What's New?
Lamps, Ballasts, LED

Presented by:

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Specification Engineer

GE Lighting

Legislation

2009 DOE Regulatory Update - Fluorescent

Summary: Linear T12, T8 and T5, and U-bend lamps regulated.
Effective date: July 14, 2012
2 foot-U, 4 foot and 8 foot lamps must meet minimum INITIAL LPW requirements.
Lamps above 4500K have a slightly lower standard.

Lamp	Requirement	Impact
4 foot fluorescent >= 25W Medium Bipin (T12 & T8)	89 LPW if 4500K or below 88 LPW if > 4500K (Up to 7000K)	• All Standard 4' T12 lamps are eliminated F32 minimum 2850 lumens: • Standard SP lamps at 2800 lumens don't meet standards • Current F32/SPX, High Lumen, F30, F28 & 25W meet standard
8 foot fluorescent (Slimline) >= 52W (T12 and T8)	97 LPW if 4500K or below 93 LPW if > 4500K (Up to 7000K)	• Generally, 8' T8 lamps meet standard • Most T12 lamps eliminated except 60W SPX/WM T12
8 foot HO fluorescent Both T12 HO and T8 HO Cold Temp lamps exempt	92 LPW if 4500K or below 88 LPW if > 4500K (Up to 7000K)	• Many 8ft T12 HO eliminated (Both 110W nominal and 95W nominal) • 8' T8 HO lamps meet standard • Cold Temperature Lamps are Exempt
2 foot U-lamps >= 25W Includes 6", 3" and 1-5/8" spacing (T12 and T8)	84 LPW if 4500K or below 81 LPW if > 4500K (Up to 7000K)	• All T12 2 ft. U-lamps are eliminated • T8 U-Bend Standard SP lamps are eliminated • Only a few T8 SPX U-bend lamps will meet standard
4 ft. T5 Lamps >= 26W (T5 HE lamps)	86 LPW if 4500K or below 81 LPW if > 4500K (Up to 7000K	• All T5 HE lamps meet standard (This regulation prevents manufacture of inexpensive T5 CW lamps)
4 ft. T5 HO Lamps >= 49W (T5 HO Lamps)	76 LPW if 4500K or below 72 LPW if > 4500K (Up to 7000K	• All T5 HO lamps meet standard (This regulation prevents manufacture of inexpensive T5 HO CW lamps)

2009 DOE Regulatory Update

Halogen Lamp Calculator

Summary: Halogen PAR lamps including PAR38, PAR30 and PAR20 within the 40 – 205 watt range are being regulated by minimum Lumen per Watt (LPW) standards.

Effective date: July 14, 2012

Impact: Standard PAR Halogen lamps in all categories are eliminated.
GE PAR Halogen IR Plus lamps meet standard.
HIR PAR lamps are borderline, some current products pass, others fail narrowly.
None of the existing PAR20 lamps meet the requirement. Redesign required.
All 130V lamps are likely to be eliminated.

Par Lamp Lumen per Watt (LPW) Standard will vary by lamp diameter, voltage and wattage

Minimum LPW Examples:

- **Standard PAR38, 120V: LPW Standard = 5.9 X P(E.27) (P=Lamp Wattage)**
- **60Watt PAR38: LPW = 5.9 X 60(E.27) = 17.8 Lumens Per Watt**

General Purpose Incandescent Standards

Current Wattage	Max Rated Wattage	Lumen Range	Minimum Life (hrs)	Effective Date
100W	72W	1490-2600	1,000	1/1/2012
75W	53W	1050-1489	1,000	1/1/2013
60W	43W	750-1049	1,000	1/1/2014
40W	29W	310-749	1,000	1/1/2014

- Lumen range reduced 25% for Neodymium (Altered Spectrum)
- Lamps must be manufactured on or before effective date
- CA & NV can adopt 1 year earlier – Other states preempted

What does the new legislation effective July 2012 mean for Halogen PARs?

- Impacts **ALL** Glass Halogen Large and Compact PARs, specifically:
  - PAR20, PAR30, PAR30 Long Neck and PAR38 40w and above
  - Cannot produce after July 14, 2012

- Eliminates **ALL** 130v halogen Large and Compact PARs

- Today's HIR will be the only technology that meets the specs

HIR Plus

– High Efficiency Halogen

PAR38 Product	Wattage	Lumens	Life	LPW
Incandescent	85 W	930	2000	10.9
Halogen Plus	75 W	1030	2500	13.8
Halogen-IR	60 W	1050	3000	17.5
HIR+	55W	1120	4200	20.4
HIR+	48W	970	4200	20.2

Lower Watts and Longer Life mean Lower Operating Cost

NPI PAR

Specialty Exemptions

- Appliance lamps, sold at retail, not exceeding 40W
- Vibration Service Lamps sold at retail not exceeding 60W, packaged at 2 lamps or less.
- Black Light, Infrared Lamp, Silver Bowl
- Bug Light, Colored Lamps, Plant Light
- Sign, Left-Hand Thread
- 3-Way, Traffic Signal, Rough Service
- Mine Service, Marine Service





ANSI/IES/ASHRAE 90.1 2010 Whole Building Ltg. Power Densities

2007 Watts/Sq. Ft.:		**2010 Watts/Sq. Ft.:**	
• Office Buildings:	1.0	• 0.9	-10%
• Schools:	1.2	• 0.99	-17%
• Hospitals:	1.20	• 1.21	+0.8%
• Warehouses:	0.80	• 0.66	-17.5%
• Dormitories:	1.0	• 0.61	-39%

Source: Willard Warren, PE, FIES, *LD+A*, June, 2010, p. 21

Trends

Trends in Lighting

Compatibility with the architecture

Increased energy efficiency

More indirect lighting

Integration with daylighting

Improved lighting controls

Installation of cooler-color light sources

Fluorescent vs. HID in high-bay applications

More Trends in Lighting

Fluorescent and ceramic metal halide products with enhanced color qualities

Lighting designed for the aging eye

“Responsible” outdoor lighting

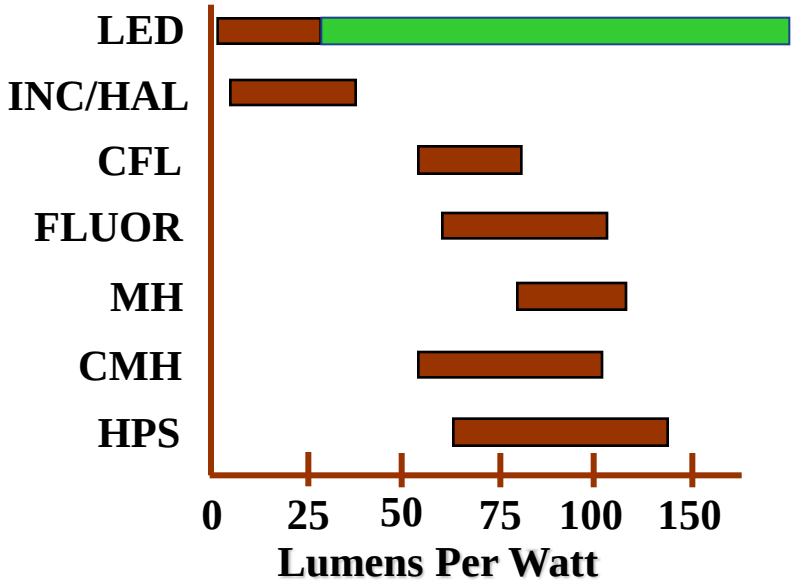
Lighting for safety and security

Theatrical/dynamic lighting effects

Increased use of LED lighting

Lamp Type Energy Efficiency

Today's lighting systems combine increased energy efficiency, enhanced color quality, and longer life.



Lamps

Compact Fluorescent Lamps

Energy Usage:

They typically consume only 1/4th the wattage of the Incandescent lamp they replace

