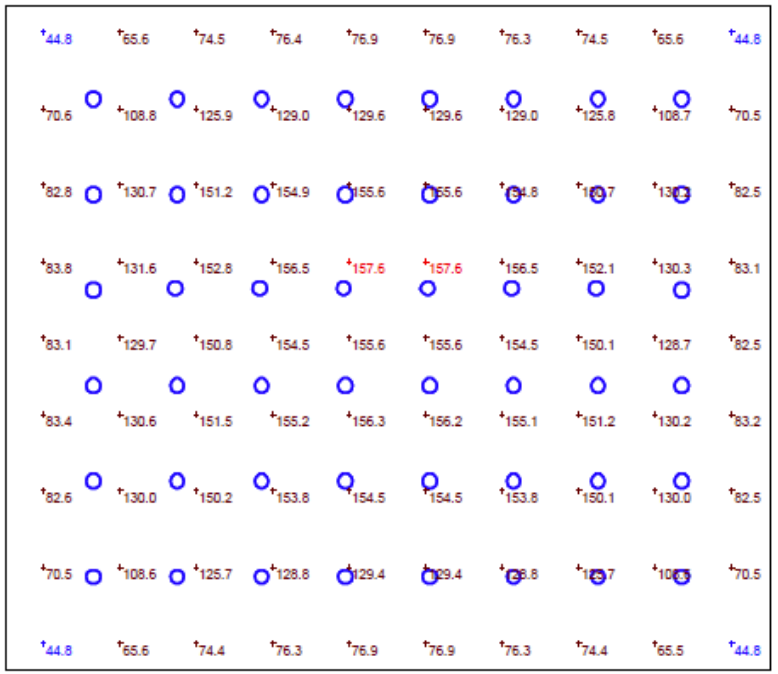
- Example of Small Warehouse or Gymnasium
- Existing Warehouse/Maintenance facility designed with (48) 400W Metal Halides – 24ft height
- Code allowed Power Density =
  - 0.8 W/SqFt Warehouse
  - 0.9 – 1.4 W/SqFt Auto/Workshop
  - 1.1 W/SqFt Gymnasium
- IES Recommended footcandles:
  - 5 - 30 fc Warehouse
  - 50 fc Automotive/Maintenance
  - 30 – 50 fc Gymnasium

Area	# of Fixtures	Fixture Type	Total Watts	Area (in sq feet)	Power Density (W/SF)	Avg FC Avg/Min	Max FC Max/Min
Warehouse / Maintenance	48	400W MH	20592 W	8700	2.3 W/SF	**115** 2.6:1	**158** 3.5:1





Recommended Options

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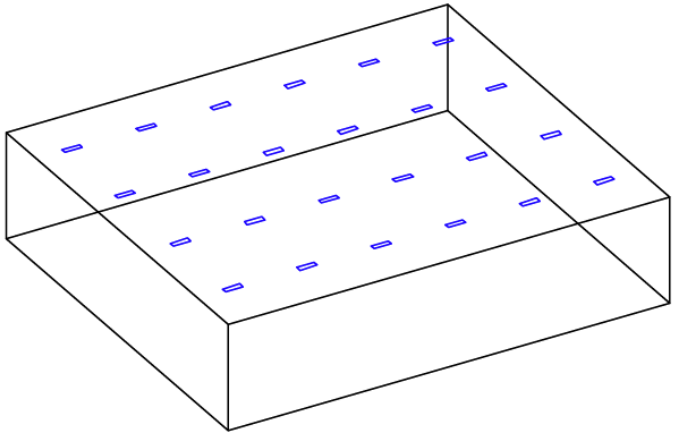
Recommended: 6 lamp T8 and T5HO systems

- Lower Light Levels
  – 6 lamp T8 w/ Low BF Ballast
- Moderately Low Light Levels
  - 6 lamp T8 w/ Low BF Ballast
- Moderately High Light Levels
  – 6 lamp T8 with Low BF Ballast
- Moderately High Light Levels and Higher Ceilings (> 35')
  – 6 lamp T8 with Low BF Ballast



Area	# of Fixtures	Fixture Type	Total Watts	Area (in sq feet)	Power Density (W/SF)	Avg FC Avg/Min	Max FC Max/Min
Warehouse and Maintenance	48	400W MH	21,744 W	8700	**2.5** W/SF	**115** 2.6:1	158 3.5:1
Warehouse and Maintenance	36	400W MH	16,308 W	8700	**1.9** W/SF	**86** 2.2:1	121 3.1:1
Warehouse or Middle School Gym	24	6L T8 28W Lamp Low BF	3024 W	8700	**0.35** W/SF	**29** 1.6:1	36 2.1:1
Maintenance or High School Gym	24	6L T8 28W Lamp High BF	4656 W	8700	**0.54** W/SF	**42** 1.6:1	53 2.1:1
Detailed Maintenance or High School Gym	24	6L T8 32W Lamp High BF	5232 W	8700	**0.60** W/SF	**48** 1.6:1	61 2.1:1
Manufacturing or College Gym (Higher Ceilings > 35ft)	36	6L T5HO 47W Lamp	7344 W	8700	**0.84** W/SF	**51** 1.6:1	64 2.0:1

