

How to select LED bulb to replace HPS bulb

Need to match human visual perception of night brightness (scotopic vision) instead of matching daytime perception (photopic vision) measured by light meters intended for use with photographic cameras

Incandescent Bulb Label

Lighting Facts <small>Per Bulb</small>	
Brightness:	820 lumens
Estimated Yearly Energy Cost	\$7.23
<small>Based on 3 hrs/day, 11¢/kWh Cost depends on rates and use.</small>	
Life	1.4 years
<small>Based on 3 hrs/day</small>	
Light Appearance	
<small>Warm</small>  <small>Cool</small>	
<small>2700 K</small>	
Energy Used	60 watts



CFL Bulb Label



Lighting Facts Per Bulb	
Brightness	870 lumens
Estimated Yearly Energy Cost	\$1.57
Based on 3 hrs/day, 11¢/kWh Cost depends on rates and use	
Life	5.5 years
Based on 3 hrs/day	
Light Appearance	
Warm ▲ Cool	
2700 K	
Energy Used	13 watts
Contains Mercury	
For more on clean up and safe disposal, visit epa.gov/cfl .	

Home Depot LED Bulb Selection

					
<p>EcoSmart 8-Watt A19 LED (40W equivalent)</p>	<p>Phillips 12-Watt A19 LED (60W equivalent)</p>	<p>EcoSmart 13-Watt A19 LED (60W equivalent)</p>	<p>Phillips 17-Watt A21 LED (75W equivalent)</p>	<p>Cree TrueWhite® 10.5-Watt LED Downlight (65W equivalent)</p>	<p>EcoSmart 24-Watt LED Flood (125W equivalent)</p>
<ul style="list-style-type: none"> • Replaces: 40W incandescent bulb • Light output: 430 lumens • Color: soft white (3000 K) • Bulb life: 50,000 hrs • Uses: general purpose, indoor • Dimmable 	<ul style="list-style-type: none"> • Replaces: 60W incandescent bulb • Light output: 800 lumens • Color: soft white (2700 K) • Bulb life: 25,000hrs • Uses: general purpose, indoor • Dimmable 	<ul style="list-style-type: none"> • Replaces: 60W incandescent bulb • Light output: 850 lumens • Color: soft white (3000 K) • Bulb life: 25,000hrs • Uses: general purpose, indoor • Dimmable 	<ul style="list-style-type: none"> • Replaces: 75W incandescent bulb • Light output: 1,100 lumens • Color: soft white (2700 K) • Bulb life: 25,000hrs • Uses: general purpose, indoor/outdoor • Dimmable 	<ul style="list-style-type: none"> • Light output: 575 lumens • Color: soft white (2700 K) • Bulb life: 35,000hrs • Uses: ceiling recessed lighting cans, indoor/outdoor • Dimmable 	<ul style="list-style-type: none"> • Light output: 1,300 lumens • Color: cool/bright white (3000 K) • Bulb life: 25,000hrs • Uses: indoor/outdoor, security lighting • Dimmable

LED Color Range



6400K Super Day Light



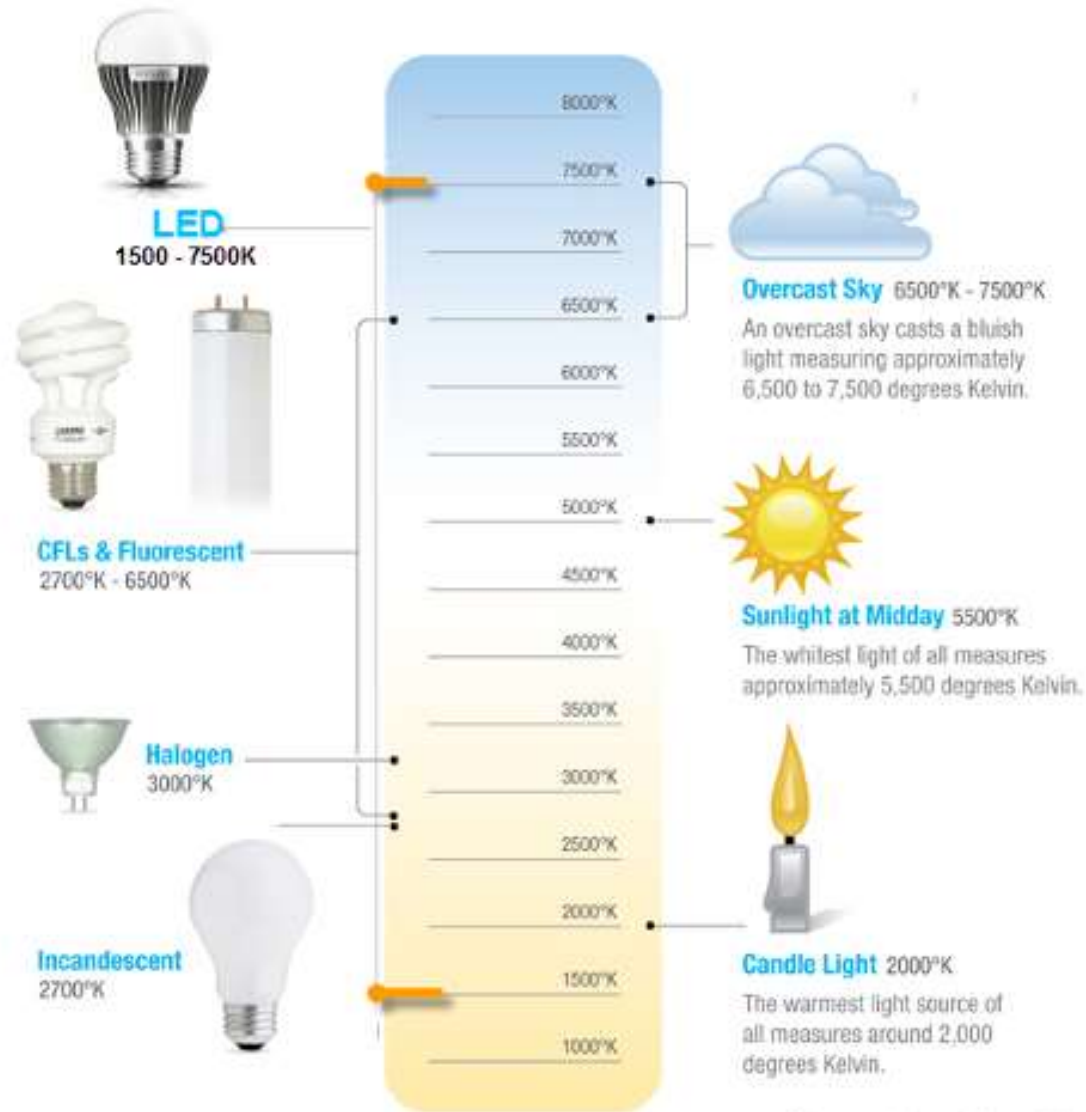
5000K Day Light



4100K Cool White



2700K Warm White

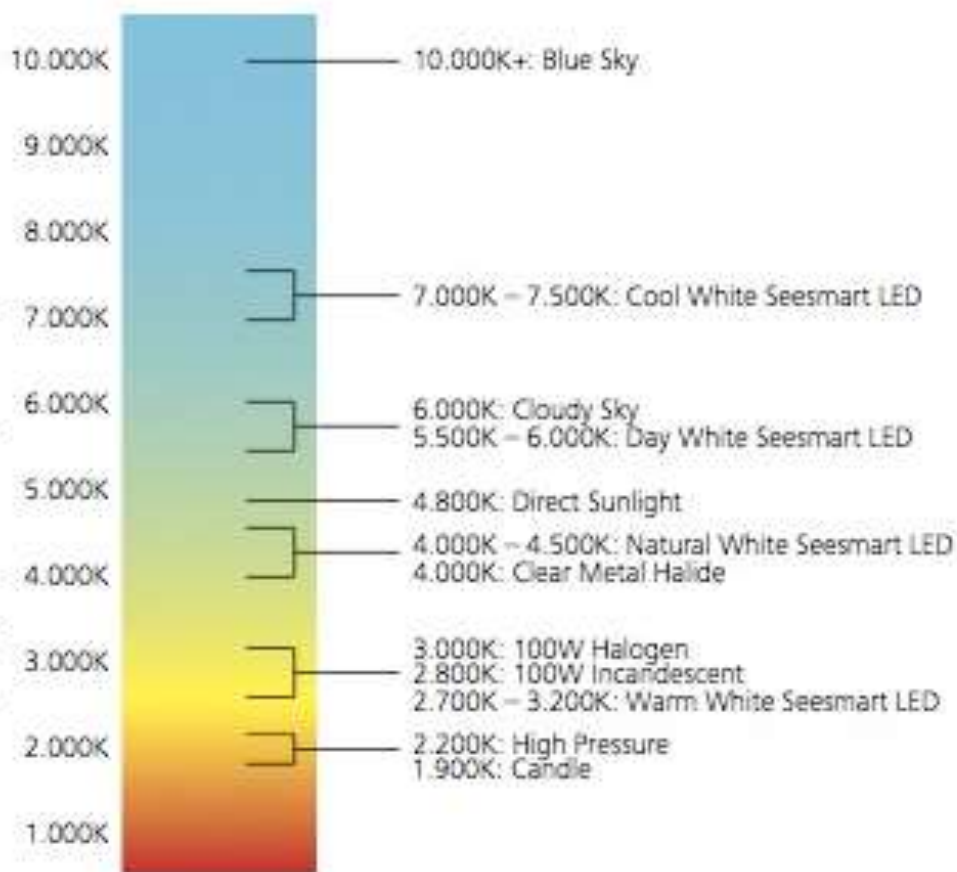


Measurements shown in degrees Kelvin.

