



Lighting Design Lab

LEDs:
A closer look

Eric Strandberg, LC

AP photo
Anil Duggal, who heads up GE Global Research's Organic Electronics Project



Our Sponsors





Our goal is to promote
energy efficiency through
quality design

**Energy *effective* practice that is better
than standard practice!**



What is an LED?

» **Light Emitting
Diode**

» Color

» White





LED for beacons and signals



Questions to ask about LEDs

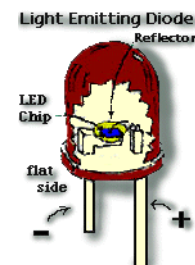
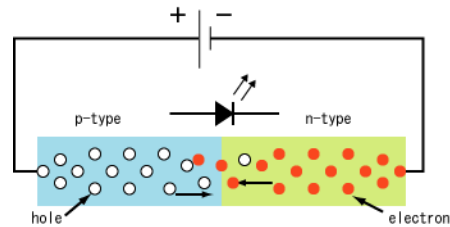
- » **How much light do I get (lumens or FC)**
- » **How much energy do I save**
- » **What is the light quality**
 - » Color temperature (CCT)
 - » Color rendering (CRI)
 - » Color consistency (binning)
- » **Do I save any money**





How do LEDs work?

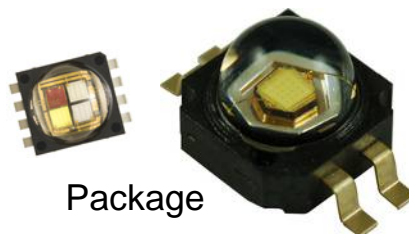
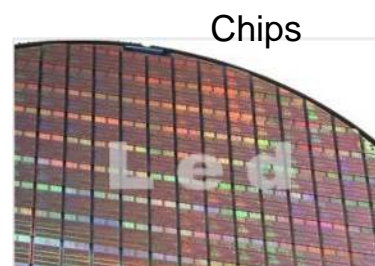
» Like a normal diode, the LED consists of a chip of semiconducting material impregnated, or doped, with impurities to create a p-n junction.



LED basic components

» LED chips are made of silicone (like computer chips), and then mounted in a “package” that has electrical leads and sometimes heat sinking.

» Just because the chips are high quality, does not guarantee that it is in a high quality package





Heat management

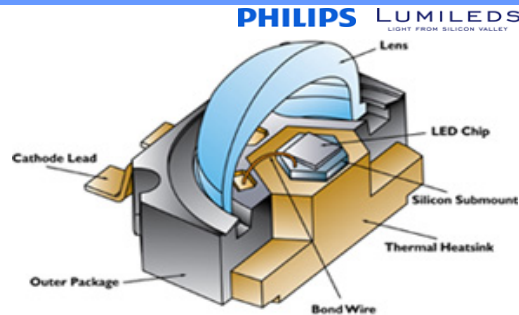


» **Getting heat away from the junction is critical to LED performance;**

» *Life*

» *Light output*

» **The package is then attached to a heat sink, that then becomes a part of; either a “lamp” or a luminaire**



Managing heat in power LED systems for optimal performance

When designing a solid-state solution with power LEDs, **one cannot underestimate the importance of the thermal system design**, as encapsulated in the phrase “Think Thermal First”.

-Rudi Hechfellner, Technical Marketing Manager
Philips Lumileds Lighting Company



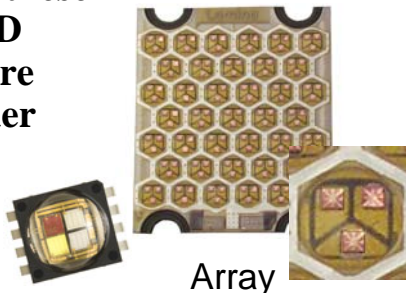
LED basic components

» **The package then becomes either a “lamp”, an “array” or a luminaire.**

» **Definitions of these and other LED components are currently under review**



Lamp



Array

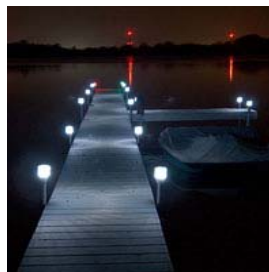
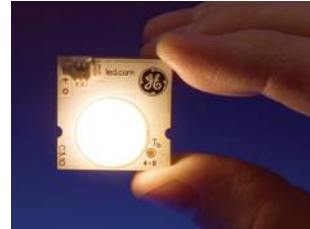


Luminaire



Leds are small...

» Which can make for small sized fixtures... and potential problems with heat dissipation

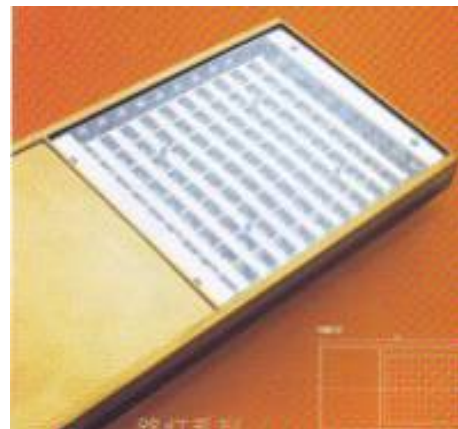


Heat management

» If the fixture/ lamp is too small, and/or the power is too high, then over heating can occur.



16 watt



120 – 140 watt



» **Lumens/watt can be reduced at a # of points:**

- » Chip has X lumens/watt
- » Package has less
- » Powersupply = less still
- » Luminaire = still lower l/w than the original chip.



100 lumens/ watt



40 lumens/ watt



What does the product replace?