Recommendation Options 1

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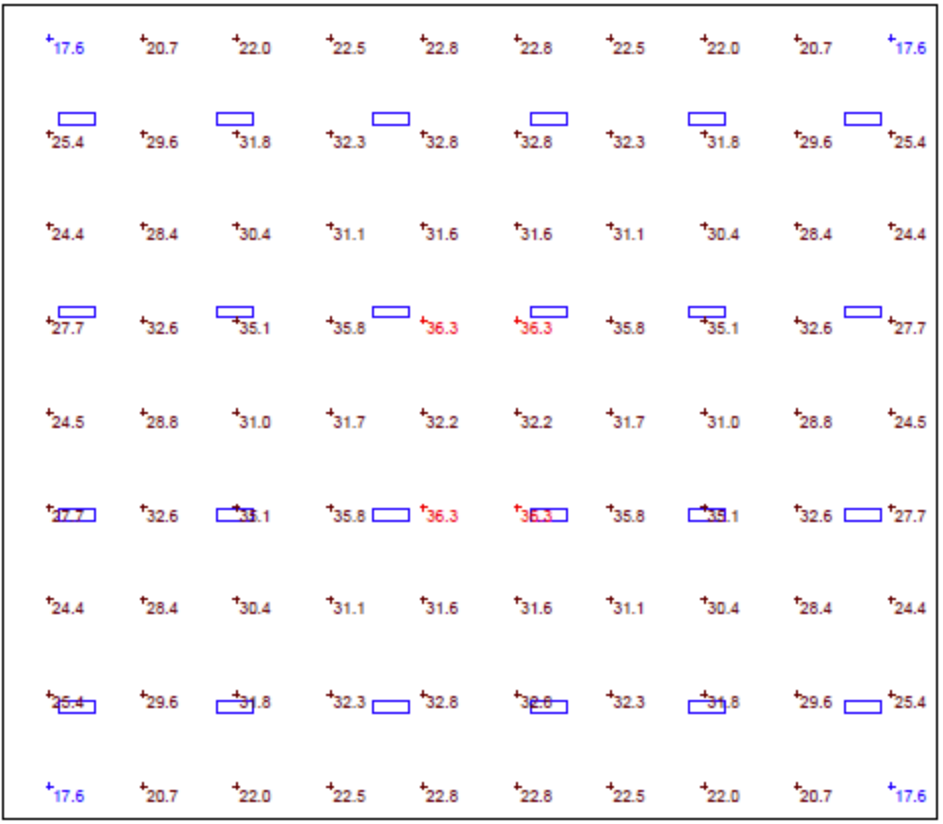
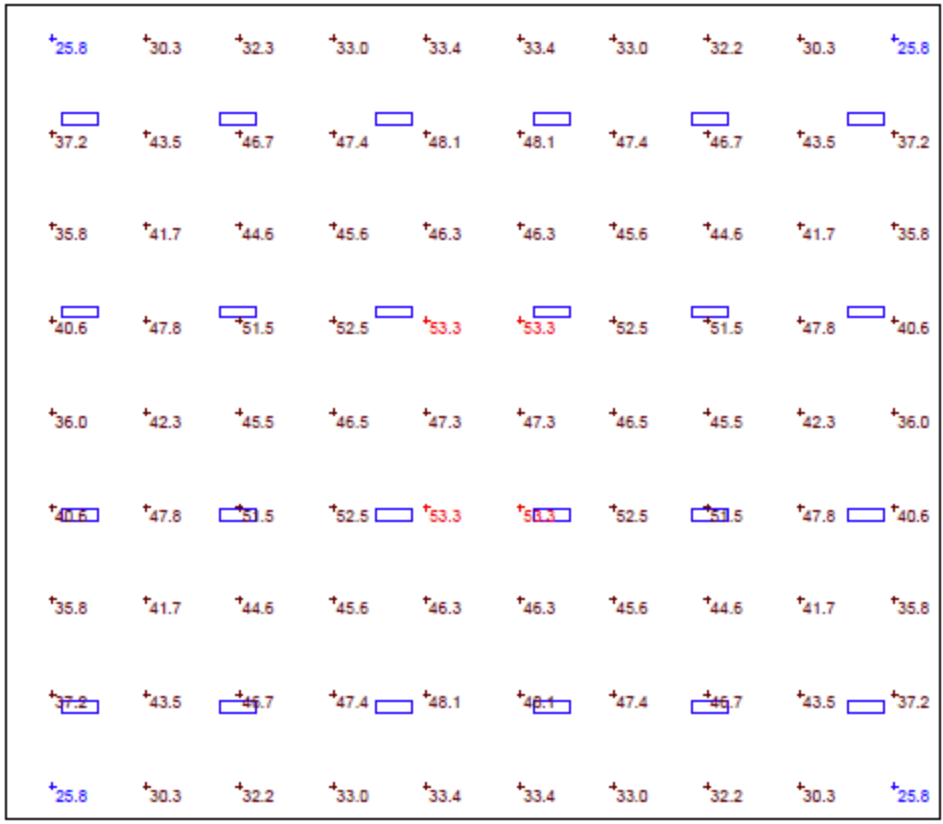
24 – 6-lamp 28W T8 Low Ballast Factor



STATISTICS

Description	Symbol	Avg	Max	Min	Max/Min	Avg/Min
Calc Zone #2	+	28.7 fc	36.3 fc	17.6 fc	2.1:1	1.6:1

24 – 6-lamp 28W T8 High Ballast Factor



STATISTICS

Description	Symbol	Avg	Max	Min	Max/Min	Avg/Min
Calc Zone #2	+	42.0 fc	53.3 fc	25.8 fc	2.1:1	1.6:1

Recommendation Options 2

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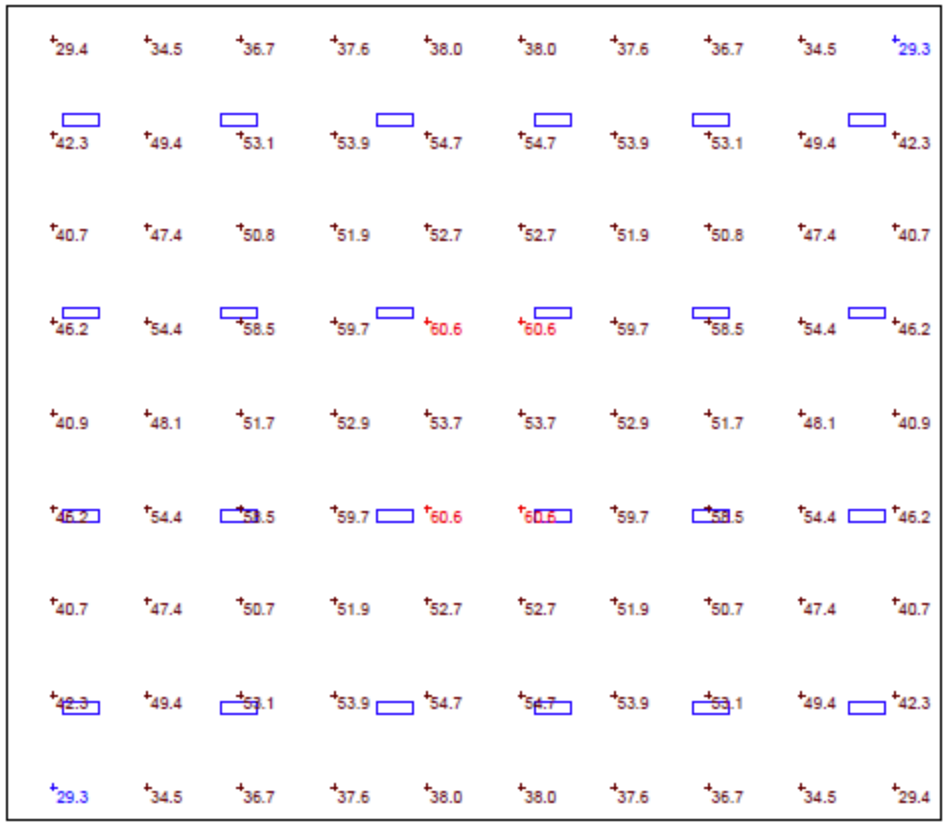
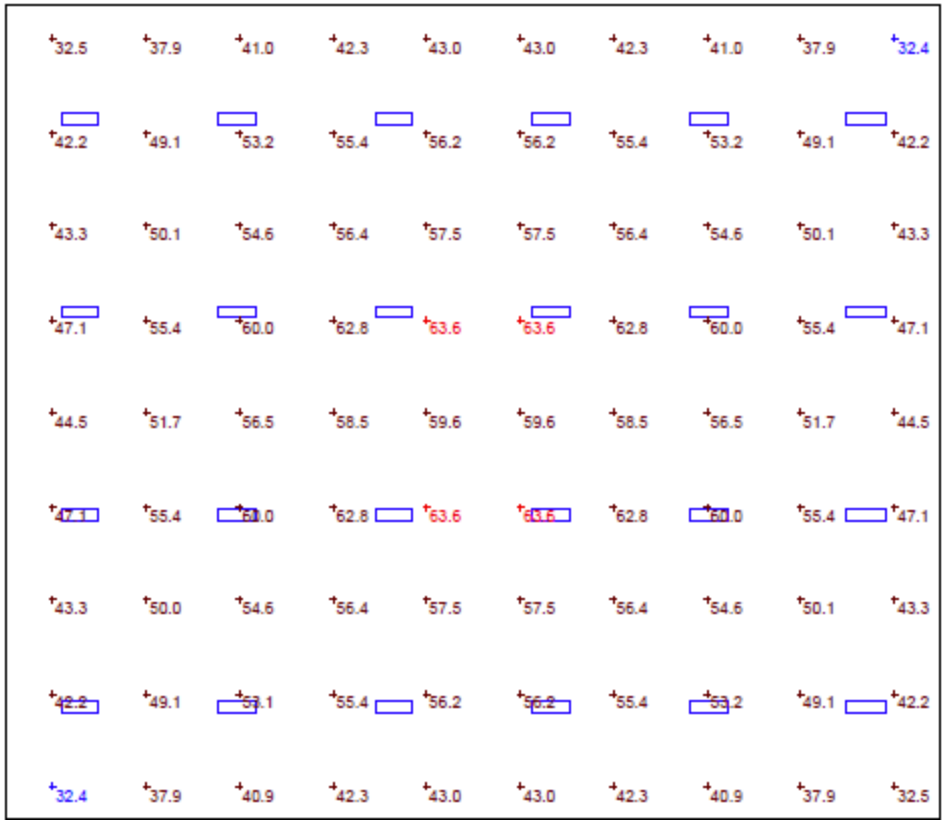
24 – 6-lamp 32W T8 High Ballast Factor (24’ Mounting Height)