Basic LED Reference Example



Kelvin Color Temperature Scale Chart

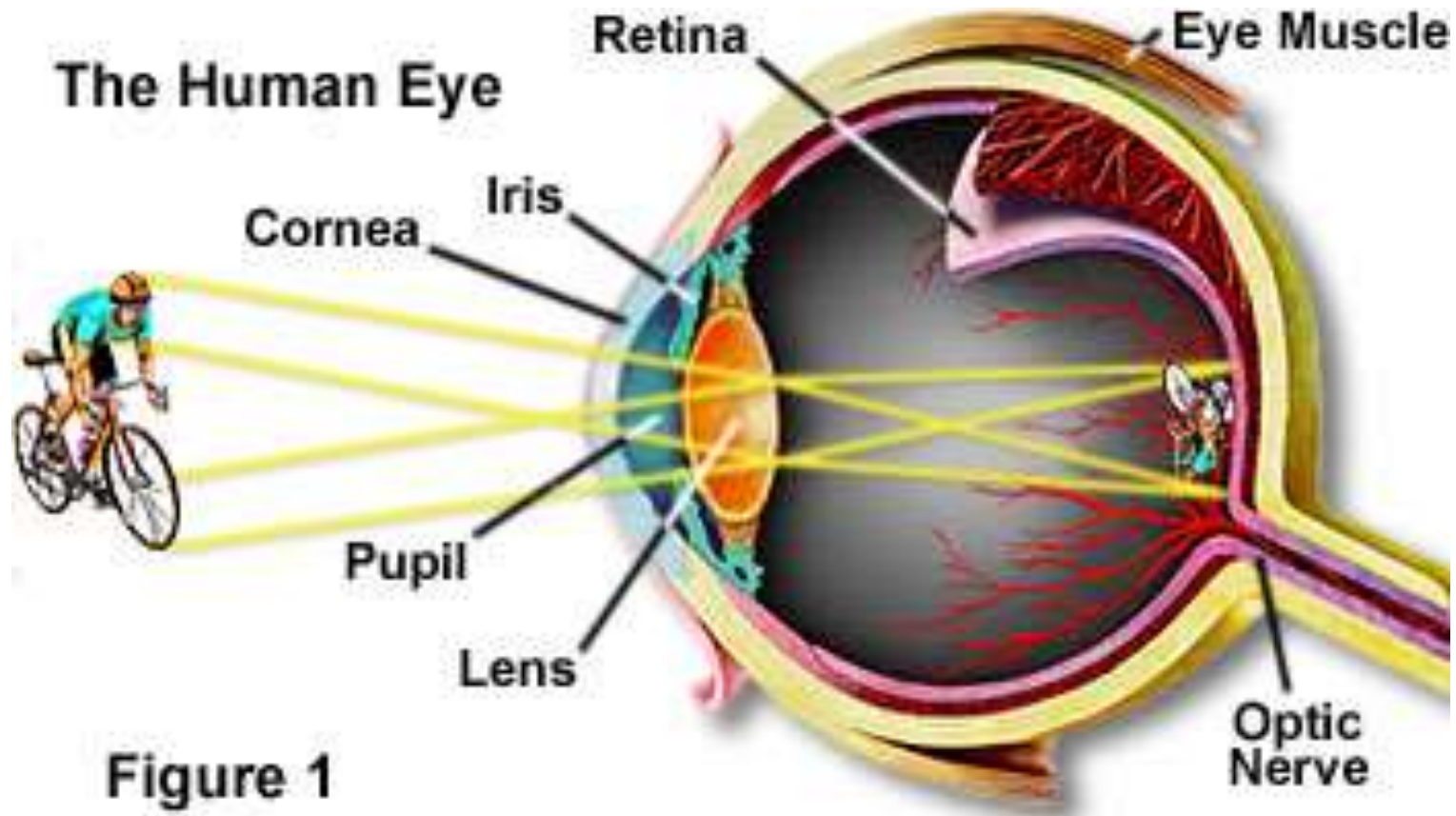


For colors based on black body theory, blue occurs at higher temperatures, while red occurs at lower temperatures. This is the opposite of the cultural associations attributed to colors, in which "red" is "hot", and "blue" is "cold".

LED Color Range



Human Eye



Human Retina Rods and Cones

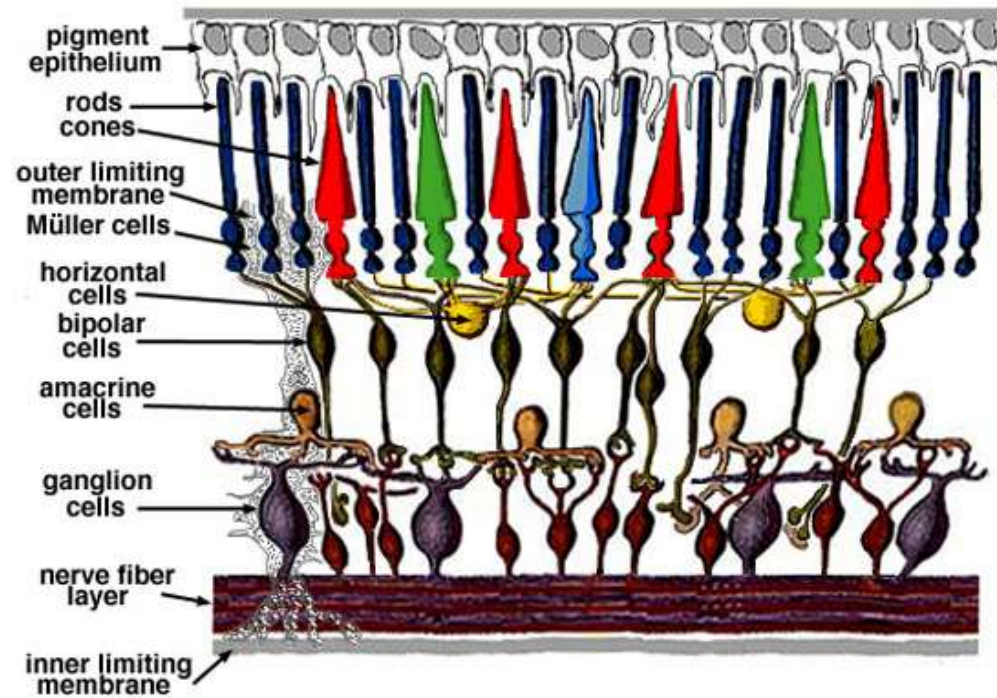
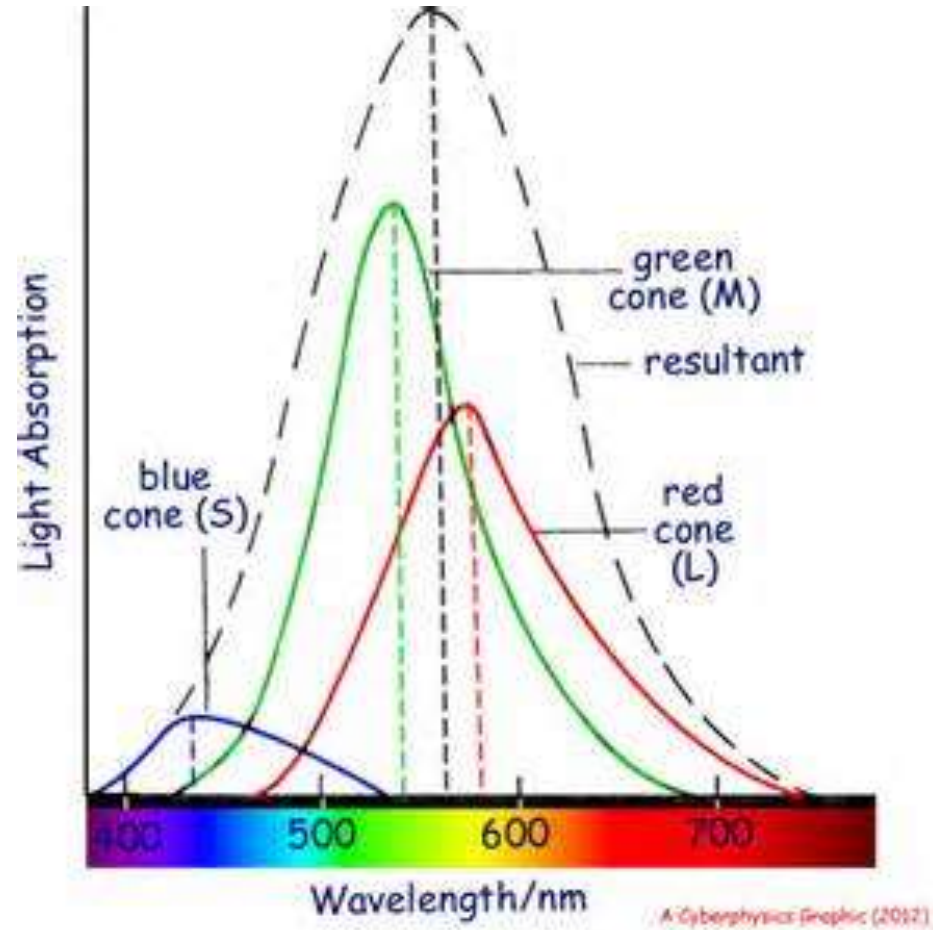
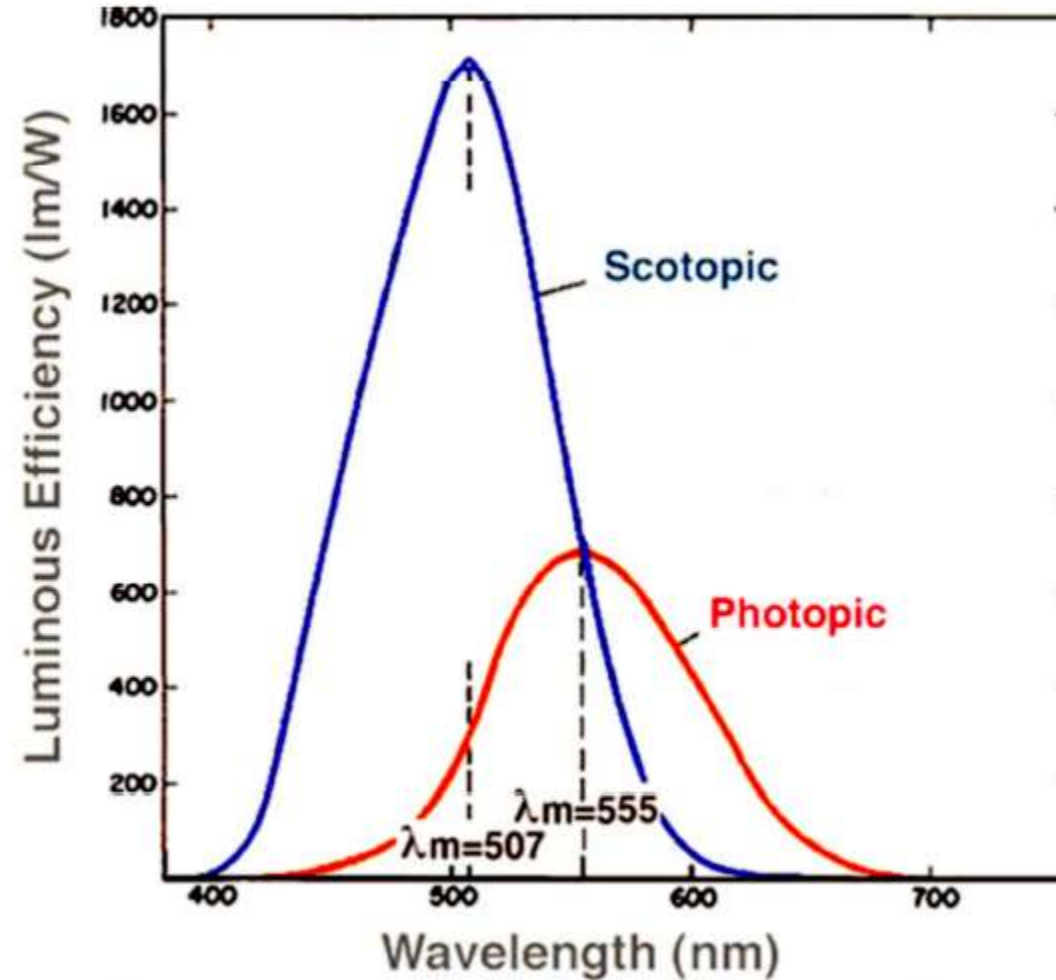