- » **7watt – 250 lumens -40 lm/w**
- » **35,000 hrs**
- » **23K – 27K CCT**

25 watt incandescent = 215 lumens



What are you replacing?

Halogen Inc.

60 watts

800 lumens

3,000 hrs



CFL

15 watts

950 lumens

10,000 hrs

LED*

12 watts

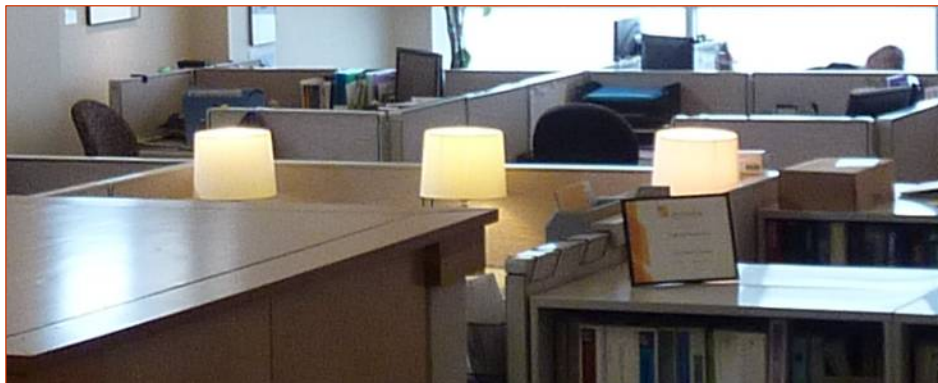
810 lumens

25,000 hrs

*Sylvania Ultra A



Which one is the 60 watt incandescent?
12 watt LED?





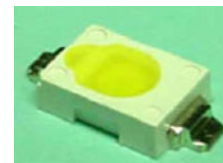
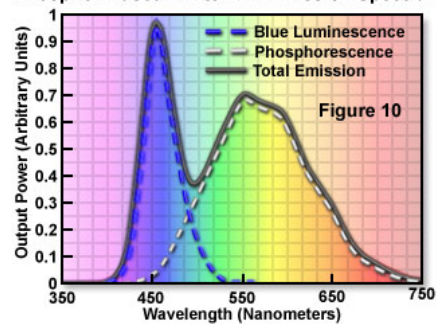
Which is the 50 watt halogen?
12 watt LED?



"White" LEDs

» **White light LEDs**
are generally
made by taking a
blue LED and
"doping" it with
yellow phosphors

Phosphor-Based White LED Emission Spectrum





LEDs & color

» If what you are expecting is like incandescent, (2700 to 3000 Kelvins), then you may be somewhat disappointed. They don't usually come that warm*.



3,000 K



4,000 K



6,000 K

*Warmer color has lower efficacy.



LEDs and color



Photo courtesy BetaLed

The cool color looks like metal halide, (or "moonlight") which can make them a good fit for exterior applications*.

Note the yellow HPS on right and the bluer LED on the left.

*Recent studies suggest that blue light can effect melatonin production...





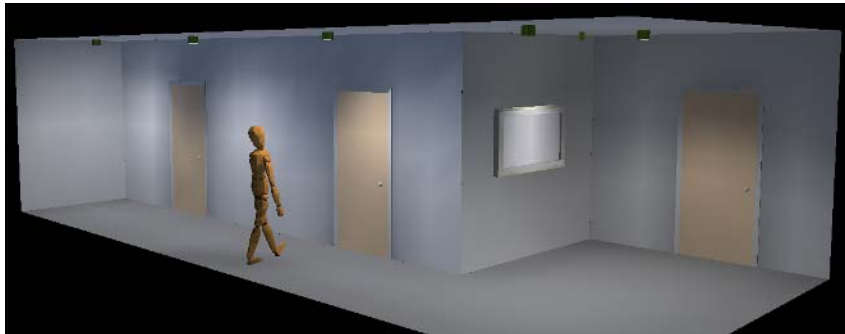
Applications

- » **“A” Lamp**
- » **Recessed**
 - » Par
- » **Outdoor**
 - » Parking
- » **LED “MR16”**



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LED Corridor Test Simulations

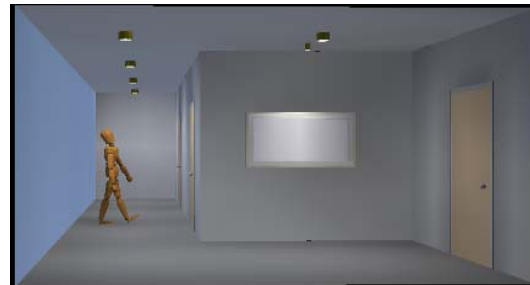
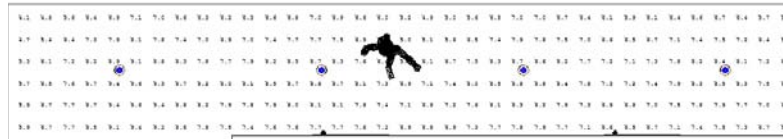




The basic model

The corridor in the simulation is 6' wide and 35' long, with a 10' wide entry and 9' ceiling.

Reflectances are (80/50/20). All simulations use 5 fixtures in the same locations, except where indicated



Area = 300.00 Sq Ft
Total Watts = 350
Lighting Power Density = 1.167 Watts/Sq Ft

**Foot candles are based on initial lumens in all cases as LED files do not include mean lumens. Appropriate light loss factor can be applied.

All simulations done w/ AGI32 software and manufacturer supplied photometric files as of 4/2009



LED-E

DESIGN FEATURES

Exceeds the light output and distribution of a 65W BR30 incandescent lamp or an 18W compact fluorescent luminaire (lamp and reflector trim), while consuming less than 14 watts.