26-watt CFL

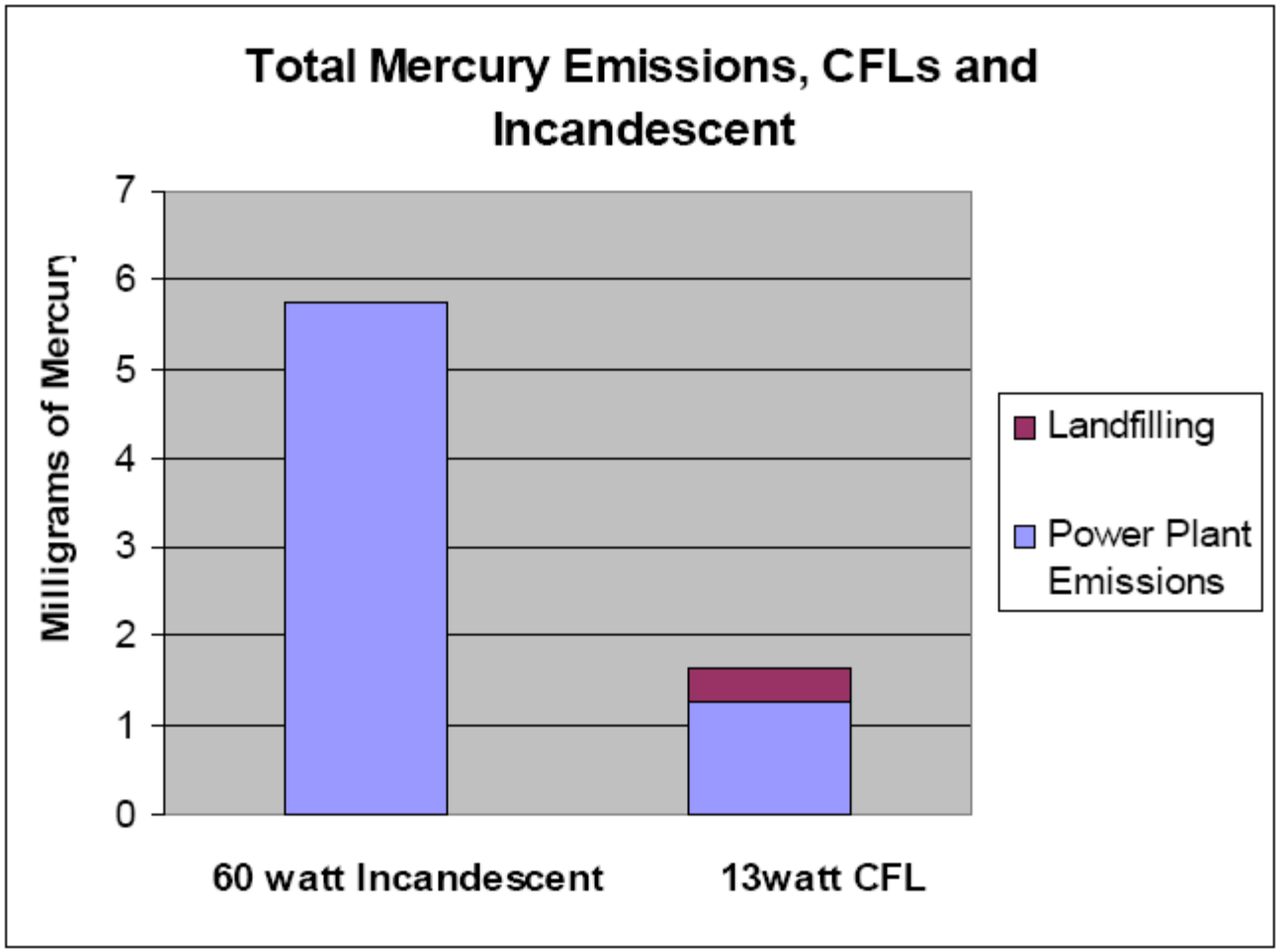
Replaces

100-watt Incandescent

Lamp Life

They last 10 to 20 times longer than Incandescent

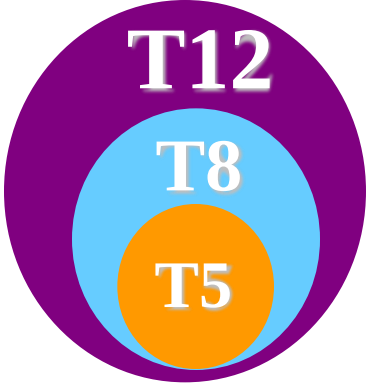
1 = 10+



8000 hours

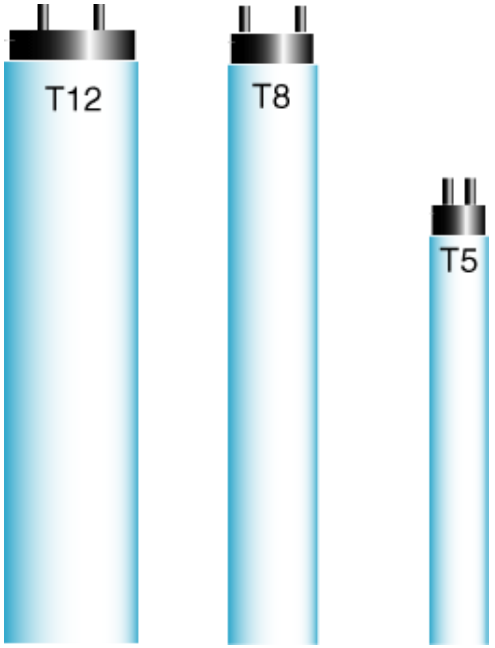
Total Mercury Emissions

Lamp Nomenclature

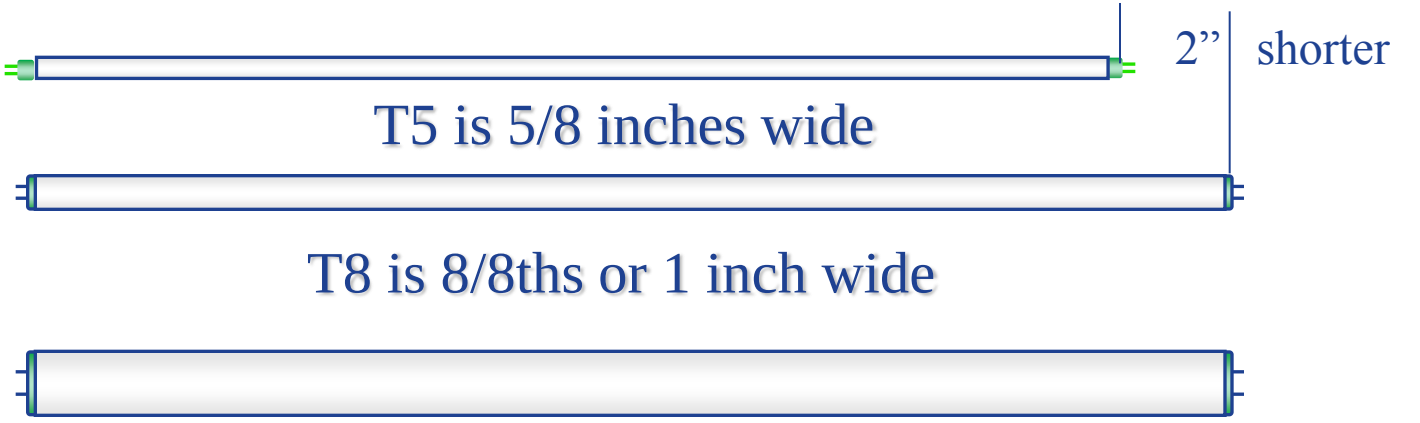


- Smaller diameters
- Increasing lamp/ballast system efficiencies
- Long life/extra long-life
- Better CRI and more colors
- Reduced mercury designs

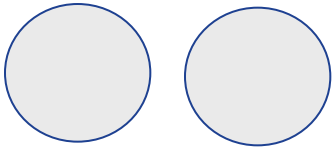
Medium Bipin



Miniature Bipin



Comparison of Lamp Types

Lamp Type		Lumen Output	Lumens per watt	Material Content
2 x T12		100%	70 -72	100%
2 x T8		98%	80 - 95	67%
2 x T5		100%	80 - 90	42%
1 x T5 HO		87%	80 - 85	21%

High Output Watt Miser ® Lamps

F54T5/WM = 51-Watt Lamp

Save 5% energy per lamp vs. standard F54T5 lamp!

Customer/Application Need

- Provide energy saving lamp for high-bay retrofits
- Maintain lumen output
- Improve lumens/watt
- Maintain long T5 lamp life

Lamp Specification

- 51W T5 High Output lamp
- 5000 initial lumens (same as current 54W lamp)
- 98 initial lumens/watt
- 25,000 hr rated life

SKUs: F54T5/830/WM/ECO
F54T5/835/WM/ECO
F54T5/841/WM/ECO
F54T5/850/WM/ECO
F54T5/865/WM/ECO

High Efficiency T5 Watt-Miser® Lamps

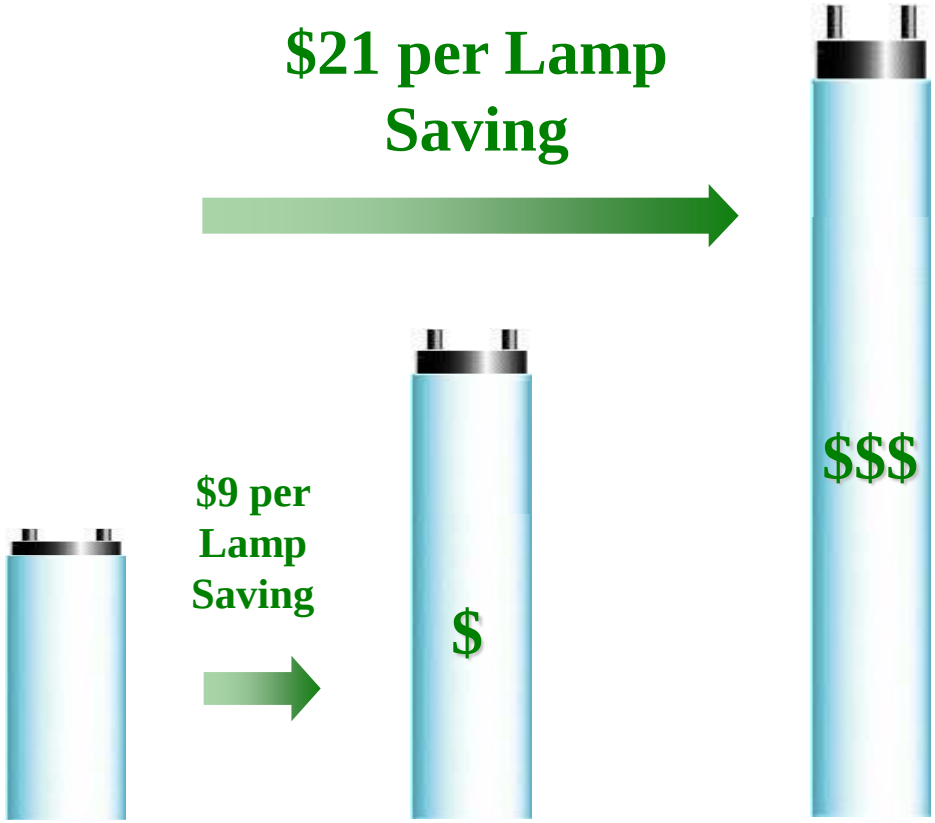
Save 5% energy per lamp versus standard High Efficiency lamps!