Fig. 2. Simple diagram of the organization of the retina.

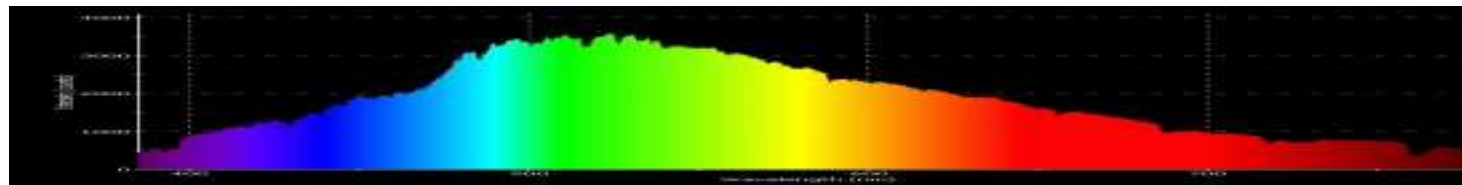
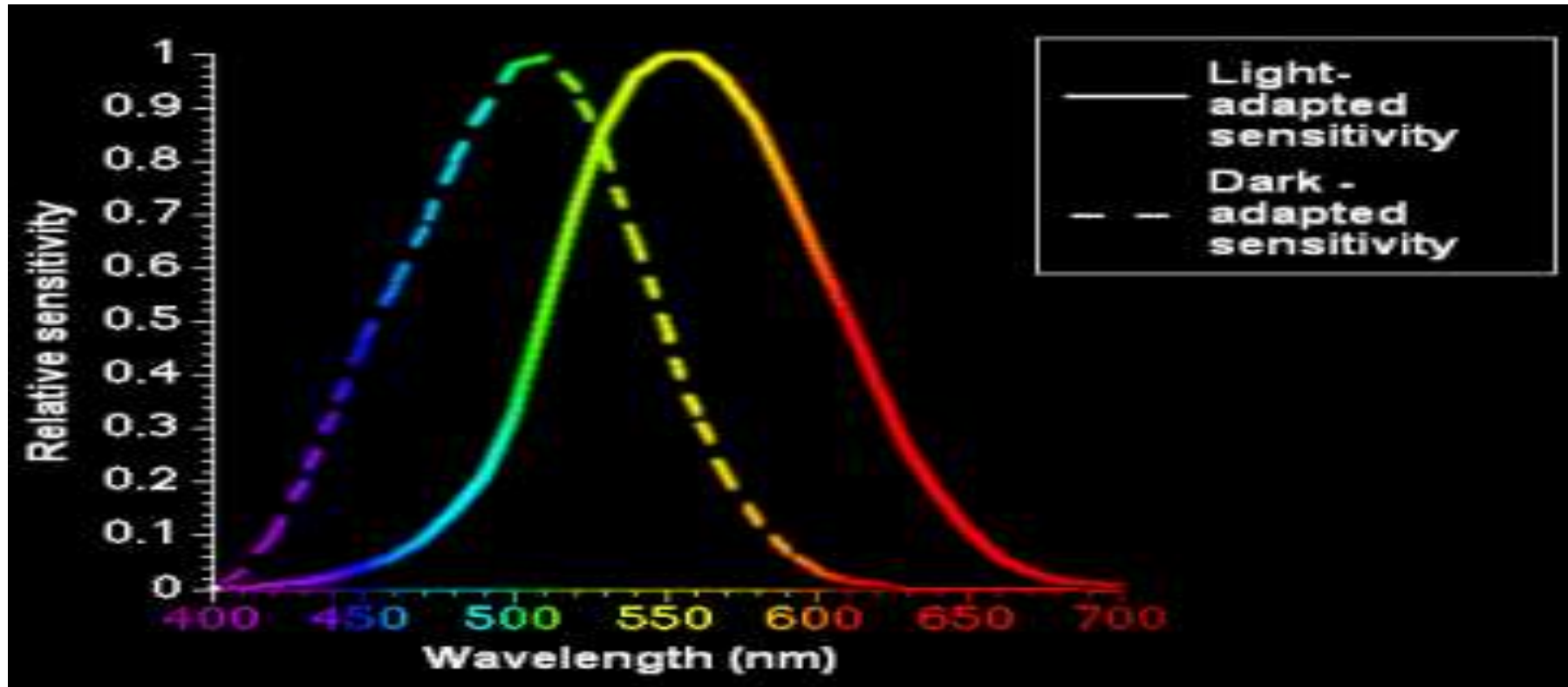
Cone Vision (Photopic)