STATISTICS

Description	Symbol	Avg	Max	Min	Max/Min	Avg/Min
Calc Zone #2	+	47.8 fc	60.6 fc	29.3 fc	2.1:1	1.6:1

24 – 6-lamp 47W T5HO (35’ Mounting Height)



STATISTICS

Description	Symbol	Avg	Max	Min	Max/Min	Avg/Min
Calc Zone #2	+	50.6 fc	63.6 fc	32.4 fc	2.0:1	1.6:1

Cost Analysis

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- Simple Payback Calculation for an existing 400W MH retrofit

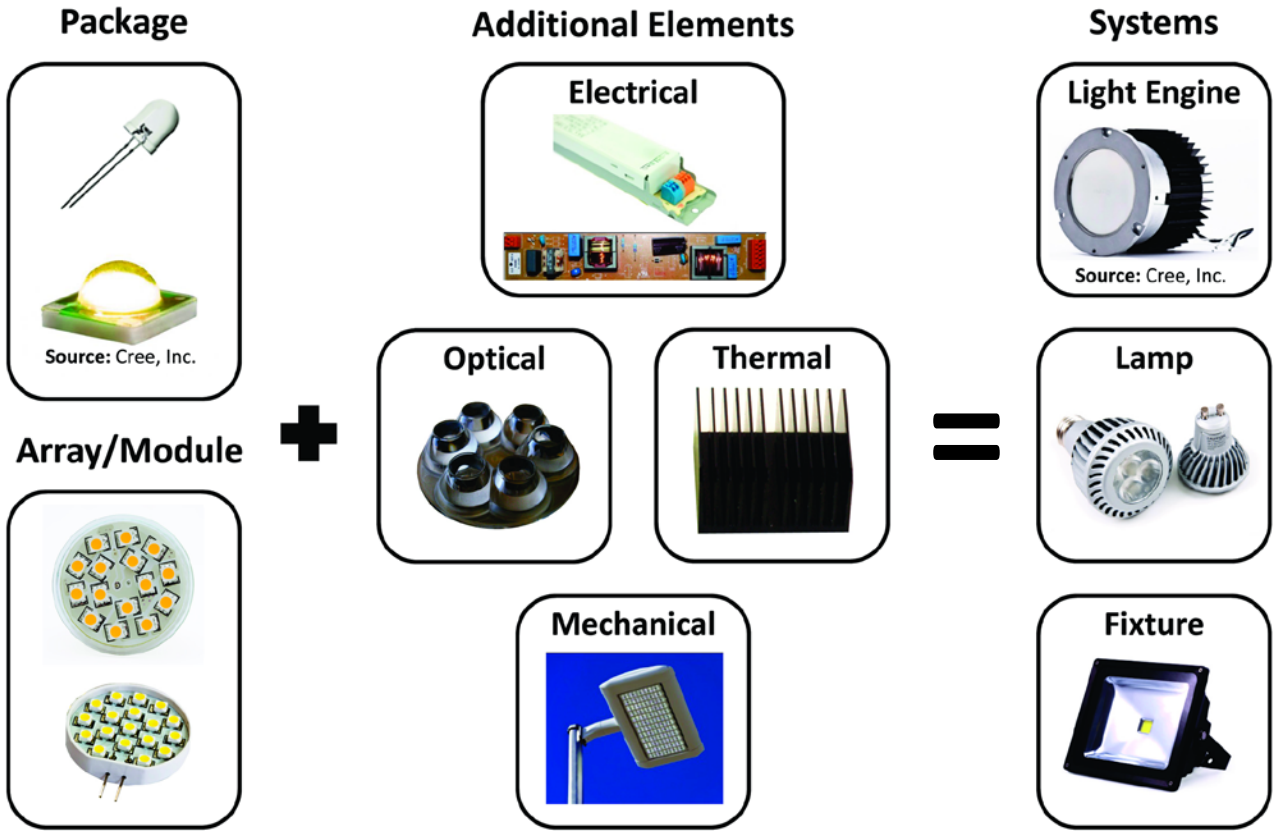
Fixture Information	Existing # of Fixtures	Existing Fixture Type	Existing Total Watts	Rec. # of Fixtures	Rec. Fixture Type	Rec. Total Watts	Annual Op Hours
Warehouse or Middle School Gym	36	400W MH	16,308 W	24	6L T8, 28W Lamp, Low BF	3024 W	3600
Maintenance or High School Gym	36	400W MH	16,308 W	24	6L T8, 28W Lamp, High BF	4656 W	3600
Detailed Maintenance or High School Gym	36	400W MH	16,308 W	24	6L T8, 32W Lamp, High BF	5232 W	3600
Manufacturing or College Gym	36	400W MH	16,308 W	36	6L T5HO 47W Lamp	7344 W	3600

$$$ Payback	Incremental Cost	Annual kWh Savings	Electric Cost Savings at $0.08/kWh	Maintenance Savings per year	Utility Incentive	Simple Payback
Warehouse or Middle School Gym	$5,496	47,822	$3,826	$108	$3,348	**0.5**
Maintenance or High School Gym	$5,520	41,947	$3,356	$108	$2,936	**0.7**
Detailed Maintenance or High School Gym	$5,592	39,874	$3,190	$108	$2,791	**0.8**
Manufacturing or College Gym	$9,900	32,270	$2,582	$72	$2,259	**2.9**