Average= 6.7
Max= 9.2
Min= 3.2
Max/Min= 2.9

14.7 watts

Average= 7.0
Max= 9.6
Min= 3.1
Max/Min= 3.1

65 watt BR30

Average= 8.4
Max= 11.4
Min= 3.9
Max/Min= 2.9

CFL-18
(19 watt)

Average= 9.9
Max= 13.6
Min= 4.2
Max/Min= 3.2

CFL-18
(19.3 watt)

Does it save electricity? Yes, but, lower light levels.



LED-A

LED Lighting Solutions

Hallway

	6' Spacing		8' Spacing		10' Spacing	
	Workplane Illuminance	Wall Illuminance	Workplane Illuminance	Wall Illuminance	Workplane Illuminance	Wall Illuminance
LR6	12.6	6.8	9.6	5.2	7.6	4.0
65W BR30 White Baffle	12.0	5.3	9.1	4.0	7.2	3.2
18W CFL White Baffle	13.0	6.6	10.1	5.1	7.9	4.0
50W PAR30 White Baffle	14.6	3.1	11.2	2.6	9.1	1.8

Notes:

Average initial illuminance in footcandles, reflectances = 80/50/30, workplane height = 2.5', ceiling height = 9', Six lights per hall, width = 6'



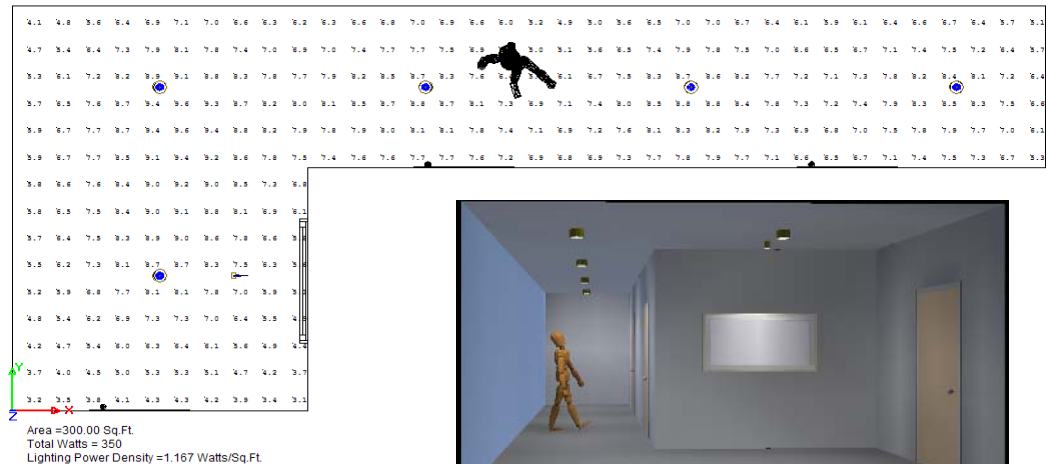
LED-A

Average= 5.8
Max= 7.5
Min= 3.0
Max/Min= 2.5

Average= 7.0
Max= 9.6
Min= 3.1
Max/Min= 3.1



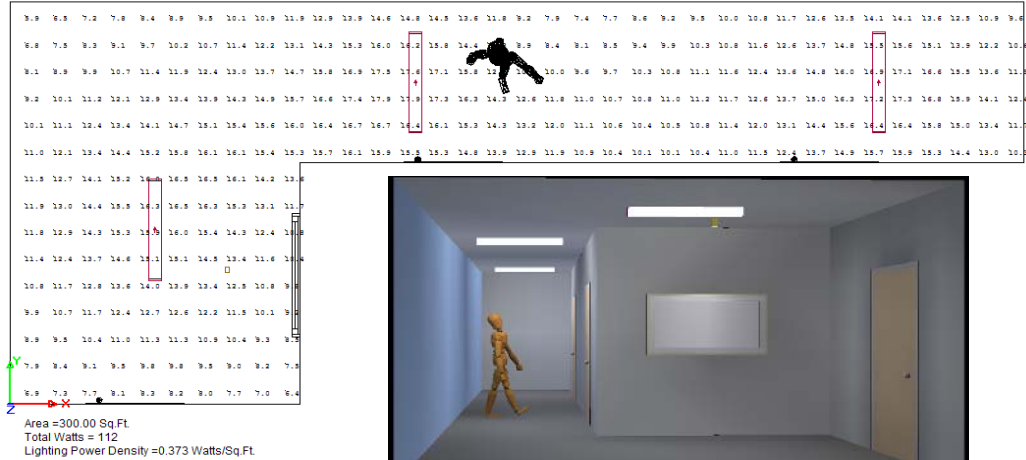
BR30 - 65 watt





Committed to energy savings
while holding light levels?
48" (1 x 4) 28 watt (29)

Average= 12.5
Max= 18
Min= 5.9
Max/Min= 3.0



The results

*Total wattage includes a 25 watt LV halogen accent light in all simulations.

**Foot candles are based on initial lumens in all cases as LED files do not include mean lumens. Appropriate light loss factor can be applied.