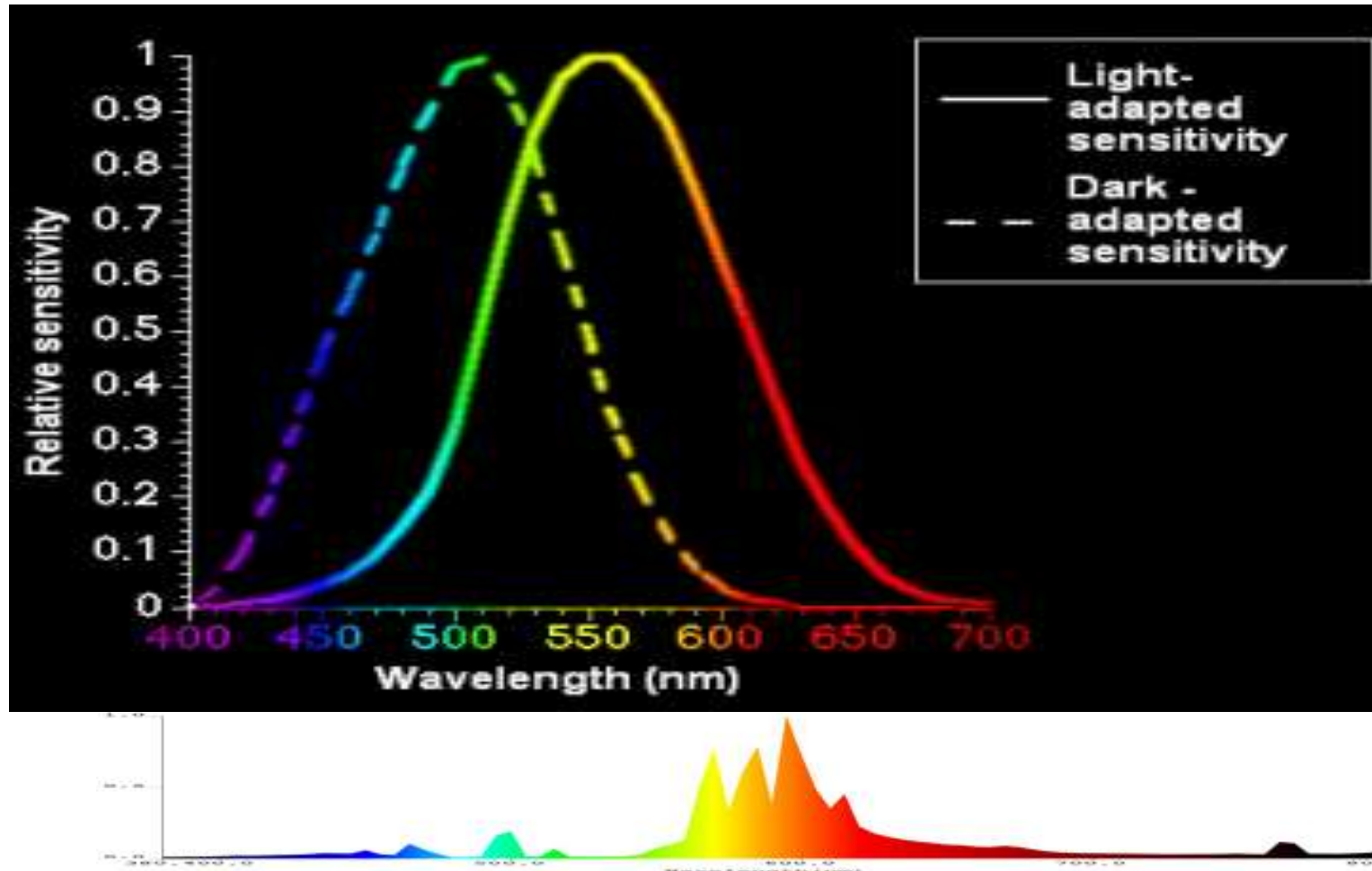
Rod (Scotopic) and Cone (Photopic) Sensitivities



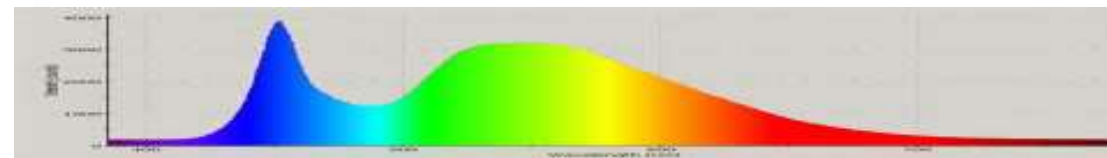
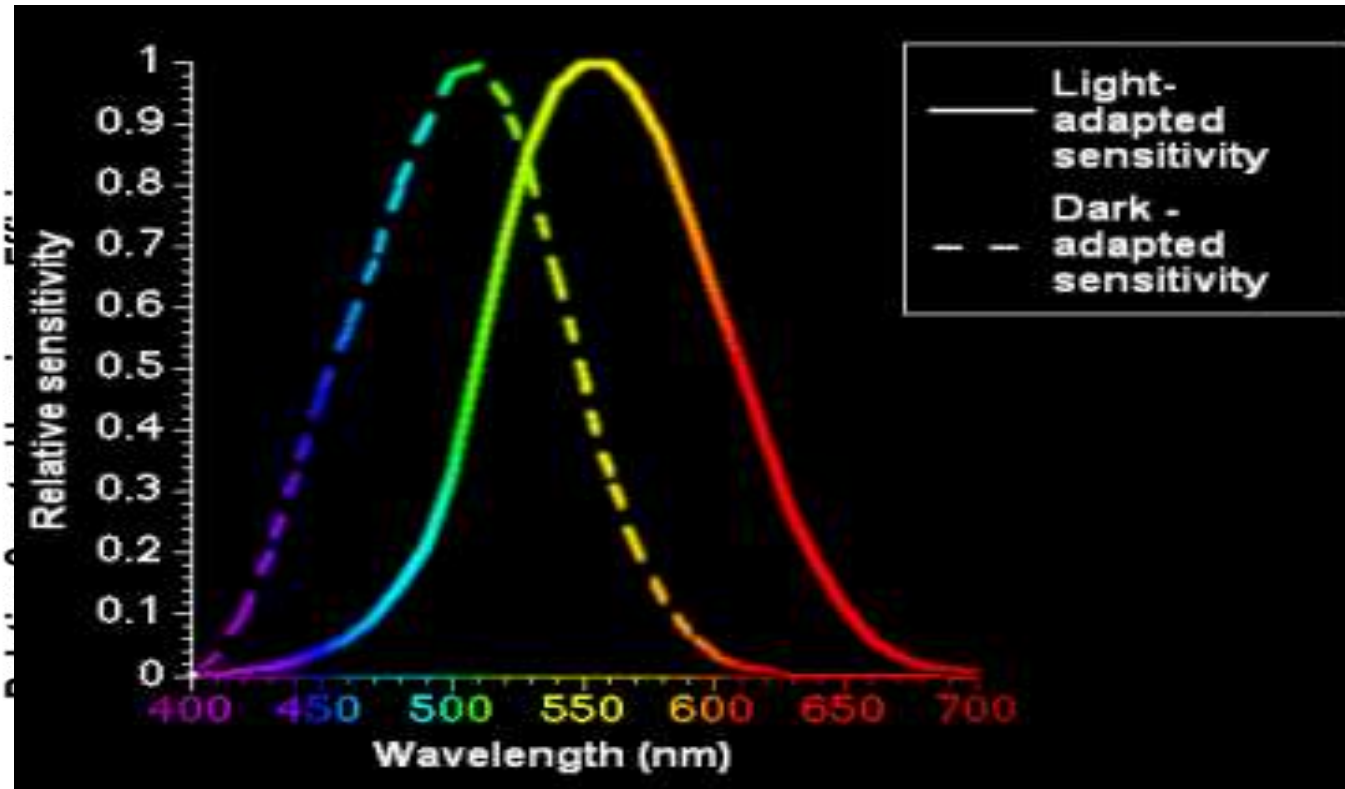
Incandescent Bulb Spectrum (5000 K)



Sodium Street Lamp Spectrum (HPS bulb)



White LED Color Spectrum



Scientists at the Lawrence Berkley Laboratory (LBL) developed the concept of scotopic lumens. The S/P ratio. This ratio helps convert traditional Lumens into actual lumens perceived by the eye under moonlight, a more accurate estimate of the amount of light.