El Paso Electric

Solid State Lighting (SSL)

LED Technology, Program Updates and Best Practices



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Why LEDs?

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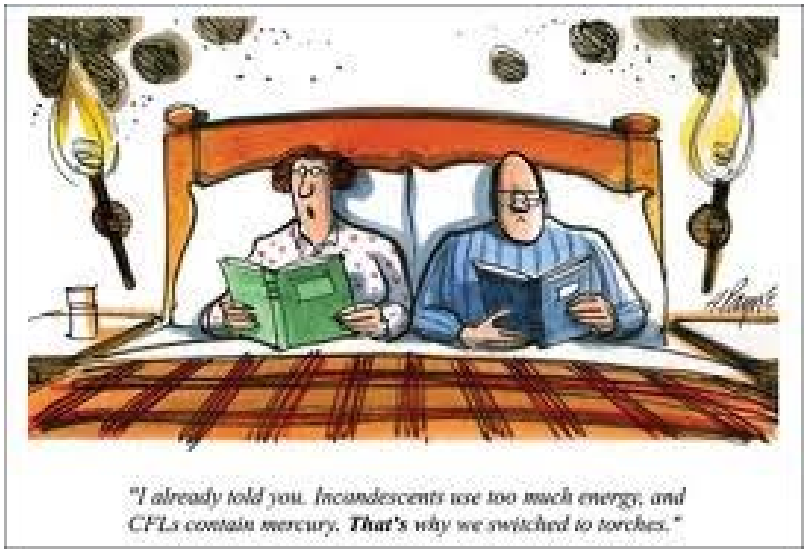

The Good

- Lamp life (maintenance savings)
- Efficacy (most efficient light source)
- Environmental benefits (no mercury)
- Small
- Operational - Instant on; Rapid Cycling; Like cold; Integrate w/ controls; Color changing
- **Way to address new regulations and laws: Lowering lighting power allowances; slowly eliminating incandescent, halogen and other less-efficient products**

The Bad

- Cost
- Confusing – Different world for lighting community and users

Efficacy (lm/W) of Available Technologies

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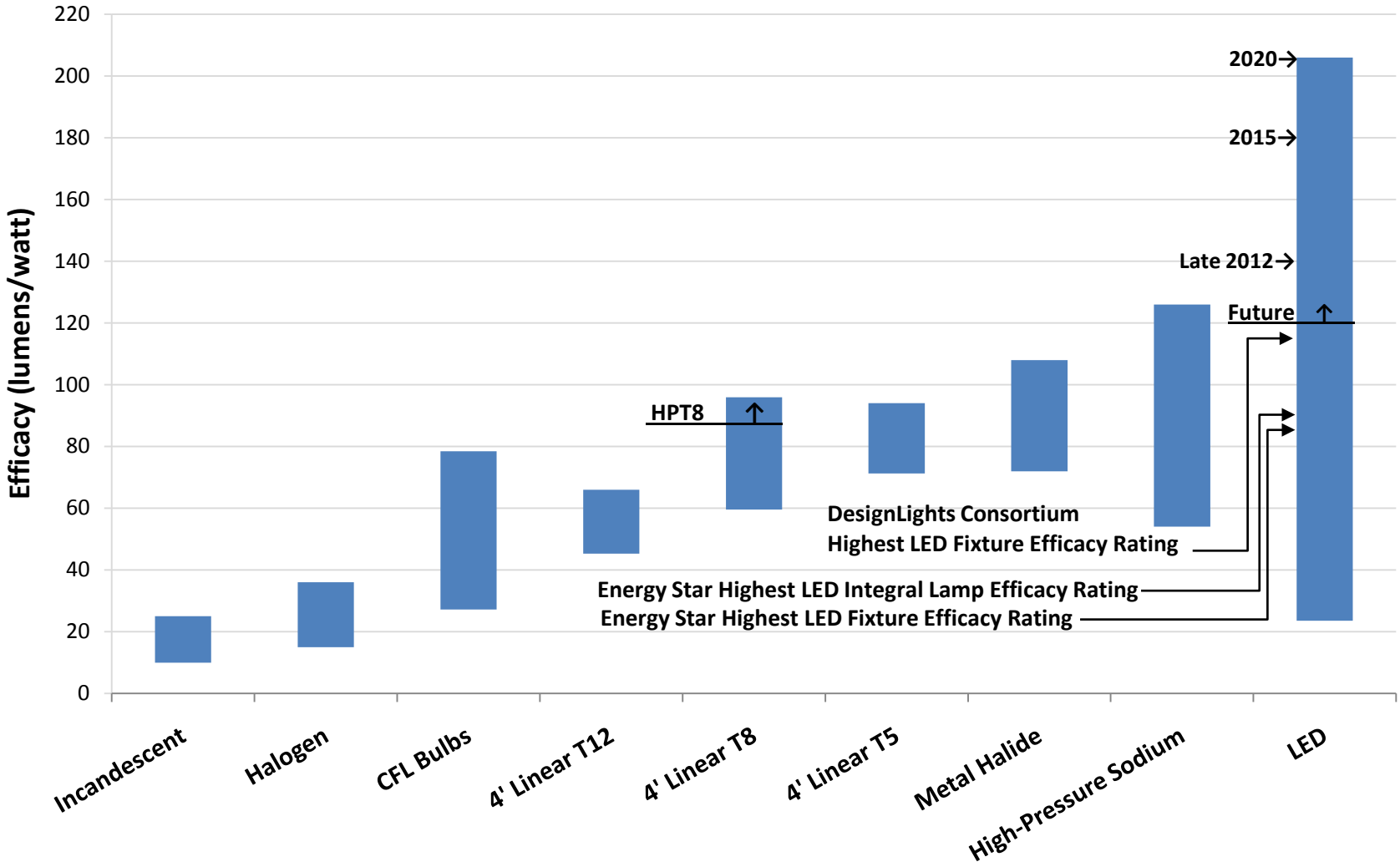

Ways in Which LEDs can Fail?