Customer/Application Need	Lamp Specification
• Provide energy saving lamp for T5 • Maintain lumen output • Improve lumens/watt • Maintain long T5 lamp life	• Save 5% on wattage by lamp type • Maintain current lumen output by lamp type • 25,000 hr rated life

SKUs:

F14T5/8xx/WM/ECO = 13W lamp 1350 lumens
F21T5/8xx/WM/ECO = 20W lamp 2100 lumens
F28T5/8xx/WM/ECO = 26W lamp 2900 lumens
F35T5/8xx/WM/ECO = 33W lamp 3650 lumens
F54T5/8xx/WM/ECO = 51W lamp 5000 lumens
All lamps offered in 3000K/3500K/4100K/5000K/6500K

T5 Energy Savings… T5 47W Watt Miser® Plus



Dec 2010

Watts:	54W	51W	47W
Light Output:	5,000	5,000	4,800
Life (3hrs/12hrs):	30K/36K	30K/36K	30K/36K

Assumptions: $.10 kwh, 30,000 hrs burn, Savings per one 54W T5 lamp

4’ T8 Options

Lamp Platforms:

- F32T8 HL “Super T8”
- F32T8 SP/700(78) & SPX/800(86)
- F32T8WM = 30W
- F28T8 = 28W
- F32/25T8 = 25W at 4’

T8 vs T5 Efficacy For Office Environment

Luminaire	# Lamps	Initial Lumens	Maintained Lumens	BF	LLF	Watts	# Fixtures Required	Footcandles	Watts/Ft Sq	Mean Lum/Watt
T5 Perforated Basket	2-51W	5000	4600	1.00	0.76	107	10	53.6	**1.34**	85.98
T5 Perforated Basket	2-28W	2900	2660	0.96	0.73	59	15	47.0	**1.11**	86.56
T8 Perforated Basket	3-32W	2950	2800	0.89	0.78	84	12	48.6	**1.26**	89.00
T8 Perforated Basket	3-32W	2950	2800	1.15	1.00	108	10	53.0	**1.35**	89.44
T8 Perforated Basket	3-28W	2725	2562	1.10	0.96	91	12	55.2	**1.37**	92.91
T8 Perforated Basket	3-28W	2725	2562	1.10	0.96	91	10	47.0	**1.14**	92.91
T8 Perforated Basket	3-32W	3100	2915	0.89	0.77	84	10	53.6	**1.05**	92.66
T8 Parabolic	3-32W	2950	2800	0.89	0.78	84	10	58.3	**1.05**	89.00
T8 Parabolic	3-32W	3100	2915	0.89	0.77	84	8	49.0	**0.84**	92.66

Design based on the number of fixtures required to provide 50 footcandles at a 2.5' workplan. Room dimensions 40' x 20' x 9'.

Based on ambient temperature of 77 deg.

The Most Efficacious System? **Typically the T8 lamp is more efficient but it does depend on the lamp/ballast system.**

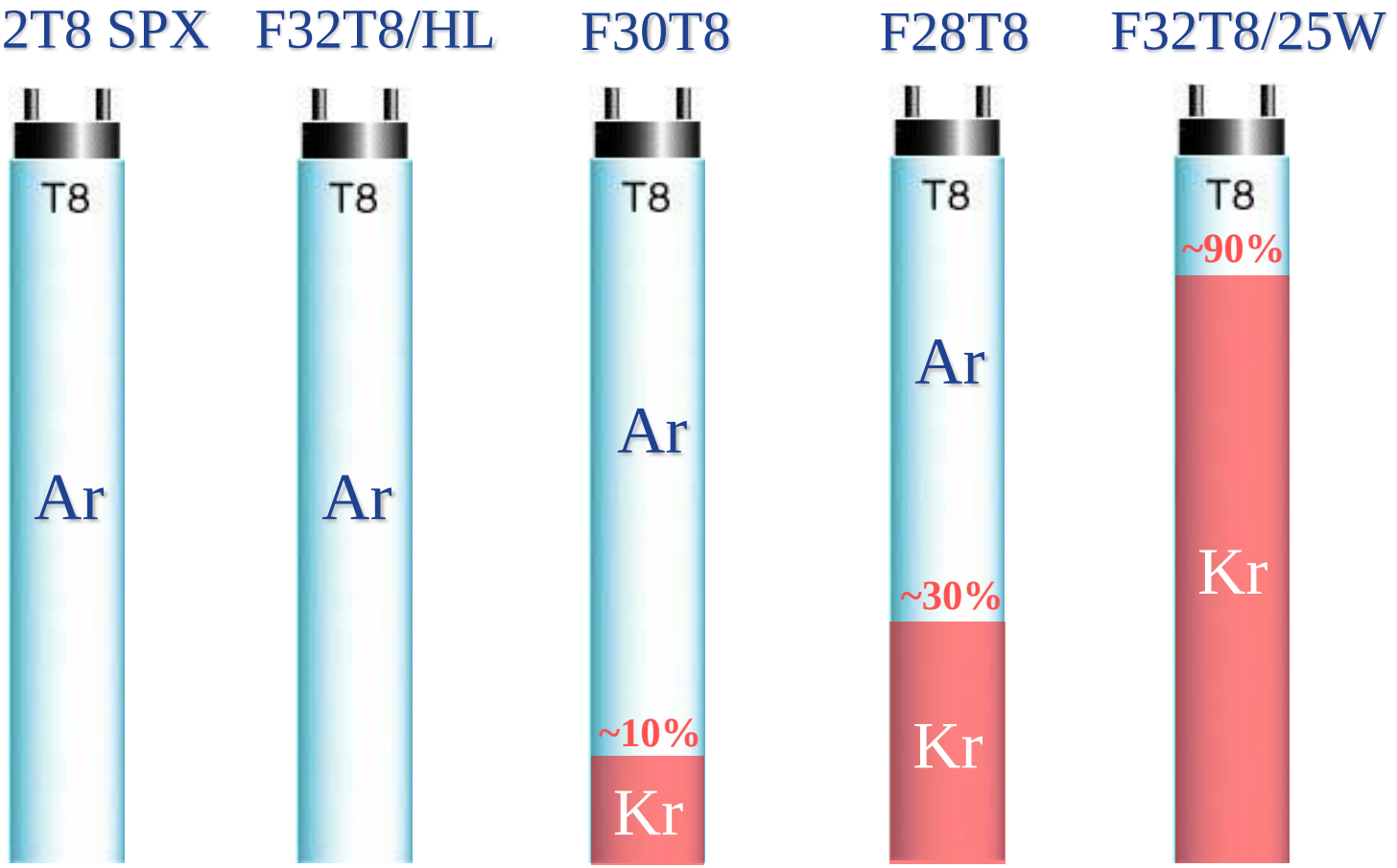
As can be seen, the 3100 lumen 32W T8 and the 28W T8 are more efficient than the 2950 lumen 32W T8 and the 51W T5. The 28W T5 does very well but requires more luminaires.

If you consider the T8 in a parabolic luminare, the 3100 lumen 32W T8 really stands out.

Note 1: Many people simply look at the lumens/watt figure. I prefer to calculate the watts/ft sq because this really shows you how much energy is going to be required to get the desired results.

2: GE has a 51W T5 that has the same lumens as everyone's 54W lamp. This actually helps the T5 come closer to the T8.

Energy Saving 4’ T8 Fluorescent Lamps



	F32T8 SPX	F32T8/HL	F30T8	F28T8	F32T8/25W
Light Output:	100%	105%	95%	92%	89%
LPW:	92	97	93	97	100

Ballasts

Fluorescent T8 Ballast Products

First Cost-Only Customer

GE Magnetic T12

Old Technology
Low System Efficiency
LT 30% THD
Large Can Size

Dedicated Voltage
& Multi-volt
<10% THD
Small Can
<1.7 Crest Factor
.87,.77,1.15 BF
120, 277V, 120-277V,
347V

Highest System Efficiency
Multi-Voltage
Striation Control
UL Type CC Anti-Arcing
Active Current Regulation
UL 55C Ambient Rating
-20F Starting
1.41 Crest Factor
.87, .77, 1.0, 1.18 BF
120-277V, 347V

T8 and T5
For Frequent Switching
Program Start
0-10V Dimming
Available
>100,000 cycles
Multi-Voltage
Efficiency & Start Time
same as UltraMax
Parallel
Striation Control
T5 Anti-Arcing
T8 - .60, .71, .88, 1.15 BF
120, 277V, 120-277V
T5 1.0 54W, 28W .95 &
1.15
120-277V

Performance Features

Fluorescent Ballast EPAct Regulation

EPAct establishes minimum efficiency standards that affects fluorescent ballast for 4 and 8 foot lamps.