Pupil Lumens = Photopic Lumens * [S/P] 0.78

Here are some types of lights with their traditional and pupil lumens

Source of Light	Watt	Lumens	Lumens/Watt (Photopic Lumens)	S/P Ratio (correction factor)	Pupil Lumens	Pupil Lumens/Watt
Low Pressure Sodium	250	32500	130	0.2	9250	37
High Pressure Sodium	365	37000	101	0.62	25530	70
Metal Halide	455	36000	79	1.49	48960	108
T8 Fluorescent (3000 K)	36	2800	78	1.13	3080	85
LED Light	15	1500	100	1.9	2475	165

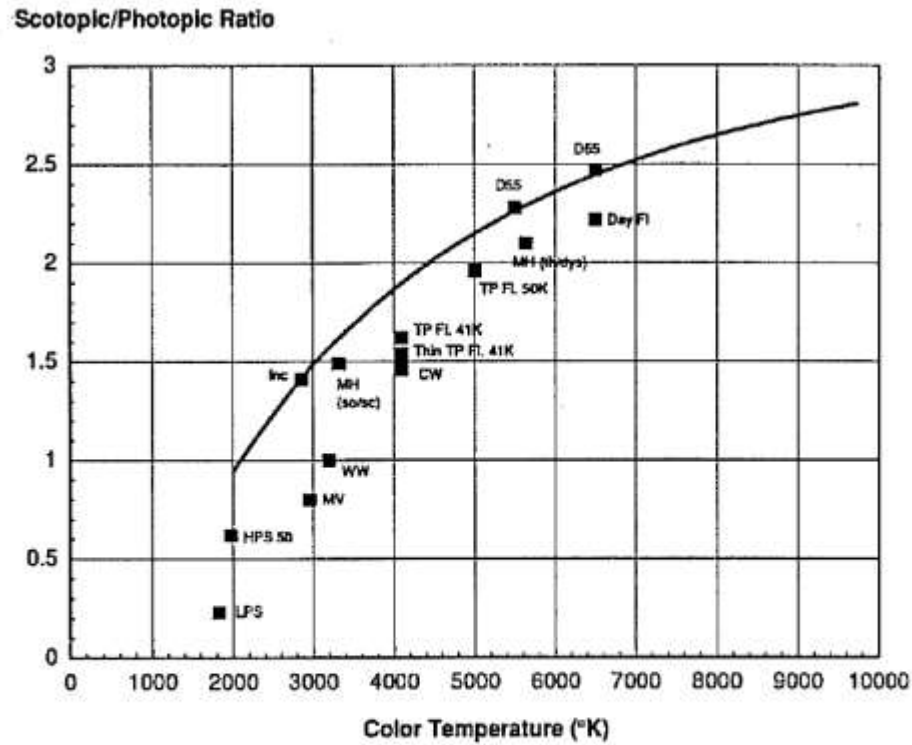


Figure b—Scotopic/photopic ratio vs. color rendition index for various light sources

<http://eetd.lbl.gov/sites/all/files/publications/lbl-30844.pdf>

How to select LED to replace HPS (yellow) street bulb

- A 100 watt HPS100 bulb produces 9500 lumens of yellow light (2700K) for which human night vision has very low sensitivity
- For a 3000K LED divide lumens by 2; for 4000K divide lumens by 3
- Equivalent LED lumens need to be
 - 4800 for 3000K demo luminaire at parking lot corner of Galiano and Giralda
 - 3200 for 4000K demo luminaire at parking lot corner of Galiano and Giralda
- For Luminoso LED with efficiency of 110 lumens/watt, we need
 - 44 watts for 3000K 45 watt CB45 available for ~\$75
 - 30 watts for 4000K 36 watt available for ~\$75
- <http://api.icentera.com/v2/getfile.aspx?f=D32728F9CB036C10E8AA08E6530E2A7171E1C8F43C33D8B28862391B2443F022B4311DA97912DF88>
- <http://www.lrc.rpi.edu/researchAreas/pdf/GrotonFinalReport.pdf>
- <http://www.hoveyelectric.com/hovey-electric-power-blog/bid/73956/Scotopic-vs-Photopic-Vision-How-Your-Eyes-Perceive-Light-Quality>

Benefits of Switching from Yellow HPS to 3000-4000K LED bulbs

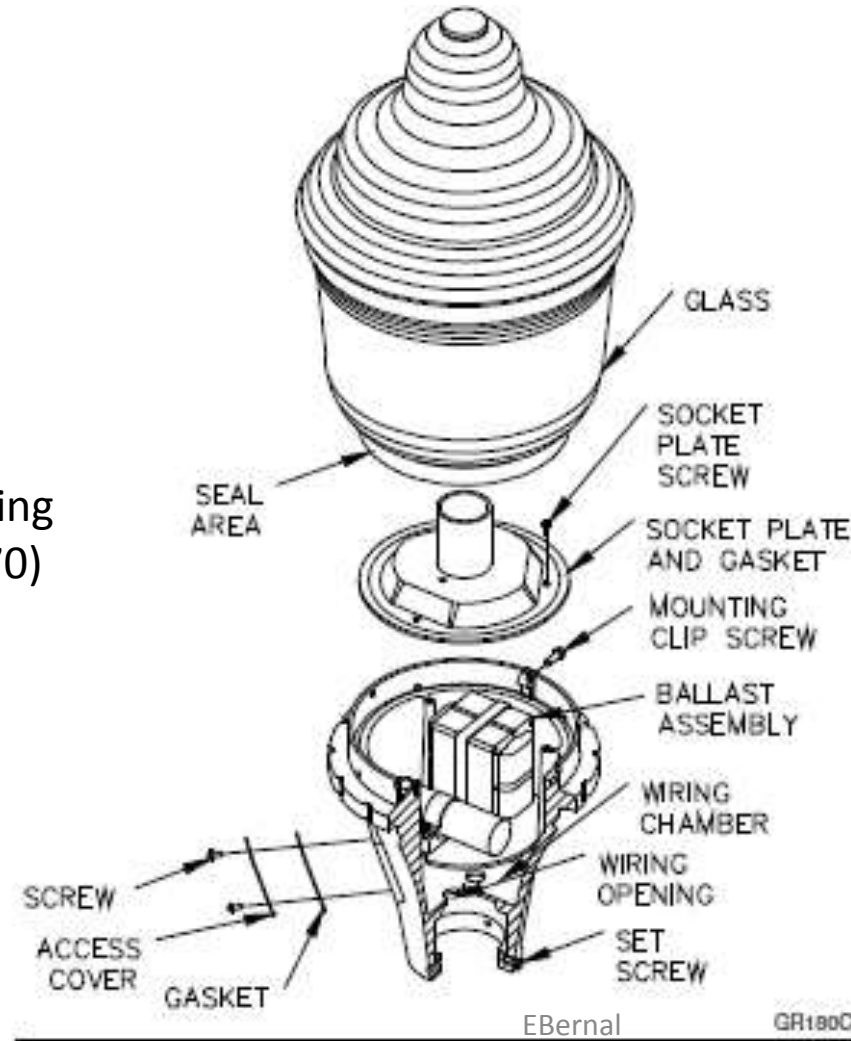
- Lower energy consumption 50% Reduce carbon footprint
- Improve color rendering Clearer night vision for law enforcement
Lower light pollution
- Reduce maintenance Relamp every 5 years v 1 year
Reduced lights out
- Reduce cost PW assumes relamping for 583 v 106 now
By spending more on metering
By switching to PL-1 tariff (?) from SL-1

Option 1

\$180 per Arcadian pole

1. Remove ballast assembly

2. Replace HPS with LED bulb using licensed electrician following National Electrical Code (NFPA 70)

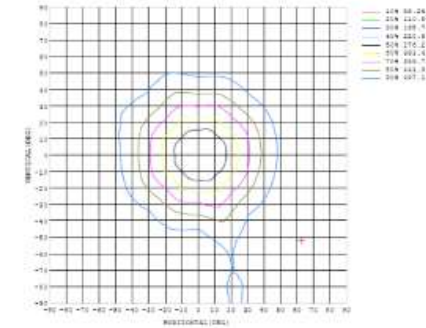


HPS Replacement

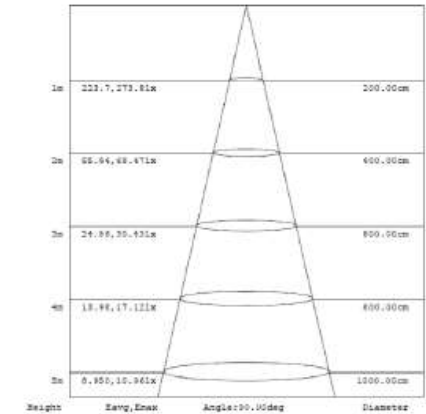
PERFORMANCE SUMMARY

Efficacy:	115 LPW
Delivered Light Output:	5,200 - 6,075 Lumens
Input Power:	45 Watts
CRI:	Ra > 85
OCT:	3000K / 4000K / 5000K
Input Voltage:	120-277 / 347-480 VAC
Input current:	0.38 - 0.16 / 0.13 - 0.09 Amps
THD:	< 16% (at 120V)
Power Factor:	>0.98 (120V)
Frequency:	50/60Hz
Standard Warranty:	5 Years
Standard Lifetime:	Designed to L70 minimum 50,000 hours
Base:	E26 or E39
IP Rating:	IP64
Impact & Heat Resistant Polycarbonate Housing	
Instant On at 100% Output; No Warm-Up Time	
Weight:	2.1 lbs
Optimum Operating Temp:	-4° - 149°F; Max Temp: 157°F
Universal Burn Position	
Over 2X Operating Life of HID lamps	
3G Vibration Tested	