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- **LED: Lumen Depreciation;** Complete Failure (very rare)
- Color consistency and rendering: Over time in a product or in an “equivalent” replacement
- Electronics: Driver or Control(s)
- Thermal Management System
- Optics
- Mechanical components

Questions You Should be Asking Yourself?

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1. Am I getting enough light (lumens) out of the LED?

   +

   How does the efficacy (lumens/Watt) of the LED product compare?
2. Is my LED really going to last as long as it says?
3. Does the LED deliver the color characteristics I need?
4. Has the product been reviewed and qualified by Energy Star or DesignLights?

LED Qualification Criteria: DesignLights and ENERGY STAR

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Qualified Product Lists - To qualify for incentives, LED Fixtures and Lamps must be pre-qualified under one of the following options:

- **Energy Star LED Lamps:** http://www.energystar.gov/ → Find Energy Star Products → LED Light Bulbs
  - Integral Lamps – "LED Light Bulbs"
- **Energy Star LED Fixtures:** http://www.energystar.gov/ → Find Energy Star Products → Business & Government → Commercial LED Lighting
  - Recessed Downlights
  - Under-cabinet task lighting
  - Desk task lamps
  - Wall-wash luminaires
  - Bollards
- **Design Lights Consortium (DLC) LED Fixtures:** http://www.designlights.org/ → Solid State Lighting → Qualified Products List (QPL)
  - Outdoor Area/Roadway
  - Outdoor Decorative
  - Outdoor Wall-mount
  - Parking Garage
  - Track and Directional
  - Refrigerated Case
  - Display Case
  - Linear Panels/Troffers (2x2, 2x4, 1x4)
  - Floodlights
  - Retrofit Kits
  - Highbay & Lowbay
  - Gas Station Canopy
  - LED Linear T8 Replacement Lamps

LED Qualification Criteria: Why do we need them?

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Rapidly changing landscape with wide variation in performance

- Products are not delivering on their lifetime claims (Lumen Maintenance)
- Light (Lumen) output is not equivalent in many cases
- Color performance is not what the application requires
- General lack of consistency and truth in reporting
- Everything is changing quickly; important to regularly evaluate products

DOE's Lighting Facts: Comparing Products

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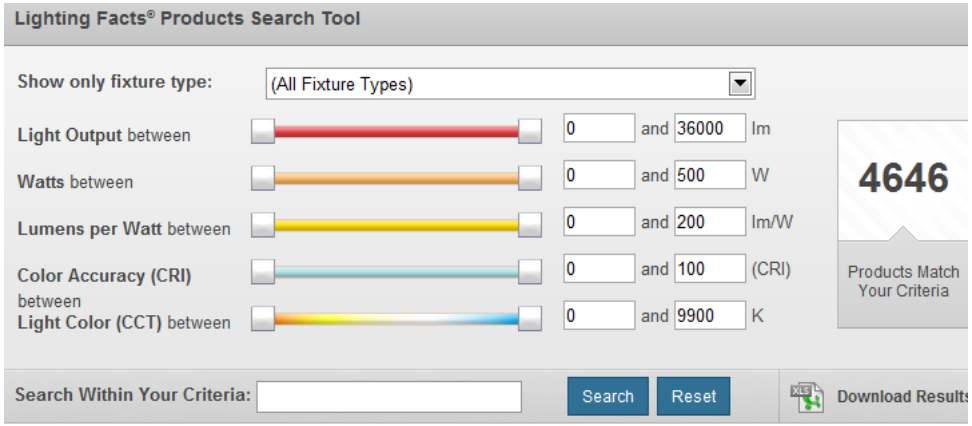
Lighting Facts Label

www.lightingfacts.com

Lighting Facts® is a program of the U.S. Department of Energy that showcases LED products for general illumination from manufacturers who commit to testing products and reporting performance results according to industry standards.

Lighting Facts Product Search Tool



Successful Applications

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Common Elements of Successful Applications

- Applications that require very direction light,
- Applications that do not require very high lighting levels or lots of delivered lumens,
- Applications that can utilize “cool” high color temperature (≥ 5000 CCT) - - - they are cheaper and have higher efficacy than their “warm” low temperature counterparts (≤ 3500 CCT).

Successful Applications

- ***Directional Replacement Lamps, Downlights and Wall Packs***: LEDs are directional by nature and work well in “spot light” fixtures and lamps
- ***Parking Garage and Outdoor Area & Roadway***: These applications use ≥ 5000 CCT LEDs and have lower overall required light levels
- ***Refrigerated Cases/Cold Environments***: LEDs produce more light and last longer in the cold

Suspect Applications to Carefully Scrutinize

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Suspect Applications
Hot Environments: Excessive heat can have a dramatic impact on lumen output and color maintenance (products much have good heat sinking capability)
High Indoor Ceiling: Currently difficult to meet light level requirements and color temperature requirements (but seeing some Lowbay and cold-storage warehouse applications)
LED Replacement Lamps for 4' Linear Fluorescent Lamps: Performance not currently comparable to cheaper fluorescents (These products are still a long way from delivering comparable performance, but LED panel fixtures are impressive)
Omnidirectional Replacement Lamps: LEDs are directional by nature; difficult to design an effective "warm" (≤ 3500 CCT) lamp that properly dissipates heat (while there are some very attractive products entering the market – high cost)
MR-16 Replacement Lamps (≥ 35 W): Small package makes heat dissipation tough; often needs high CRI and "warm" low CCT (but more and more high-quality products replacing 20 W halogens and lumen outputs continue to improve)

Exterior Applications: Role of Scotopic and Photopic Vision

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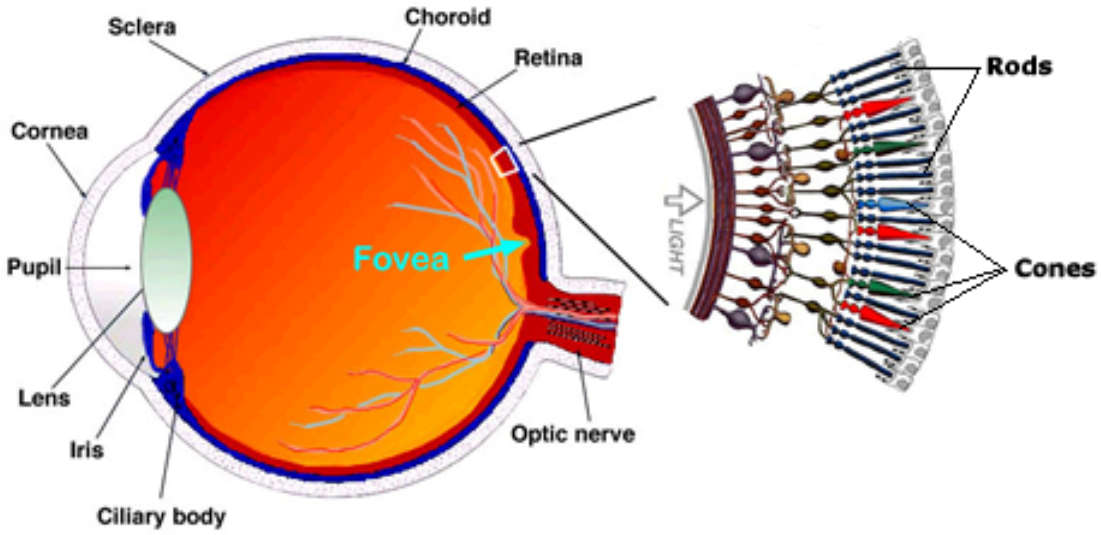
The retina is composed of rods and cones