No magnetic ballast in new fixtures January 1, 2009.

No magnetic replacement ballast after June 30, 2010.

What is a High Efficiency Ballast?

Greater than 90% Efficiency

- Less than 10% of system power consumed by ballast

Saves incremental ~2 to 5 watts per ballast (6-7%)

- Standard electronic instant start ~ 85% efficiency

High Efficiency Programs

- NEMA Premium
- CEE Compliant - Consortium For Energy Efficiency
- California Title 20
- LEED Certification Requirements

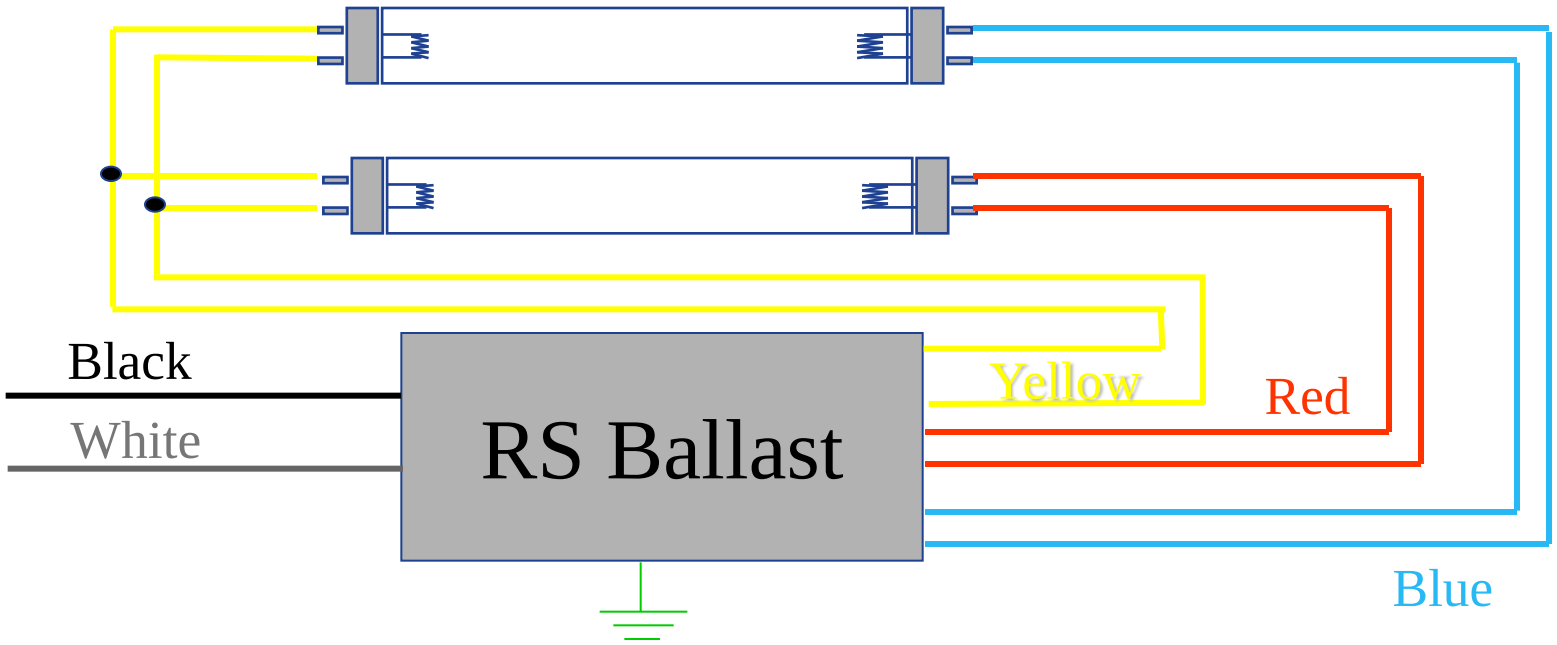
Ballasts are designed with…

- High efficient circuits
- High quality magnetics & components
- Superior thermal management
- Minimizes energy losses

NEMA Premium Ballast

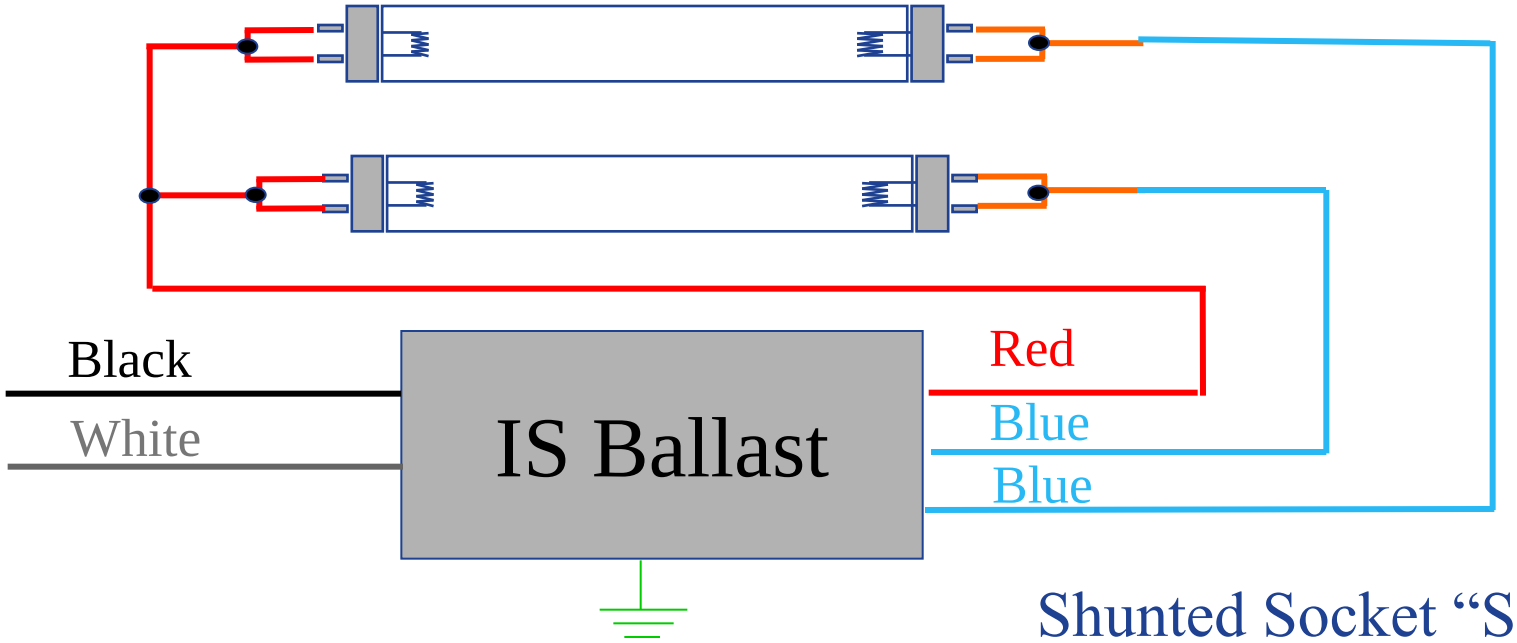
The National Electrical Manufacturers Association (NEMA) has published *BL 2-2007 Energy Efficiency for Electronic Ballasts for T8 Fluorescent Lamps.* This standard contains energy-efficiency requirements for evaluating electronic ballasts designed for use with four-foot 32-watt T8 fluorescent lamps with a lumen output greater than or equal to 3100 lumens. It covers definitions, requirements, and markings. Ballasts that meet these requirements are labeled *NEMA Premium™.* The table of contents and scope of BL 2-2007 may be may be viewed, or a hardcopy or electronic copy purchased for $28.00 by visiting NEMA's website.