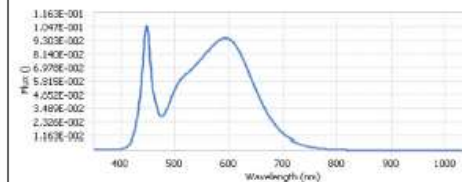
LUMINOUS INTENSITY DISTRIBUTION DIAGRAM



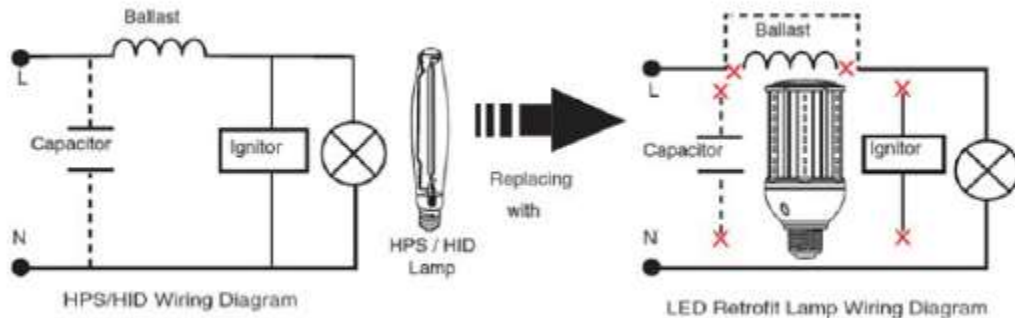
ILLUMINANCE PLOTS



SPECTRAL POWER DISTRIBUTION



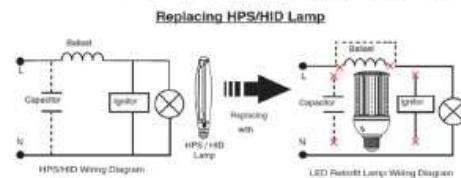
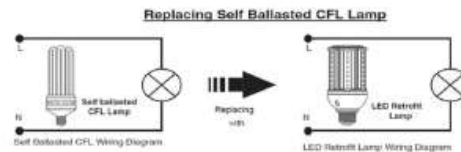
Replacing HPS/HID Lamp



REGULATORY & VOLUNTARY QUALIFICATIONS

UL Listed	Yes
LM79 Report	Yes
Rated for Enclosed Fixture	Yes

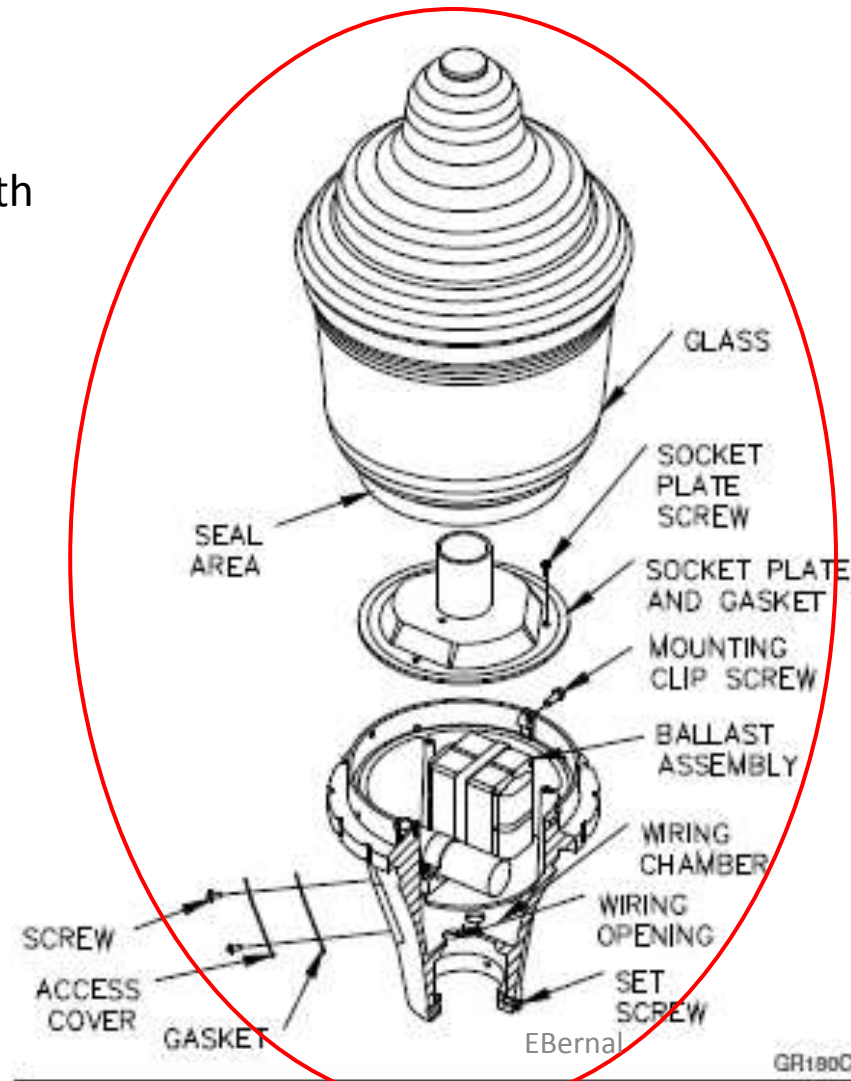
INSTALLATION INSTRUCTIONS



EBernal

Option 2 \$1505 per Arcadian pole

Replace entire luminaire with new UL approved LED one



UL Certification Mark for Luminaries






- Means that the luminary has been designed and manufactured with components that minimize the risk of electric shock or electrically originated fire hazard.
 - Wire insulation, electric sockets, other components
- Upon initial purchase of luminary, it insures that the product meets well defined safety standards, per above
- Irrelevant for modifications to existing luminaires modified by licensed electrician following the national electrical code NFPA 70

LED Conversion cost per pole (conservative) replace HPS70 with 45Watt LED in Arcadian Acorn and KIM fixtures

Item	Per FPA70(\$)	Per UL (\$)
LED bulb	80	80
Luminaire		1,325
Labor	100	100
TOTAL	180	1,505
TOTAL for 583 poles	105,000	877,000
Metering¹	180,000	116,000
Total with Metering	285,000	993,000

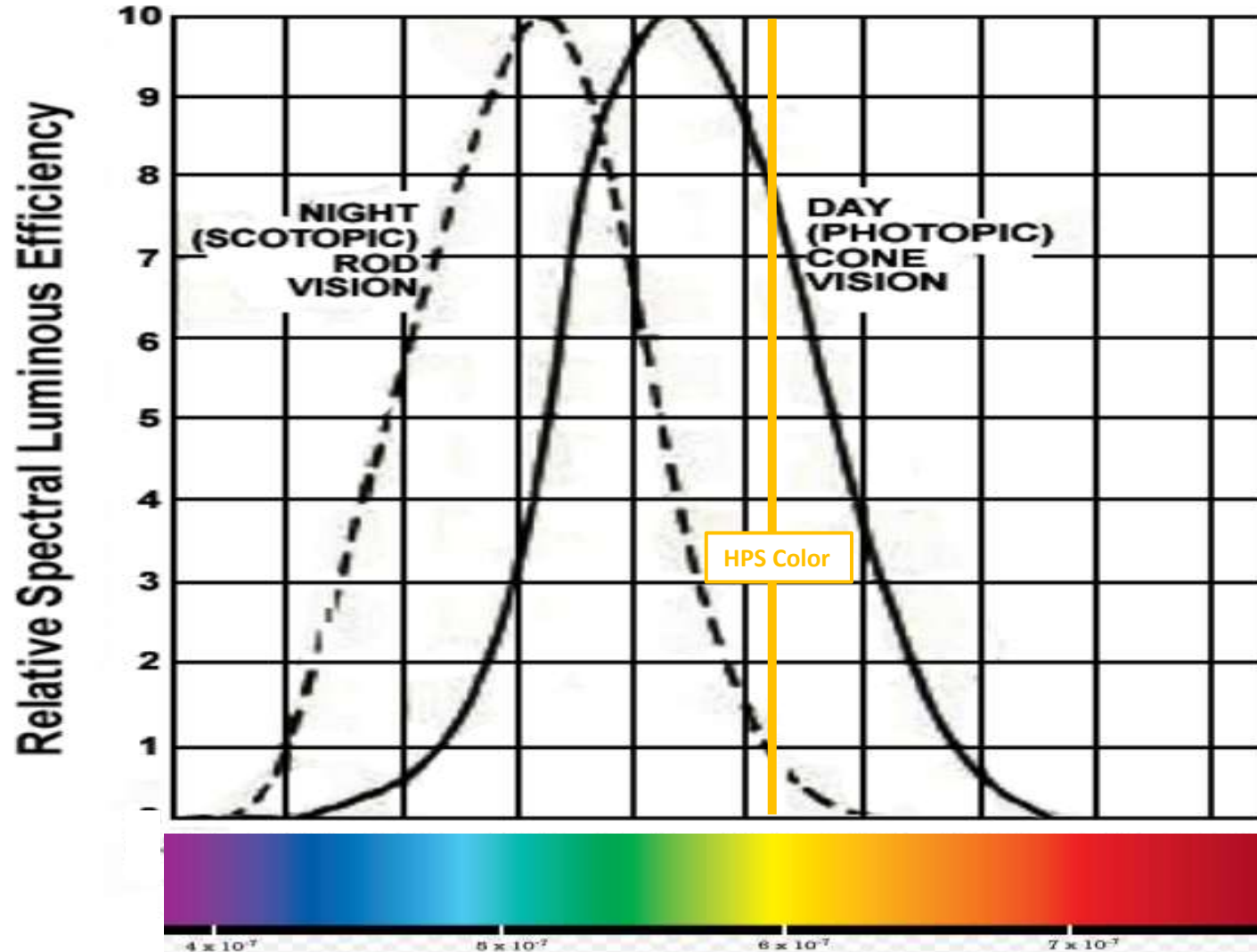
1. Assumes 1 FPL meter per 10 light poles, at average cost of \$3,000 installed cost per meter