Rods - provide "scotopic" or low intensity night vision.

- Provide our night vision ability for very low illumination,
- Are a thousand times more sensitive to light than cones,
- Are much slower to respond to light than cones,
- Occurs only when very little light is available (e.g. in country on moonless night)

Cones - provide "photopic" or high acuity day vision.

- Provide our day vision,
- Determine overall brightness or darkness of images,
- Provide our color vision
- Dominant state if outside during day of inside under conventional lighting

Mesopic Vision

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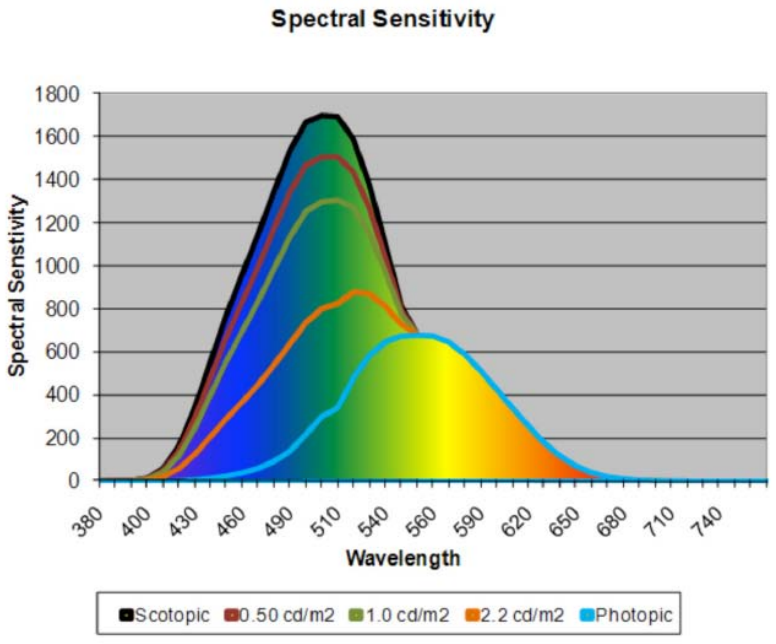
Mesopic vision is between those two extremes:

- Both the rods and cones are contributing to what you see
- Experienced beginning at dusk in virtually all outdoor lighting conditions, including a moonlit sky
- Focus of a great deal of research now to develop a “Mesopic” photometry or lumen metric



Why is this Important?

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- Our light meters and the general recommendations based upon them (IES RP-8 & RP-33) do not take scotopic impact into account
- As with Spectrally Enhanced Lighting (SEL), there is an opportunity to either:
  - increase perceived light using products with more blue light or
  - Save more energy by providing same perceived light with less wattage
- IES publishes Mesopic multipliers (adjustment factors) to account for these effects in outdoor projects/designs. These and the DOE SEL calculation approaches are broadly recognized and accepted. However, if claims sound too good to be true, they probably are!
  - See IES Position Statement PS-02-09, "Use of Spectral Weighting Functions for Compliance with IES Recommendations" http://www.ies.org/store/position_statements.cfm
- **Word of Caution**: Advertisers have made exaggerated claims about increased energy efficiency based on various spectral modifying factors and alternative weighting functions.

IES Mesopic Multipliers

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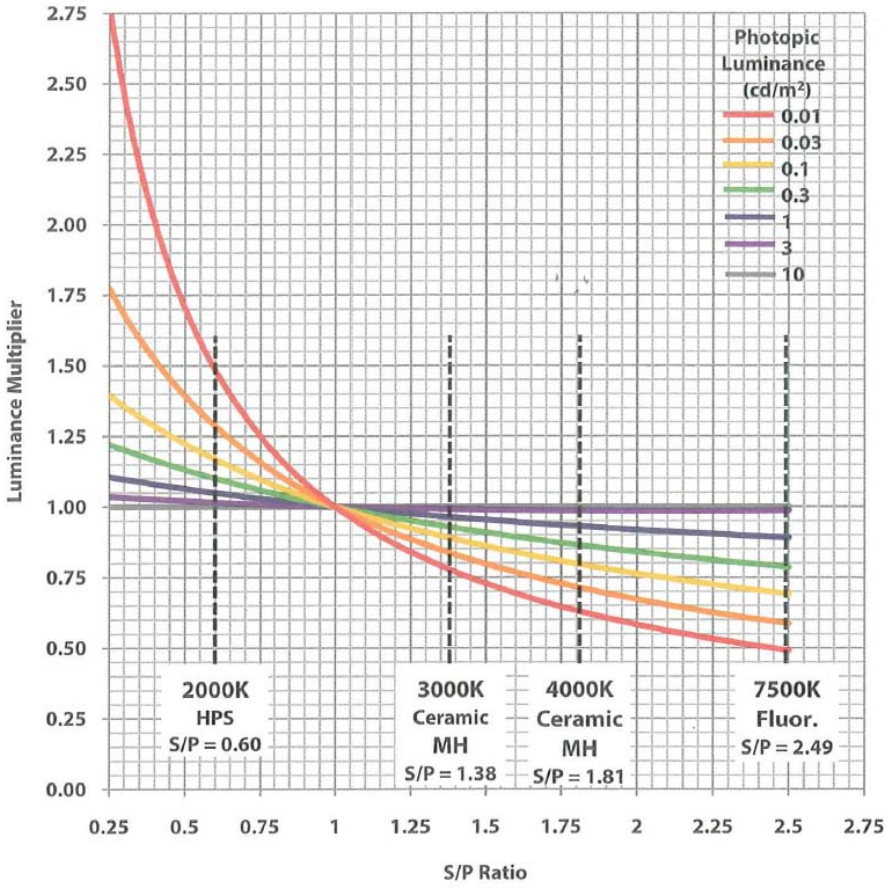
- **Illustrative Example:** If photopic recommendations call for 0.6 average maintained footcandles (horizontal) and 0.2 average maintained footcandles (vertical)
  - Multiply by approx 0.95 for 3000K CMH (0.57 and 0.19)
  - Multiply by approx 0.90 for 4000K CMH (0.54 and 0.18)
  - Multiply by approx 0.85 for Cool LED (0.51 and 0.17)