Product/ Lamping	Watts per fixture	Total watts*	Average FC** on floor	Max FC	Min FC	Max to Min ratio
Incandescent BR30	65	350	7	9.6	3.1	3.1
CFL-18	19	120	8.4	11.4	3.9	2.9
CFL-18	19.3	121.5	9.9	13.6	4.2	3.2
CFL-26	28.6	168	11.7	16.5	5.8	2.8
LED-A	11.5	82.5 (94)	5.8 (6.97)	7.5	3.0	2.5
LED-B	25	150	8.3	10.9	4.2	2.6
LED-C	19.2	121 (102)	10.9 (9.1)	15.3	4.9	3.1 (4.1)
LED-D	13.4	92	6.6	9	3.4	2.7
LED-E	14.7	98.5	6.7	9.2	3.2	2.9
1x4 TS	29	112	12.5	18	5.9	3.0

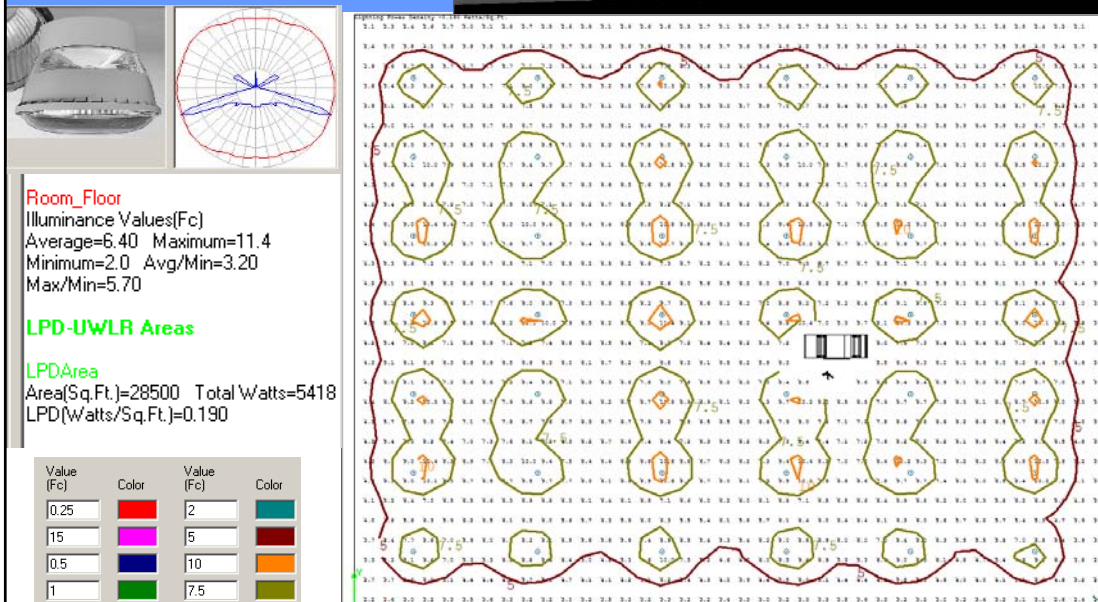
All simulations done w/ AGi32 software and manufacturer supplied photometric files.

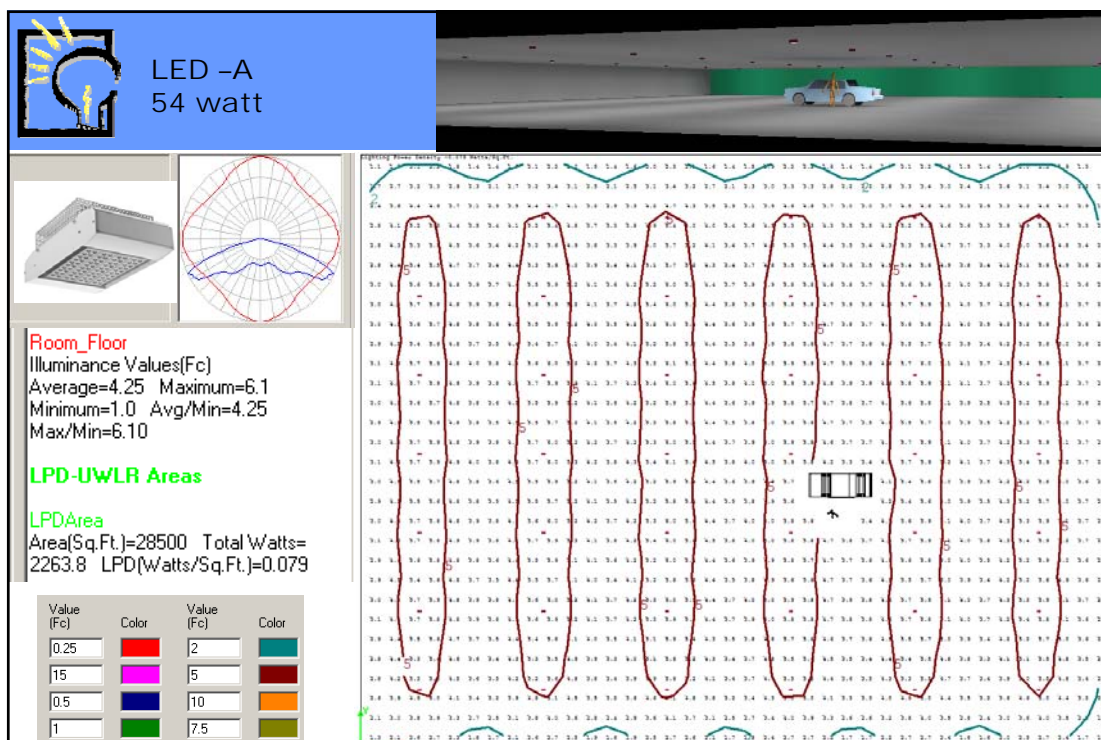
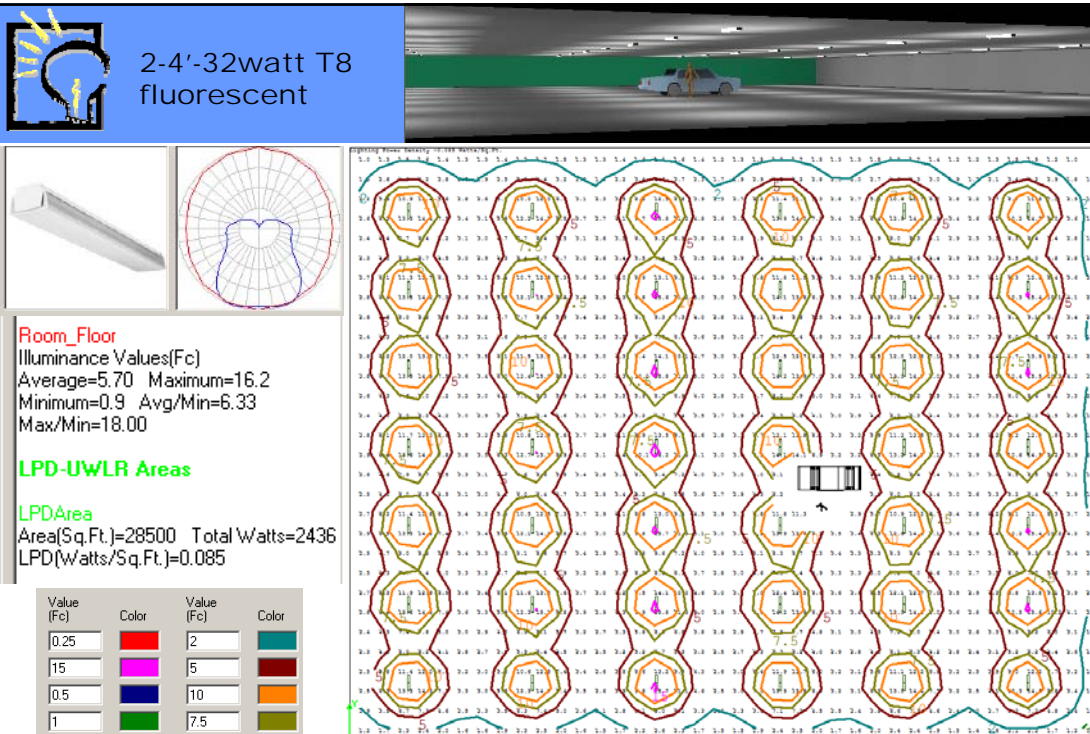