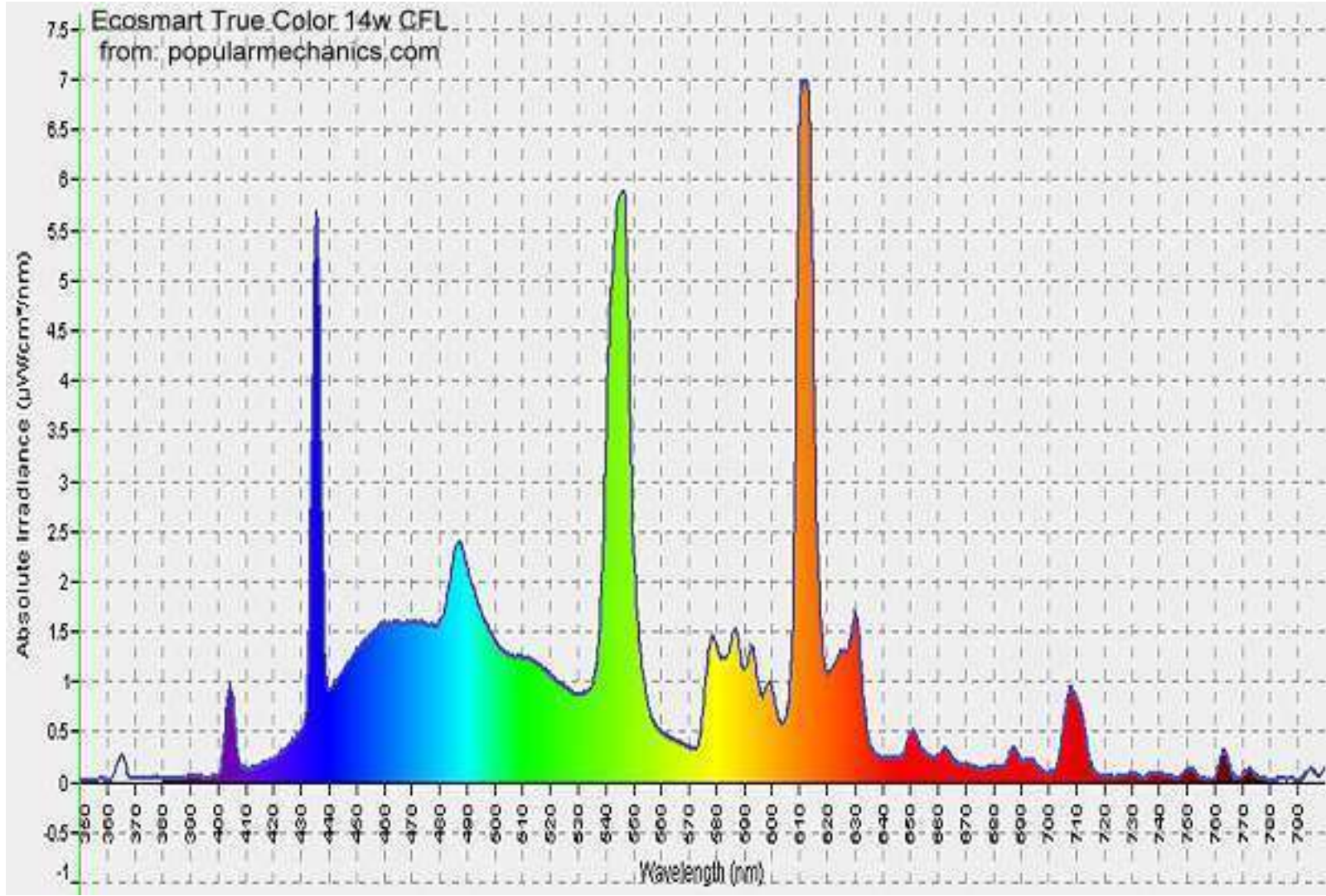
60 Watt Incandescent Bulb replacement

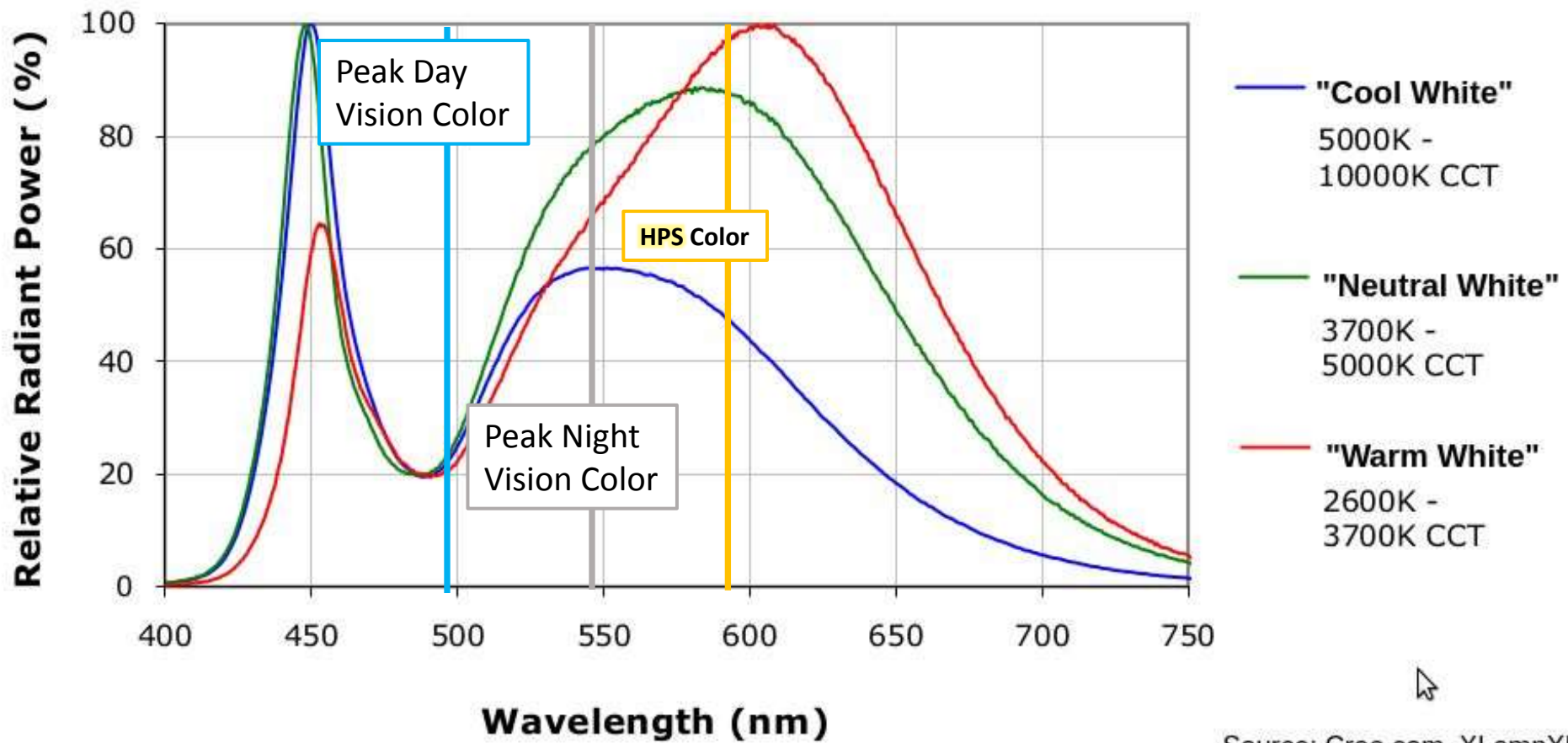
	standard incandescent	GE energy-efficient soft white	GE energy-efficient crystal clear	GE energy smart® CFL	GE energy smart® LED
					
Watts →	60	43	43	13	13
Lumens →	840	750	750	825	800
Life (years)† →	0.9	0.9	0.9	9.1	22.8
Estimated Annual Energy Cost** →	\$7.23	\$5.18	\$5.18	\$1.56	\$1.56
Annual Savings** →	\$0	\$2.05	\$2.05	\$5.67	\$5.67
	HOT – safety risk	HOT – safety risk	HOT – safety risk	Contains mercury	
	Annual replacement	Annual replacement	Annual replacement	10 yr	
6/22/2016			Ebernal		