Mesopic Multipliers: Multipliers are used to adjust recommended photopic illuminance targets for Mesopic conditions; S/P-ratios of warm white LEDs are around 1.15 and those of cool white LEDs around 2.15

LED Gas Station Canopy

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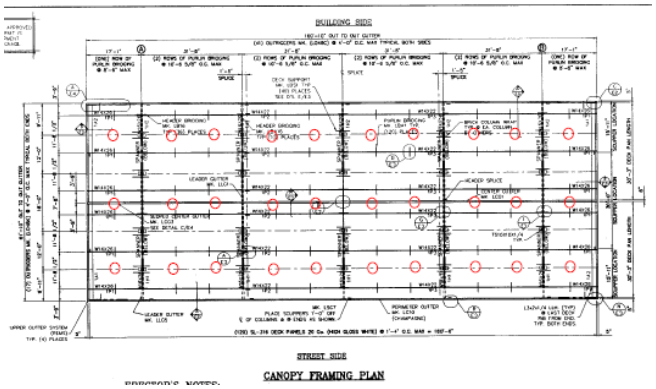
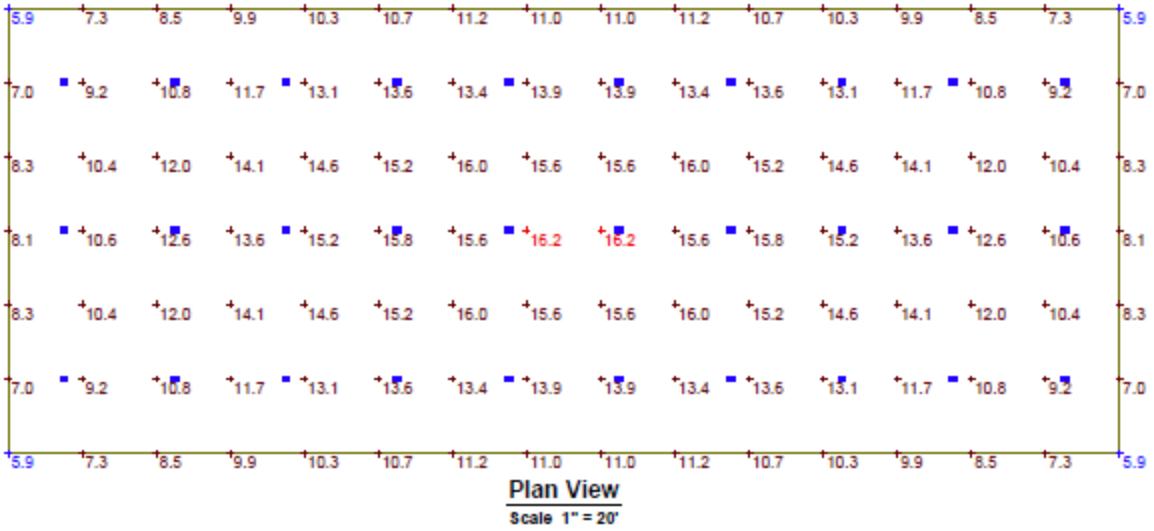
- 0.46 w/SqFt well below the stringent new requirements (btw 0.6 and 1.0 w/SqFt)
- Recommended footcandle levels, between 7.5 up to 15 fc (IES Zone recommendations)
- Surveys indicate perceived light levels are equivalent

Area	# of Fixtures	Fixture Type	Total Watts	Area (in sq feet)	Power Density (W/SF)	Average FC	Max/Min Ratio	Avg/Min Ration
LED Gas Canopy	30	136W LED Type V	4,110 W	9,000	0.46 W/SF	13.9	2.7:1	2.0:1





Costs: LED Gas Station Canopy

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- Compared LED to a 250W Pulse Start Metal Halide Alternative
- Simple Payback Calculation assuming system being replaced

	Proposed # of Fixtures	Proposed Fixture Type	Proposed Total Watts	Rec. # of Fixtures	Rec. Fixture Type	Rec. Total Watts	Annual Op Hours	Annual kWh Savings
LED versus 250W Pulse Start MH: Gas Canopy	40	250W PSMH	11,520 W	30	137W LED Type V	4,110 W	4000	29,640

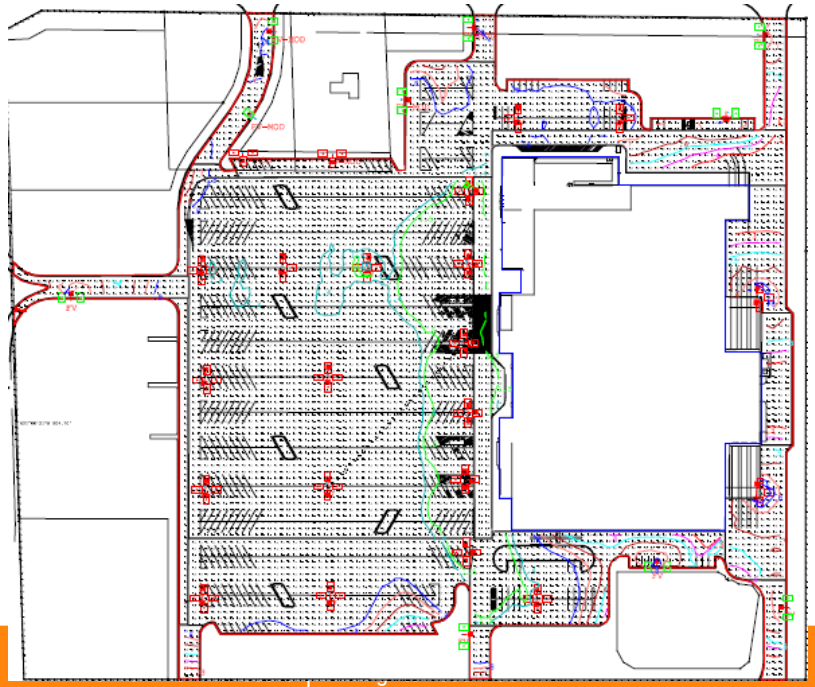
	Electric Cost Savings at $0.08/kWh	Incremental Cost per Fixture	Annual Maintenance Savings	Utility Incentive	Simple Payback
LED versus 250W Pulse Start MH: Gas Canopy	$2,371	$450	$1,500	$2,075	3.0