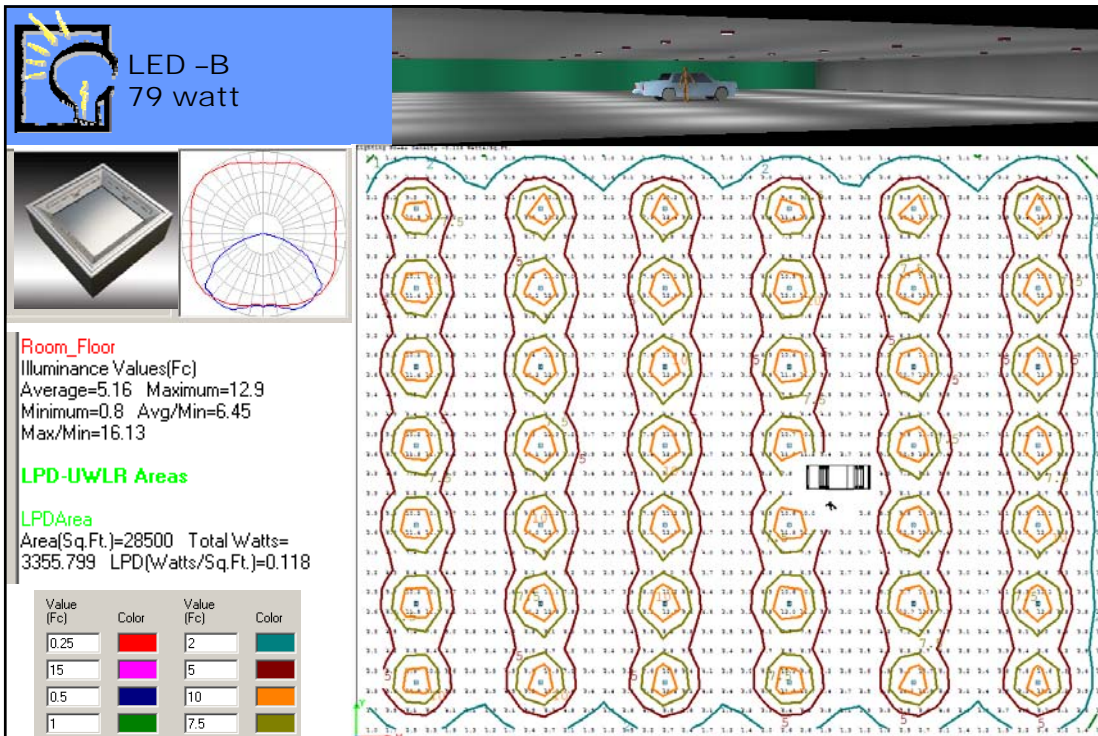
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100watt MH









Summary table.