THE END

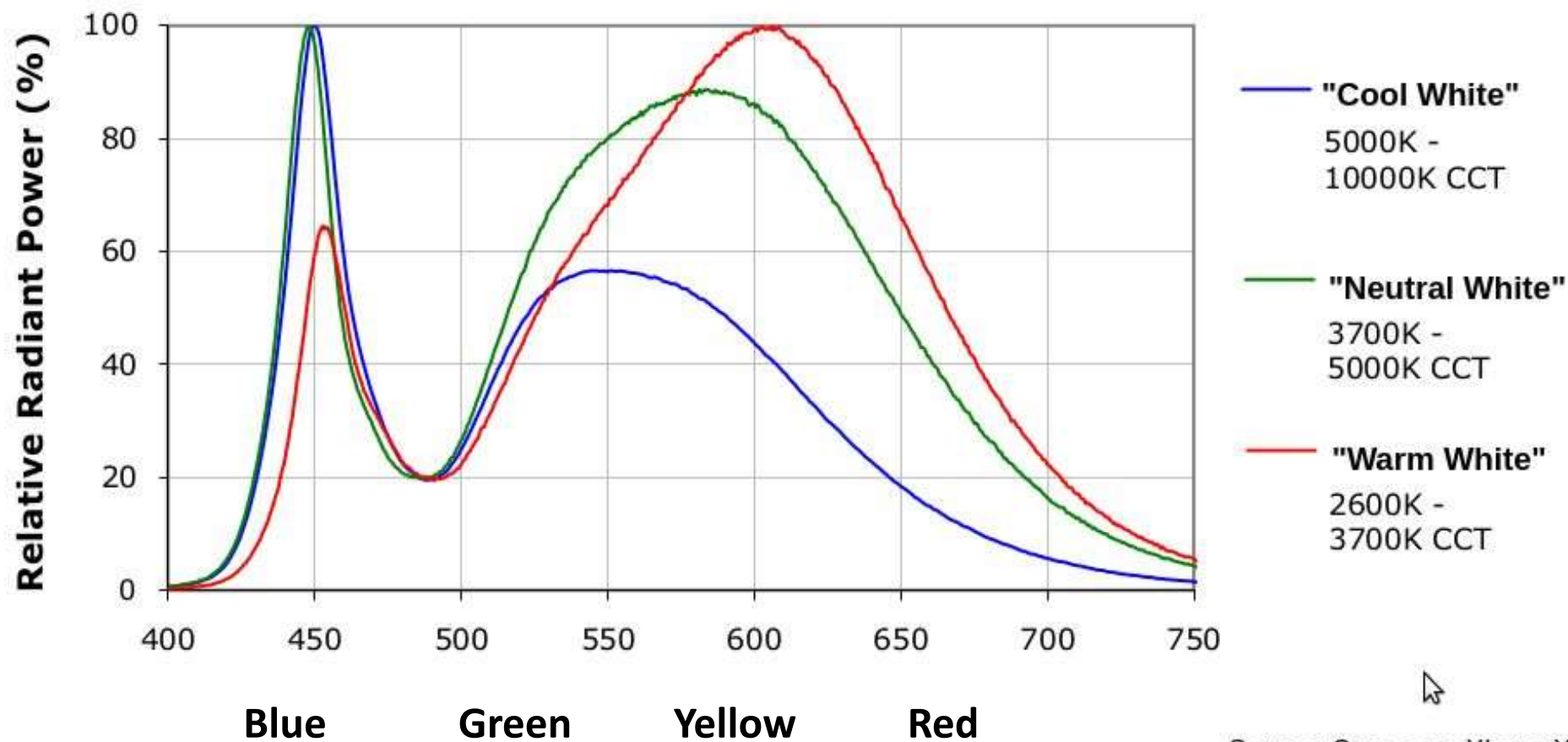
Human Night Vision poorly matched to HPS lighting







Source: Cree.com, XLampXPE



Source: Cree.com, XLampXPE

Applicable Compliance Standards

- **UL 1598**

- Standard for Luminaires Edition: 3rd
Underwriters Laboratories / 17-Sep-2008 / 304 pages

- **UL 1598C 1st Edition, May 31, 2011**

- OUTLINE OF INVESTIGATION FOR LIGHT-EMITTING DIODE (LED) RETROFIT LUMINAIRE CONVERSION KITS

- Approved to UL1598C
- Use in enclosure
- High humidity
- Hor or vert installation



Luminoso CB45
UL approved LED
Corn Bulb

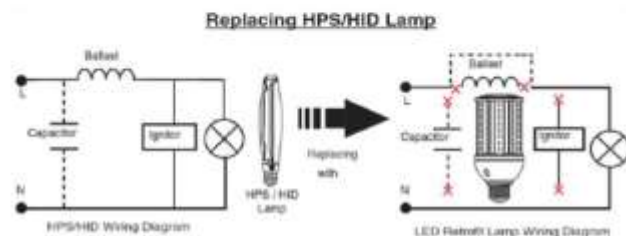
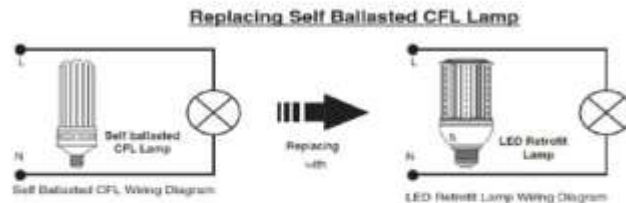
Luminoso CB45 UL Compliance

Impact & Heat Resistant Polycarbonate Housing
 Instant On at 100% Output; No Warm-Up Time
 Weight: 2.1 lbs
 Optimum Operating Temp: -4° - 149°F; Max Temp: 157°F
 Universal Burn Position
 Over 2X Operating Life of HID lamps
 3G Vibration Tested

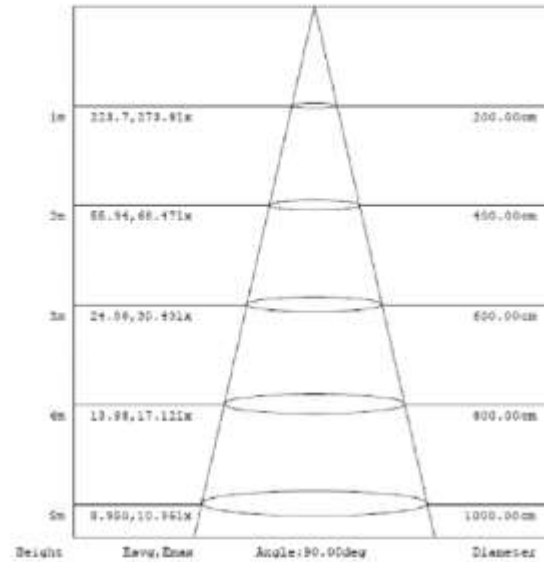
REGULATORY & VOLUNTARY QUALIFICATIONS

UL Listed	Yes
LM79 Report	Yes
Rated for Enclosed Fixture	Yes

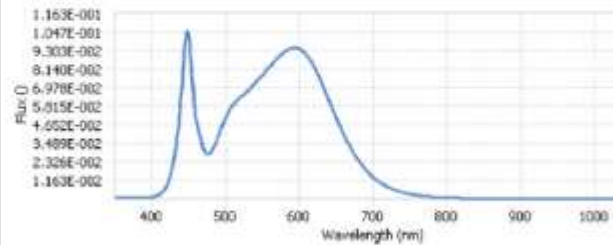
INSTALLATION INSTRUCTIONS



ILLUMINANCE PLOTS



SPECTRAL POWER DISTRIBUTION





S9393

45W/LED/HID/5000K/100-277V/EX39
 45 watt - LED HID Replacement; 5000K; Mogul extended base;
 100-277 volts

Features

- High Lumen Omni-directional LED for Industrial / Commercial applications
- Replaces HID, CFL, and Incandescent
- Ballast by-pass - Direct wire only 100V - 277V
- UL approved for totally enclosed fixtures
- Damp location - IP65 rated
- DLC approved
- Base up, base down or horizontal operation
- Emits no UV light / Contains no mercury (Hg)
- 5 year limited warranty
- Classified under UL 1598C

Additional Technical Specifications

- Power Factor >0.9
- Min Starting Temp -20°C
- Max Starting Temp 65°C
- Operating Frequency 50-60Hz
- Working Voltage AC90-305V

Optional accessory: In-line surge protector [80-929](#)



S9393

Item Number	Product Line	UPC	Input Voltage	Watts	Incandescent Equivalent	Fluorescent Equivalent	HID Equivalent
S9393	Hi-Pro	045923093937	100 - 277	45	300W	65W	175W
Base	ANSI Base	Lamp Code	Dimmable/Non-Dimmable	Finish	MOL In Inches	MOD In Inches	Initial Lumens
Mogul Extended	EX39	45W/LED/HID/5000K/100-277V/EX39	Non-Dimmable	White	10 3/4"	3.69"	5400
Average Rated Hours	Kelvin Temp	Color	CRI	Beam Spread Deg	Pack	Package Type	RoHS Compliant
50000	5000	Natural Light	80+	300	12	Box	Yes
UL or ETL Listed	UL Classification	Warranty					
Yes	cULus - Damp Location Rated	5 Year Limited					

2016 Budget for LED Conversion

- \$912K (?)
- Language of resolution or budget line item restricted to “street lights”, or City owned lights?



AECOM
Recommendation + EB Cc