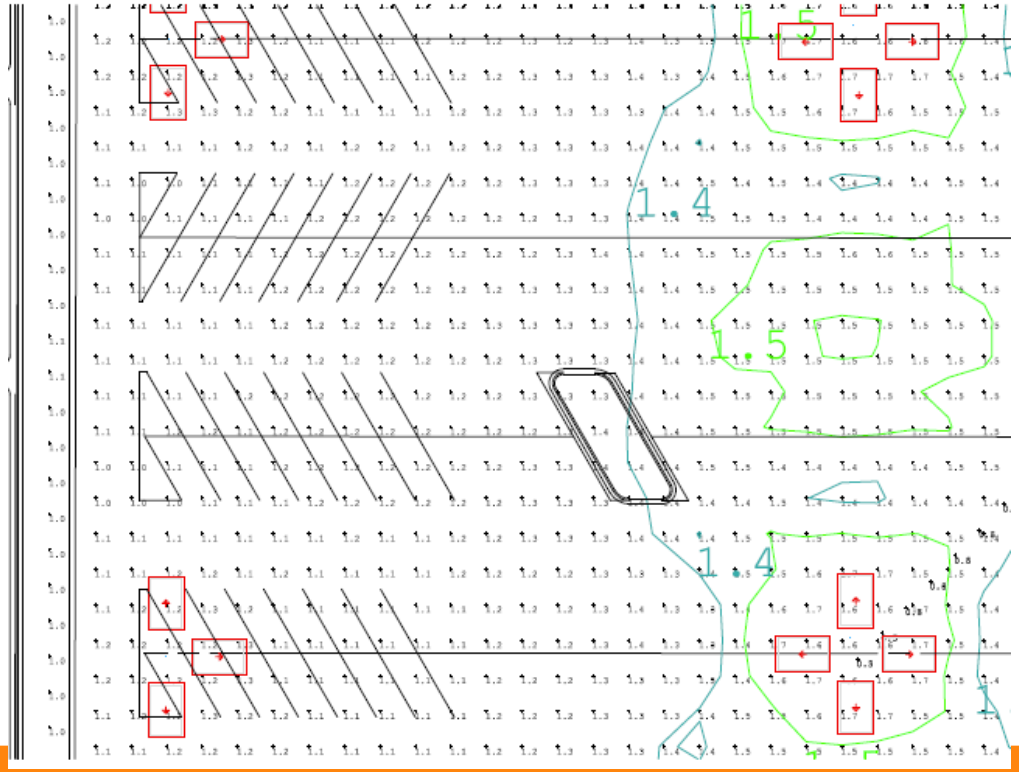
LED Area and Street

CLEAResult

- Excellent Uniformity, can be improved with newer products
- Recommended footcandle levels, between 0.6 and 1.0 fc (IES general recommendations)
- Surveys generated very positive customer feedback

Area	# of Fixtures	Fixture Type	Total Watts	Area (in sq feet)	Power Density (W/SF)	Average FC	Max/Min Ratio	Avg/Min Ration
LED Parking Lot	100	124W LED Type III Fixture	12.4 kW	200k	.062 W/SF	1.27	1.8	2.7





Costs: LED Area and Street

CLEAResult

- Compared to a 400W Pulse Start Metal Halide Alternative
- Simple Payback Calculation assuming system being replaced

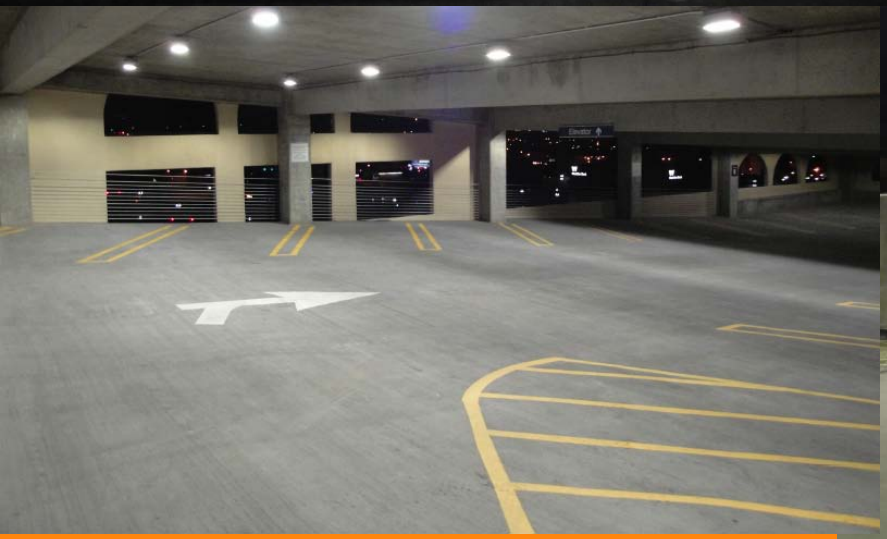
	Proposed # of Fixtures	Proposed Fixture Type	Proposed Total Watts	Rec. # of Fixtures	Rec. Fixture Type	Rec. Total Watts	Annual Op Hours	Annual kWh Savings
LED versus 400W Pulse Start MH	100	400W PSMH	45,300 W	100	124W LED Type III	12,400 W	4000	131,600

	Electric Cost Savings at $0.08/kWh	Incremental Cost per Fixture	Annual Maintenance Savings	Utility Incentive	Simple Payback
LED versus 400W Pulse Start MH	$10,528	$500	$4,000	$9,212	2.8

Mills Plaza Parking Garage

88kW; 693,466kWh

> 60% Reduction in Energy



Other Applications to Consider

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- Downlights
- Wall Packs
- Refrigerated Display Cases (Supermarket and Convenience Store)
- Streetlighting (Comparable to Area Lighting Analysis)
- Lower Wattage Track or Spot Applications
- Refrigerated Warehouses with Ceiling < 30ft

LED Resources

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- DOE SSL Home Page – www1.eere.energy.gov/buildings/ssl/ houses extensive information on solid state lighting from basic through advanced, including links to the DOE Caliper Program that performs independent LED product testing and completed Gateway Demonstration projects
- Commercial Building Energy Alliance (CBEA) has developed certain LED lighting specifications: www1.eere.energy.gov/buildings/alliances/index.html
  - Parking Garages
  - Exterior Parking
  - Refrigerated Display Cases
- DOE Municipal Solid-State Street Lighting Consortium shares technical information and experiences related to LED street and area lighting demonstrations: www1.eere.energy.gov/buildings/ssl/consortium.html
- Lighting Facts - www.lightingfacts.com which is a labeling program that helps ensure product quality via IES LM-79 test results
- Energy Star - www.energystar.gov provides detailed performance specifications/requirements on a number of LED product categories that can earn the Energy Star label

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Questions?

Presentations will be available at:

www.elpasoelectric.com

www.epesaver.com