Parking garage in the simulation is 190' wide and 150' long, with a 8' ceiling. Reflectances are (60/40/20). All simulations use 42 fixtures in the same locations,

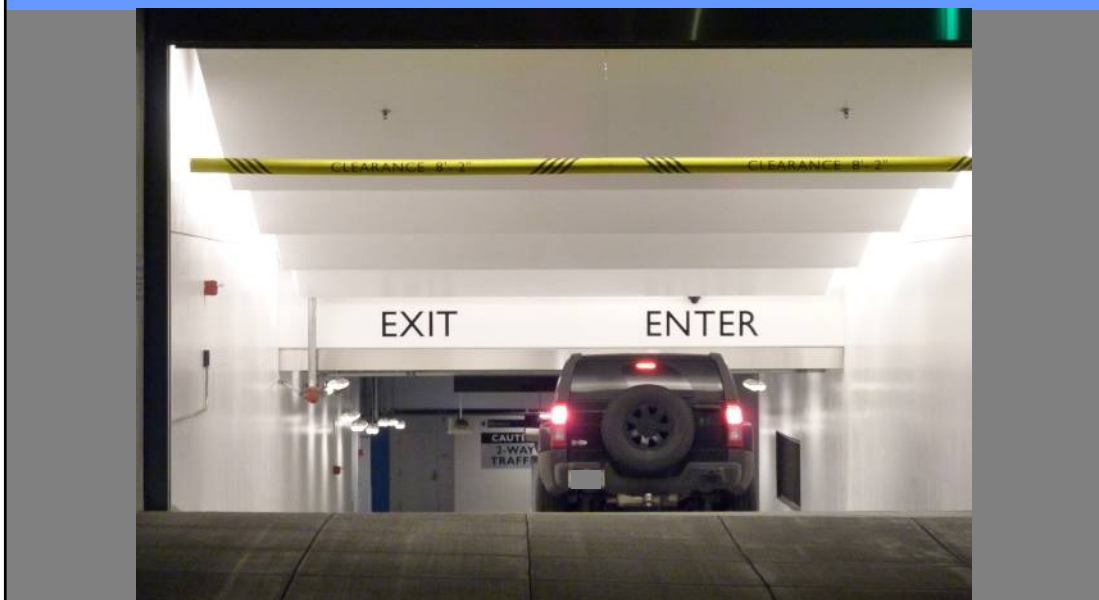
Product/ Lamping	Watts per fixture	Total watts*	Average FC** on floor	Max FC	Min FC	Max to Min ratio
100watt MH	129	5418 .19 w/sq'	6.4	11.4	2	5.7
LED-A	54	2264 .08 w/sq'	4.3	6.1	1.	6.1
LED-B	79	3355 .12	5.2	12.9	.8	16.1
Generic 8' strip 2- 32 watt T8	58	2436 .085 w/sq'	6.3	13.7	1.6	8.56

**Foot candles are initial lumens in all cases as LED files do not include mean lumens. Appropriate light loss factor can be applied.

All simulations done w/ AGI32 software and manufacturer supplied photometric files as of 6/2009



Parking with fluorescent





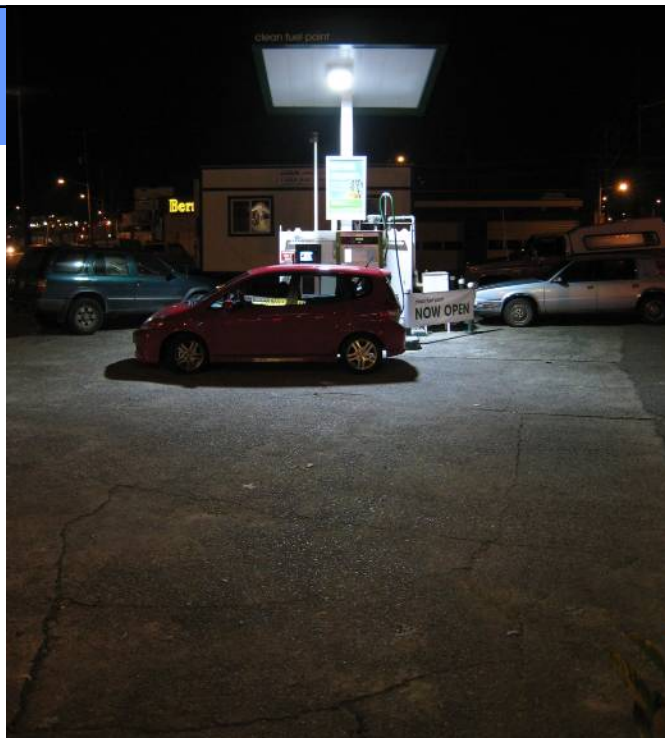
LED- exterior



About 90 watts



Could this
have been
done w/ T8
lamps for less
cost?