Rapid Start Ballast



- **Series Wired, one lamp goes out then both goes out.**
- **Two wires. Non Shunted sockets. 300 Volts Open Circuit Voltage**
- **Cathodes continuously heated. 3.6 Volts AC across Cathode**
- **Longer lamp life than Instant Start, especially at short cycles**
- **Used with dimming ballasts**
- **Lamp types: F40, F40WM, F32T8**

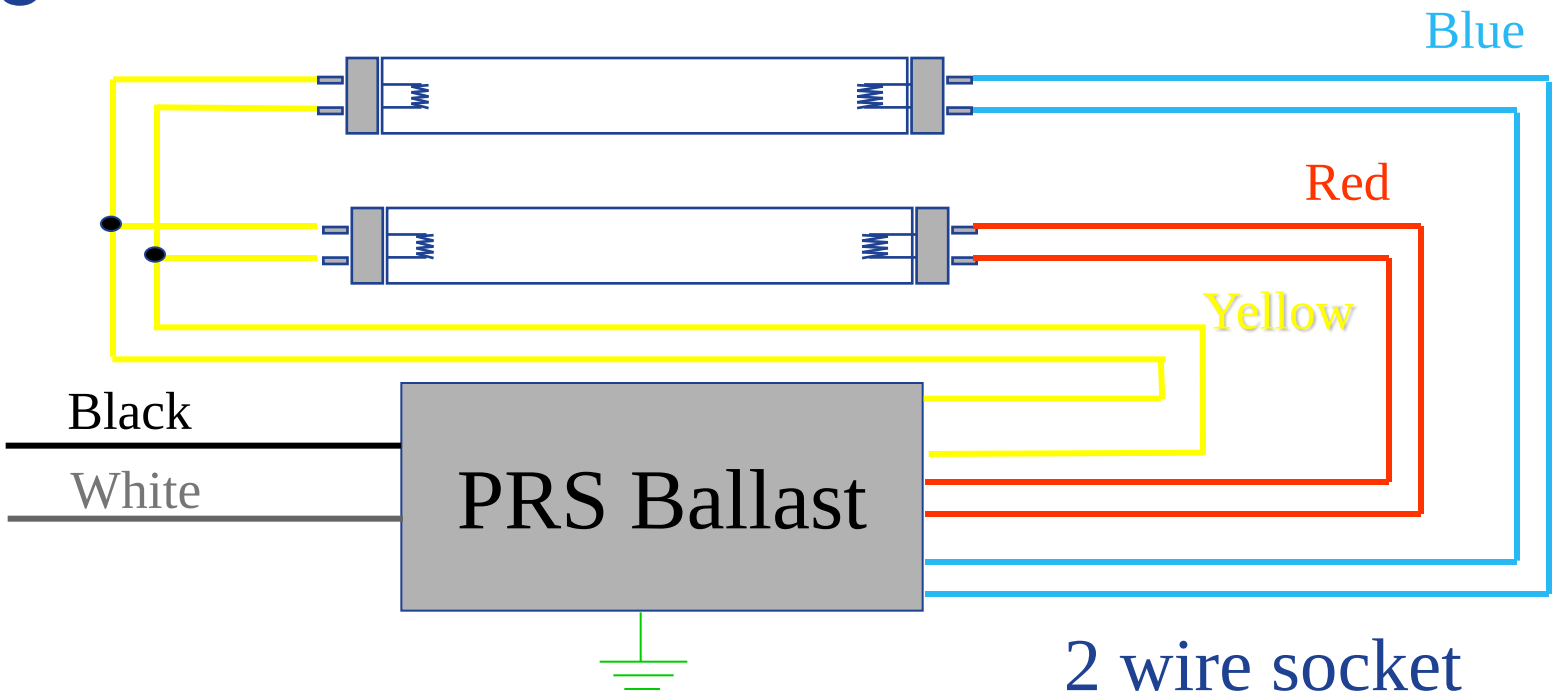
Instant Start Ballast NEMA LSD 2A-2007



Shunted Socket "S"

- **Parallel Wired, lamp goes out, the other stays on.**
- **One wire to Shunted sockets.**
- **550 Volts Open Circuit Voltage**
- **Cathodes Not heated. High OCV to start lamps.**
- **Good for long cycles of starting 1-2 times per day.**
- **Lamp types: F32T8, F28T8, F25T8, F96T8.**

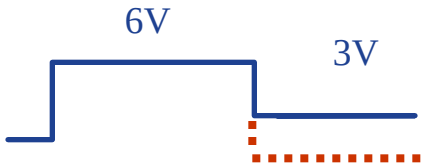
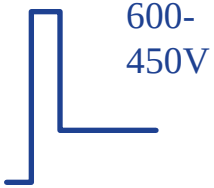
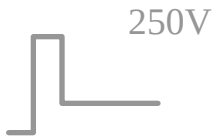
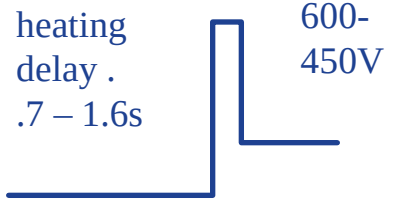
Programmed Start Ballast



2 wire socket

- **Similar to Rapid Start, but Programmed Precise Control**
- **Cathodes heated without Arc Voltage**
- **Damaging "Glow Current" near Zero !**
- **Less damage during starting = Longer lamp life at short cycles**
- **Used with dimming technology**

Industry Starting Methods

	Good Instant Start	Better Rapid Start	Best Program Start
Cathode Voltage			
Lamp Voltage OCV			
Starts (000)	3-10	20-50	50-250
Starting Temp. F	0	50	0
Market Share %	> 80%	< 1%	< 20%
Use Cathode Power	NO	Yes	Yes
Cathode Cutout			Yes/NO

Multi-Voltage Control (MVC)

ULTRAMAX ELECTRONIC BALLAST

120 to 277 Volts All In One Ballast

UltraMax Accepts an Ultra Wide Range of Input Voltages All the way from 108 up to 305 volts

One UltraMax ballast with MVC can replace two "dedicated" voltage ballasts for all 120 and 277 volt applications.

For Distributors: MVC eliminates the need to forecast, order and inventory multiple ballasts for the same application

For Contractors: One ballast per fixture type to order for the project or keep on the truck so they are always ready for the job

Multi-Voltage can dramatically reduce inventory carrying costs, simplify installation & eliminate guesswork at the job site

MVC Means You Have the Right Voltage Ballast Every Time

Anti-Striation Control

Striations, also referred to as spiraling or raccoon tailing are one of the biggest fluorescent lighting maintenance issues

Cold air from the HVAC system blowing on the lamps

Incoming voltage variations traditional ballasts can not compensate for

Lamps reaching end of life can be more susceptible to striations

New energy efficient lamp designs are more susceptible to striations

A combination of any of the above issues

Arc-Guard Protection & UL Type CC Rating

Type CC rating is a stringent UL designation for protection against arcing in electrical devices

Electrical arcing in a fixture can be caused by many things:

- Lamp that is not properly seated in the socket
- Lamp has a bad contact with the socket
- Cracked or damaged socket

Eliminate the potential for arcing to occur, even if any of these conditions are present, thus preventing potential damage to the lamps, ballast and sockets

Arcing Damage Examples

Product Safety Notification:
Fluorescent Luminaire (UL 1598) & Lampholder (UL 496) September 2008 Revision

What?
UL 1598 includes a requirement for fluorescent luminaires with instant start ballasts and bi-pin lamp-holders to use a UL Type CC anti-arcing ballast or lamp-holders marked with a higher temperature rated Circle "I" construction and marking. **GE UltraMax ballasts have a UL Type CC rating with Anti-Arc guard protection.**

Why?
Lighting fixture sockets can melt, crack and deform, creating an unsafe condition if an electric arc develops between a fluorescent lamp holder contact and a mis-seated or bent pin fluorescent lamp. Instant start ballasts have a high open circuit voltage for starting and may create an unsafe arc if the lampholder is deformed or the lamp is not seated properly.

Who does it affect?
All fluorescent luminaire manufacturers. All installers and owners that retrofit an existing luminaire are responsible for ensuring that a luminaire remains in compliance with UL 1598 when changing components. Retrofit installers and owners put themselves at risk of personal liability if changing the construction of the luminaire outside of the UL 1598 intent.

Product Safety Notification:
Fluorescent Luminaire (UL 1598) & Lamp-holder (UL 496) 2008 Revisions

UL 1598 (effective date Sept 2010)

8.8.1 A luminaire with instant-start ballast(s), incorporating bi-pin lamp-holders shall:

(a) Be constructed with a ballast(s) identified as UL Type CC, or

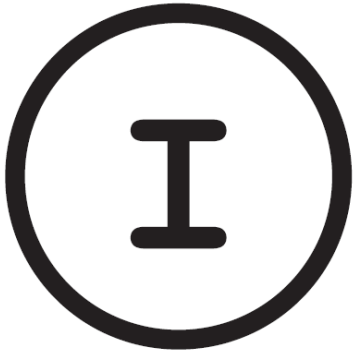
(b) Be constructed with lamp-holders intended for use with instant-start electronic ballasts in accordance with Clause 4.1. Lamp-holders marked with a circle "I" comply with these requirements.

UL 496 (effective date Dec 2010)

SD3.1 In a lampholder intended for instant-start applications, thermoplastic, industrial laminates, or vulcanized fiber material used for support of or for the retaining means for live parts shall be rated a minimum of V-0 in accordance with UL 94. Thermoset materials shall be considered to meet this requirement.

SD3.2 In a lampholder intended for instant-start applications, thermoplastic material used for the support of or for the retaining means for live parts shall have a comparative tracking index (CTI) of 4 or better in accordance with UL 746A. Thermoset materials shall be considered to meet this requirement.