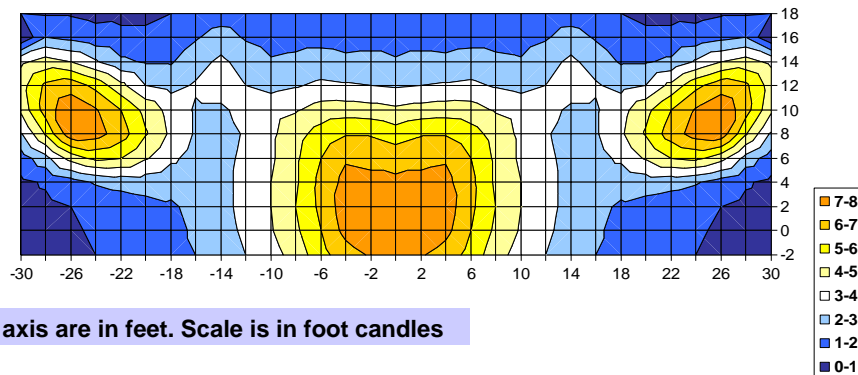


Baseline – 100 watt high pressure sodium “cobra head” street light



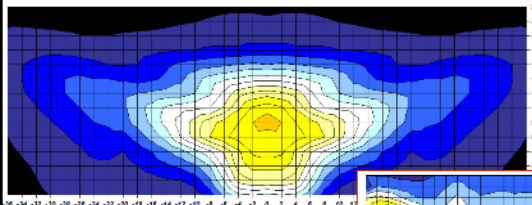
High Pressure Sodium @ 15ft

System Watts: 133

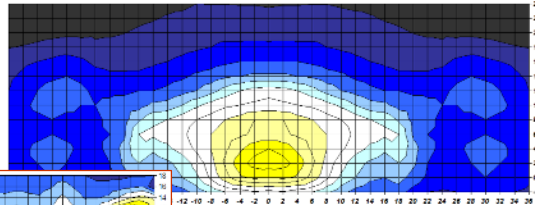


LED street lights and new MH

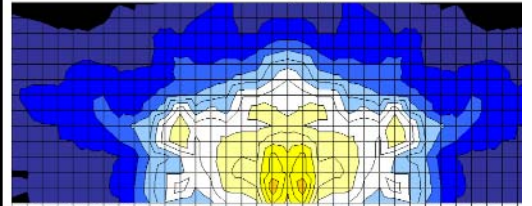
LED
System Watts: 53



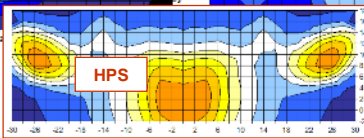
LED
System Watts: 69



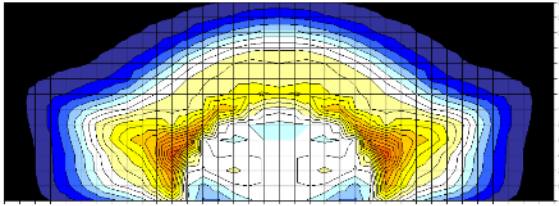
Metal Halide (77w)



HPS



LED
System Watts: 73.7





LED Streetlight testing at South Seattle Community College

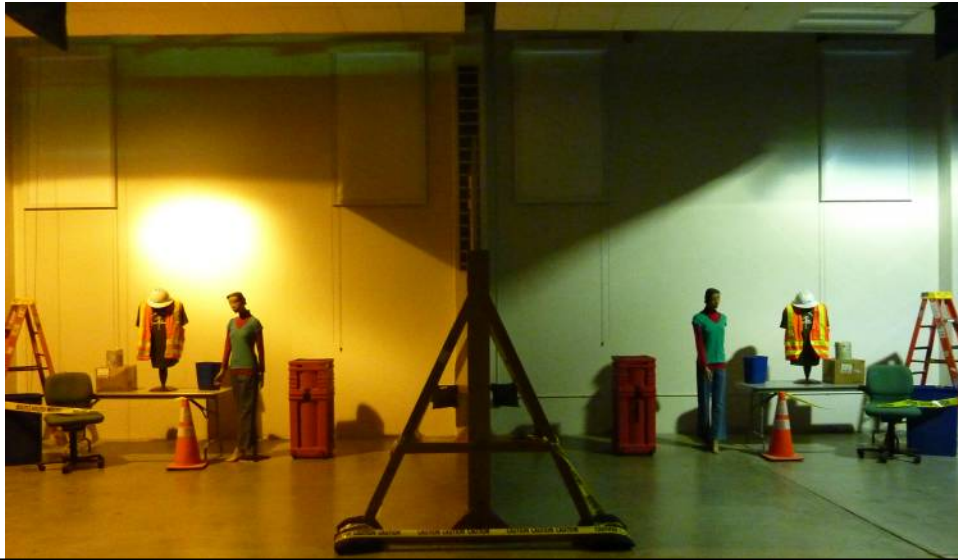


Night exterior testing site





LED vs HPS demonstration at LDL



Induction vs HPS at LDL June '05





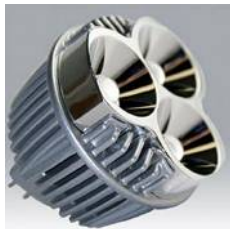
LED exterior evaluation w/ Seattle DOT



LED "MR16" lamps



Halogen lamp(s)





LED MR16 lamps compared to Halogen MR16 lamps

Product	Wattage	FC @0"	FC @6"	FC @12"	FC @18"	FC @24"	Rated Beam
LED-1	4	80	14	1.5	0	0	10 deg.
LED-2	7	52	45	27	12.5	9	
LED-3	5	13	12	11.5	8	7	
LED-4	8	33	33	21	11	6	NFL
Halogen IR	20	84	82	47	12	5	36 deg.
Halogen IR	35	295	202	65	11	9	24 deg.
Halogen	50	136	127	86	50	18	40 deg.

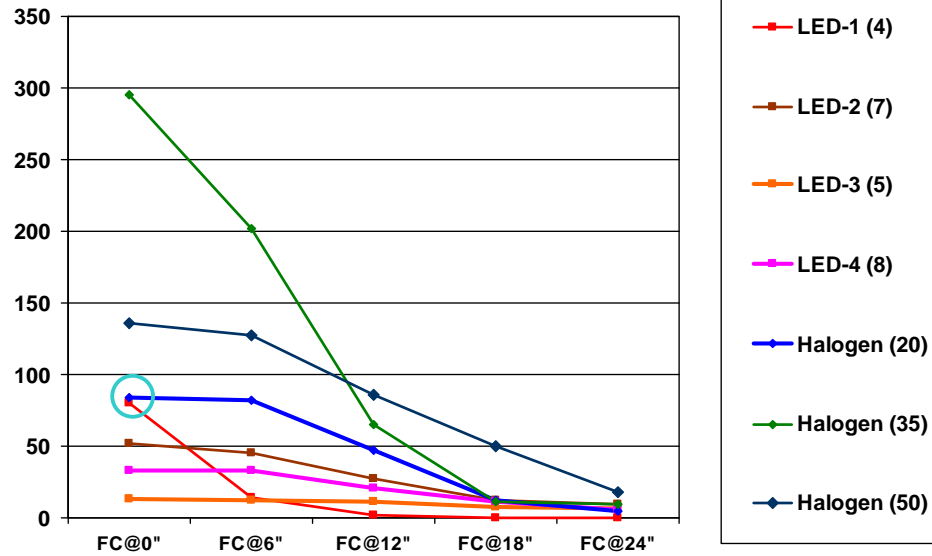


Claims for performance rarely match with measurements... or critical observations

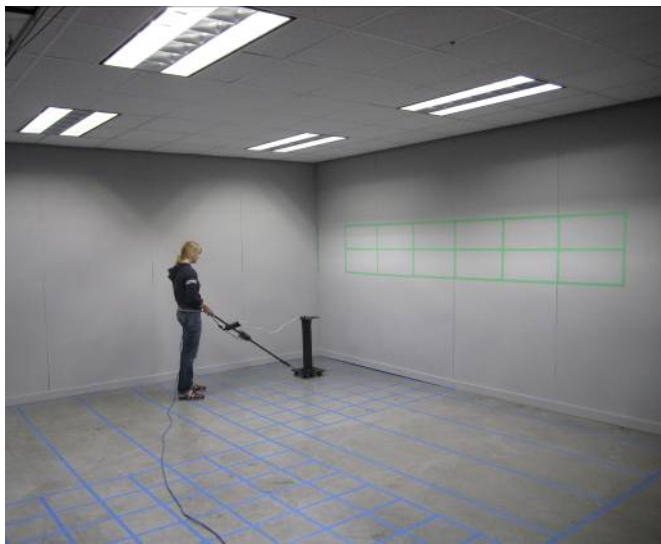
- »LED-1 (4 watts) “This is a X-\$ savings compared to a 20W MR16 halogen lamp”
- »LED-2 (7 watts) “Compare to a 40W halogen light output”
- »LED-4 (8 watts) “Output 20W halogen equivalent”



LED MR16 lamps compared to Halogen MR16 lamps



LED T8 data gathering for PNNL





Manufacturers product credibility.

» **Are there credible testing methods used for the product you are considering?**



» **LM-79-08 Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products**

» **LM-80-08 Approved Method: Measuring Lumen Depreciation of LED Light Source**



www.ies.org/shop/



How long do LEDs last?

» **When the lumens depreciate past a certain point?**

» **When a component fails?**

» Driver

» Lens

» Wiring

» **What is under warranty & by who?**





LEDs last a long time... until they don't.



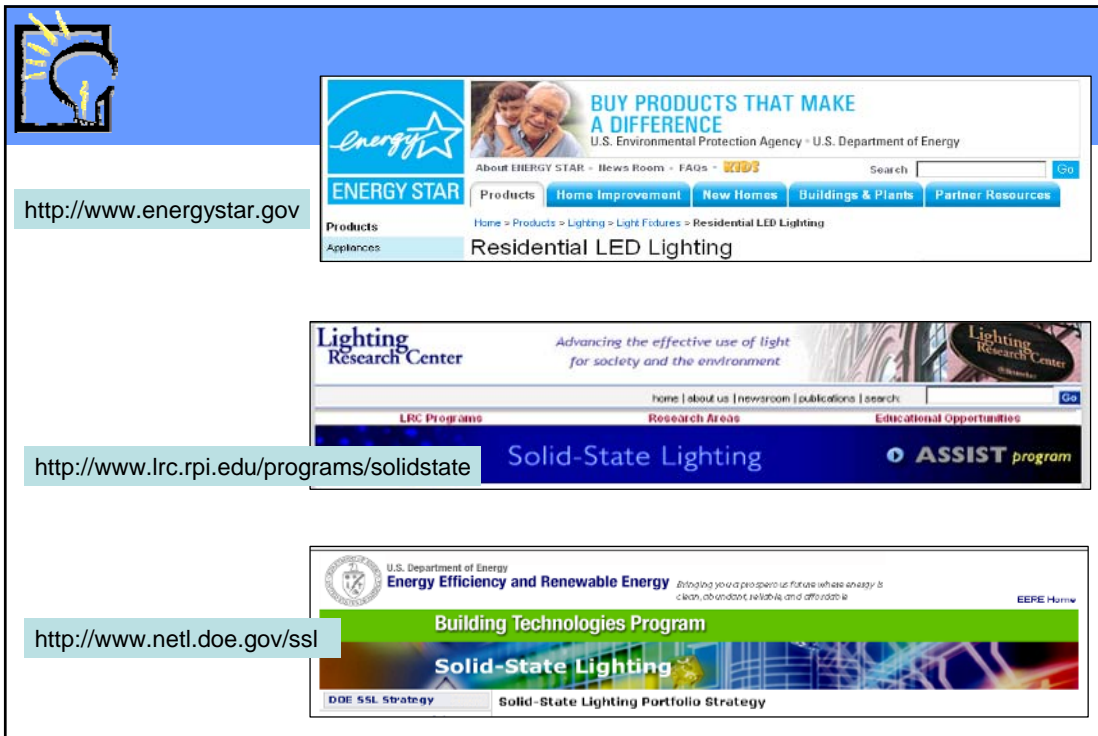
Someone says: "I want to use LEDs!"

» **Ask what their goal is.**

- » Saving energy?
- » Saving money?
- » Better lighting?
- » Being "Green"
- » Using the "Latest"



What is the embodied energy in this product?





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