Figure SD1
Marking for lampholders considered suitable for use in instant-start applications



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RoHS Compliancy

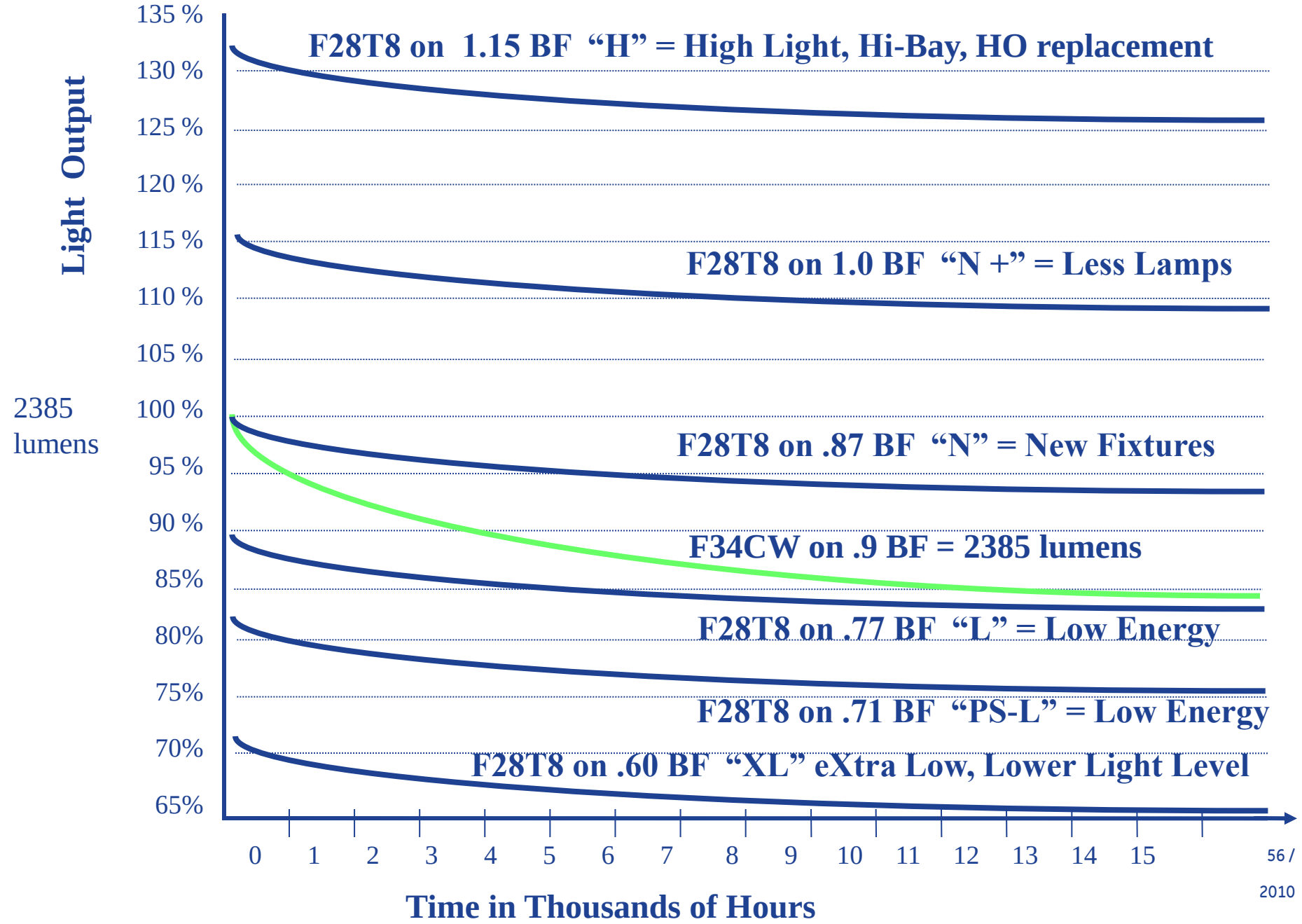
Reduction of Hazardous Substances

Ballast Factor
How does it affect light output?

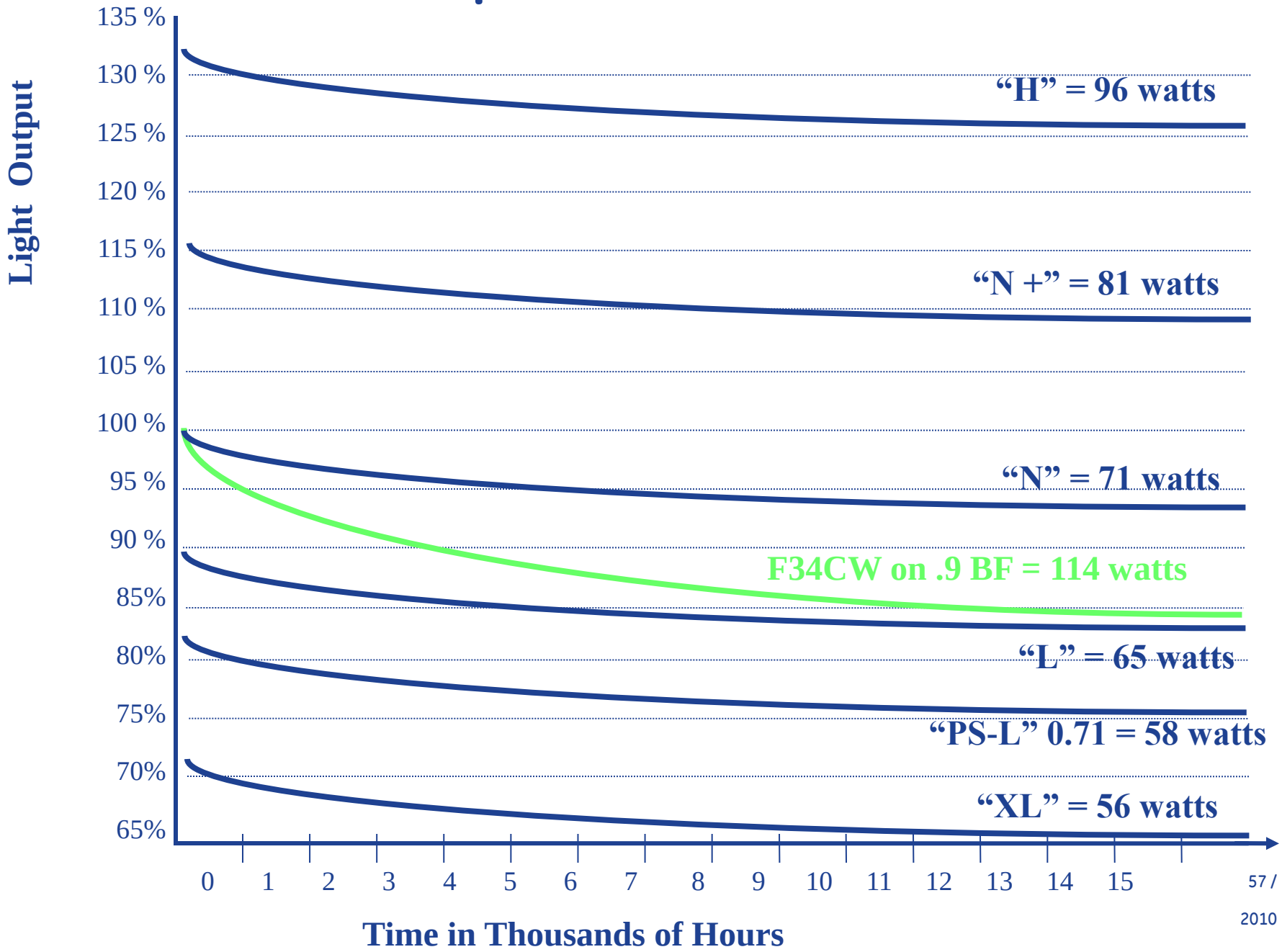
Ballast Factor is the measure of light output from a lamp operated by a commercial ballast as compared to a laboratory standard reference ballast.

The output of the ballast used = (ballast factor) x (rated lumens)

Ballast Factor Effect



3 Lamp BF & Watts



High Lumen F32 and High B.F. UltraMax

F32T8/XL/HL

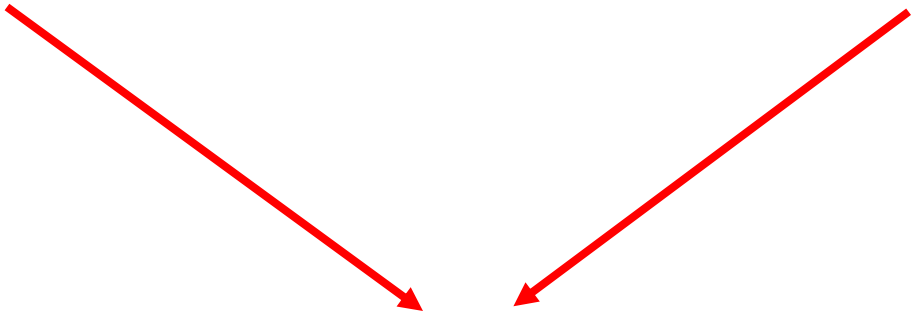
3100 Lumens vs 2800 for Standard F32
(+ 11%)

Operates on any T8 type ballast

XL long life

Ballast Factor of 1.15
(32% more light than standard .87BF)

Operates any T8 lamp



46% more light than standard F32 on Normal BF ballasts !
Or…46% fewer fixtures

Strategy for New Installations

Room Size: 100 X 100 X 12 ft. high.
Design Illuminance: 30 fc. 3 lamp.

	Generic	Hi-Lumen Lamp	Lamp/Ballast
Lamp	F32	F32/HL	F32/HL
Ballast	.87 BF	.87 BF	1.15 BF
# fixtures	56	49	36
# Columns	7	7	6
# Rows	8	7	6
Spacing	14 x 12	14 x 14	16 x16
Power Density	0.49	0.43	0.31

20 fixtures X ($$$/fixture + Labor/fixture + wire/fixture) = Big Savings

High Lumen F32 and High B.F. UltraMax

LED

What are the components of an LED System?

LED lighting system value chain

Wafer: Semiconductor process for building light emitting diodes.

Chip: Extracting, testing and packaging the basics elements of LEDs.

Materials: Most LEDs include phosphors to enhance, color correct LED light.

Packages: LED chip and phosphors placed on thermal pad with leads etc.

Systems: Package + drivers + additional thermal elements to maintain LED temperature.

Fixtures: Complete light source ready to hook up to power source and support structures.

5mm Chip vs. COB (Chip on Board)

Two types of LED used in today's LEDs

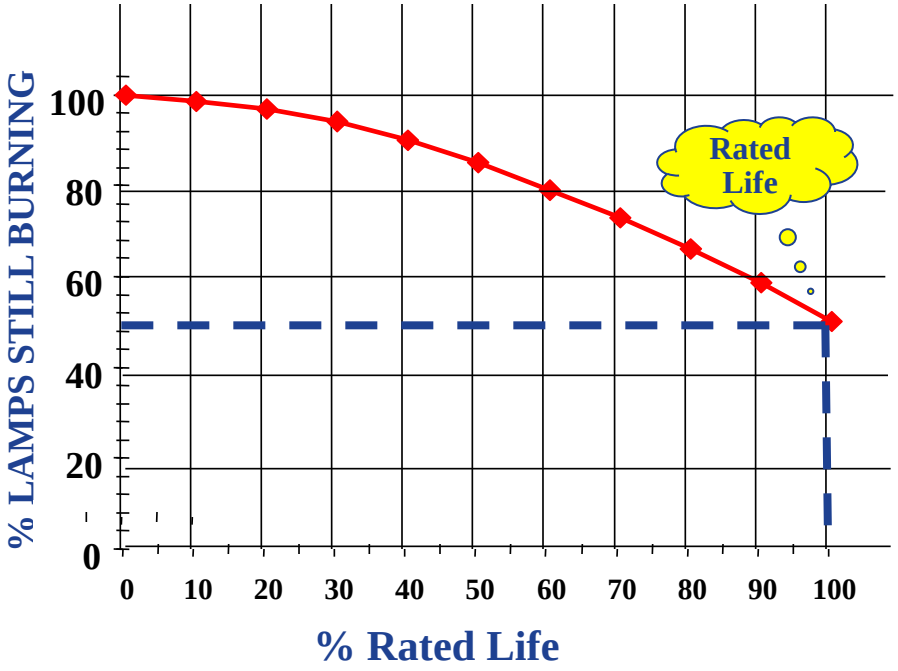
- 5 mm LEDs
- High-output Chip-On-Board

- 5 mm is an early technology but still being used
  - After 6000 hours, the output of a 5mm LED drops to 50% of its original value
- Replaced by high-output (HO) LEDs,
  - offer far superior lumen maintenance.
  - HO LEDs drop by only 5%.

- In other words, the HO LEDs will last for 10 years or more, but the cheaper 5mm LEDs will grow dim after just 2 years.

LED Life Ratings

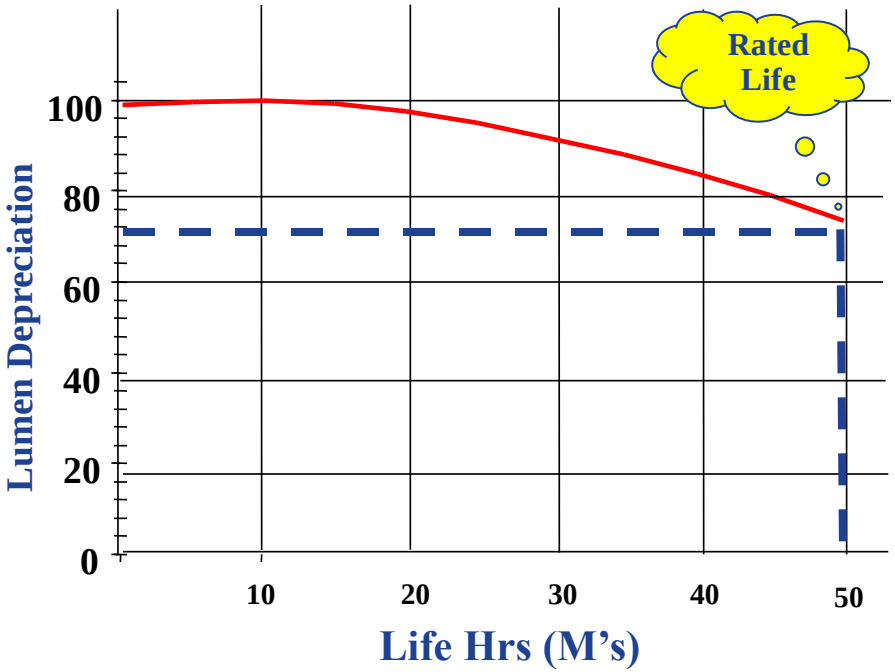
Traditional Lamps rated at B50 - 50% Mortality



B50 Life rated when 50% of a population has failed

B50 = Avg rated life

LEDS rated at 70% Lumen Maintenance



L70 Life defined as lumen depreciation to a particular point

L70 = Rated life @ 30% depreciation

US Department of Energy
SSL Caliper Testing Program

Test Round	Date	Number Tested	Number Meet	Percent Meet
1	Mar-07	08	1	13%
2	Aug-07	13	2	15%
3	Oct-07	24	11	46%
4	Jan-08	15	2	13%
5	May-08	17	4	24%
6	Aug-08	24	2	8%
7	Jan-09	09	3	33%
8	July-09	11	6	54%
9	Oct-09	21	7	33%
	Total	142	38	26%

Don't believe 74% of what you read … and even less of what you hear!

Source: U.S. Department of Energy

Conformance to Initial Claims

FTC Sues *** Inc to End Allegedly Misleading Claims

September 8, 2010...The United States Federal Trade Commission (FTC) has sued a California-based LED bulb manufacturer and its principals to stop them from exaggerating the light output and life expectancy of its LED bulbs, and misleading consumers.

In its continuing effort to stop deceptive advertising the FTC filed a complaint charging that since 2008, ***, Inc. has overstated the light output and life expectancy of its LED bulbs on packages and in brochures. The agency also charges that *** misled consumers about how the brightness of its LED bulbs compare to traditional incandescent lights.

The FTC notes that it authorizes the filing of a complaint when it has “reason to believe” that the law has or is being violated, and it appears to the Commission that a proceeding is in the public interest. The Commission also points out that a complaint is not a finding or ruling that the defendants have actually violated the law.

Copies of the Commission’s complaint and the press release about it can be found on the FTC web site.

ENERGY STAR® Program Start August 31, 2010

- **EPA now in charge of LED ENERGY STAR® Program**
  - **DOE sign MOU Sept 30, 2009**
  - **Expand and enhance energy efficiency programs for products and buildings**
  - **Re-align roles to best utilize expertise of each agency**

- **DOE completed ENERGY STAR® LED specification**
  - **Formally communicated program on Dec 3rd**
  - **Goes in effect August 31, 2010**

- **EPA will manage changes going forward with technical support of DOE**

LED Energy Star Lamp Qualifications

What: **Eligibility criteria, that must be met to allow a LED lamp manufacturer to utilize the ENERGY STAR certification mark.** **4 Lamp Categories each with its own criteria:**

1) **Omnidirectional: A, BT, P, PS, S, T**
2) **Decorative: B, BA, C, CA, DC, F, G**
3) **Directional: BR, ER, K, MR, PAR, R**
4) **Non-standard**

Who: **The DOE has turned over the administration of energy star qualification over to the EPA**

- **EPA will lead on Energy Star**
- **DOE will lead on National Building Rating Program**

When: **Goes in effect August 31, 2010**

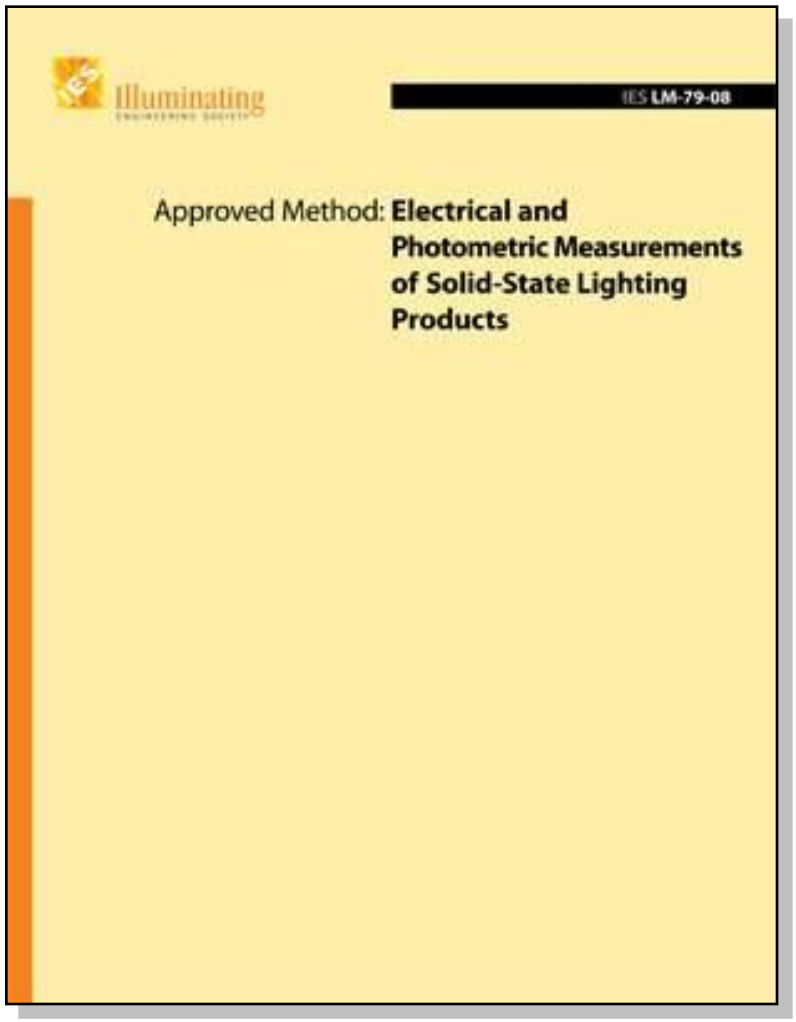
Energy Star Qualification Summary Highlights

	Omnidirectional	Decorative	Directional	Non-Standard
Minimum Efficacy	< 10 watts: 50 LPW >or = 10 watts: 55 LPW	40 LPW	<or= PAR20: 40 LPW > PAR20: 45 LPW	< 10 watts: 50 LPW >or = 10 watts: 55 LPW
Minimum Light Output	If claiming it replaces: 25W -> 200 lumens 35W -> 325 lumens 40W -> 400 lumens 60W -> 800 lumens See PDF for higher levels	If claiming it replaces: 10W -> 70 lumens 15W -> 90 lumens 25W -> 150 lumens 40W -> 300 lumens 60W -> 500 lumens	BR, ER, K & R: Luminous flux = target wattage of the replaced lamp X10 PAR and MR16 : see tool http://www.drintl.com/htmlemail/Energystar/Dec09/ESIntLampCenterBeamTool.zip	200 lumens
Lumen Maintenance	>or = 70% (L70) at 25,000 hours	>or = 70% (L70) at 15,000 hours	>or = 70% (L70) at 25,000 hours	>or = 70% (L70) at 25,000 hours
Warranty	All types: 3 year minimum			
Packaging	All types: Manufacturer must use the Lighting Facts label			

What is LM-79?

IESNA measurement methods for:

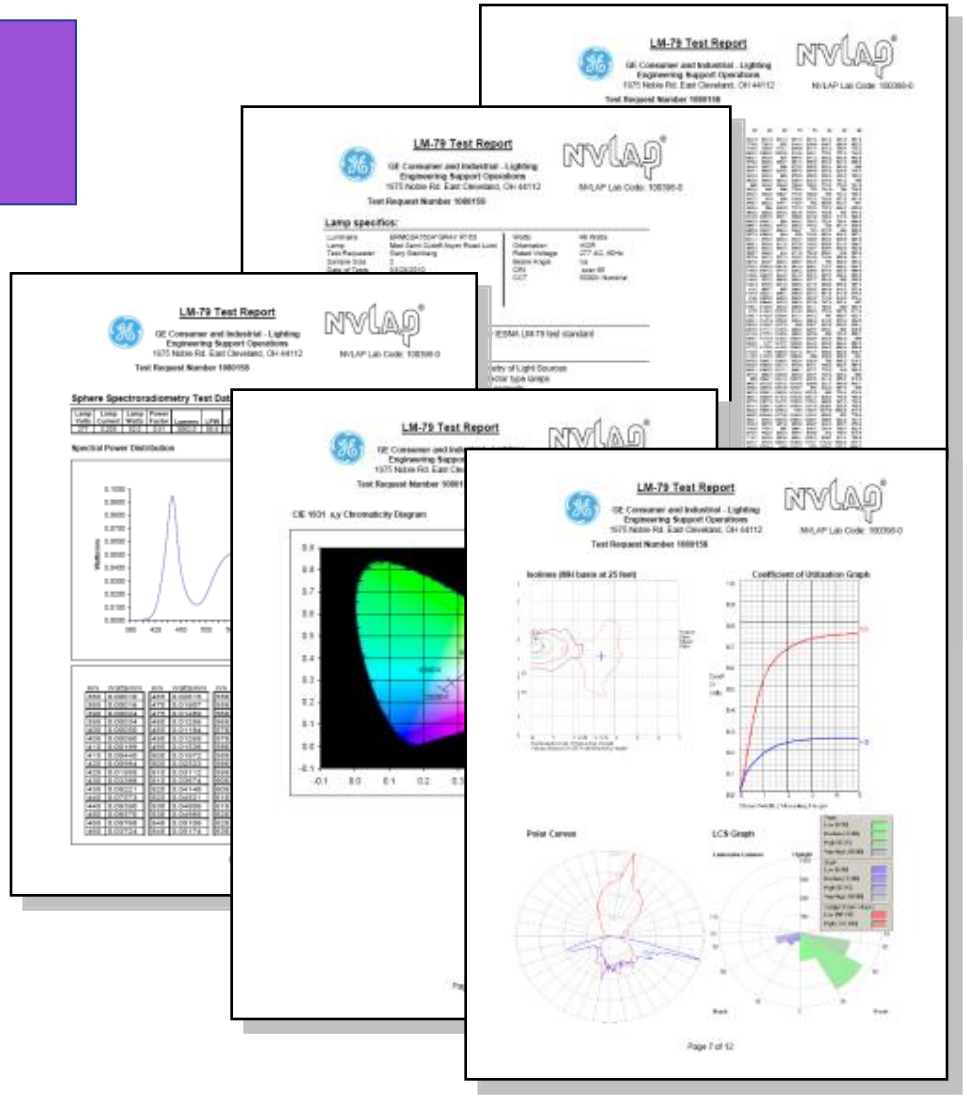
- **CCT**
- **CRI**
- **Luminous Flux**
- **Candela vs. angle**
- **Angular color variation**



What's an LM-79 Report?

Summary of test data per LM-79-08

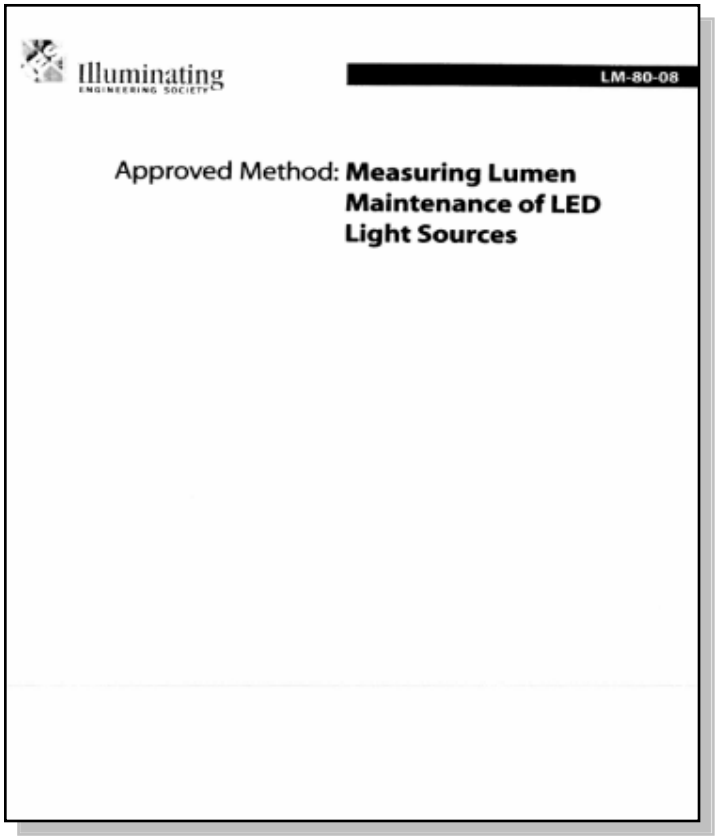
- **SPD, CCT, CRI**
- **Luminous Flux**
- **S/P Ratio**
- **Candela Table**
- **BUG Rating (TM-15)**
- **Electrical Data, LPW**



What is LM-80?

IESNA Released Document

- **Consistent Test Method for Lumen Maintenance**
- **For LEDs, LED Arrays or LED Modules**
- **3 Operating Temps and LED Case Temps**
- **Same Operating Current**
- **Test LEDs out to 6000 hours**
- **Input for ENERGY STAR®**



Does Not Predict Lumen Maintenance

Currently being addressed by WG TM21

What's in a LM-80 Report?

'Key' Items in Report

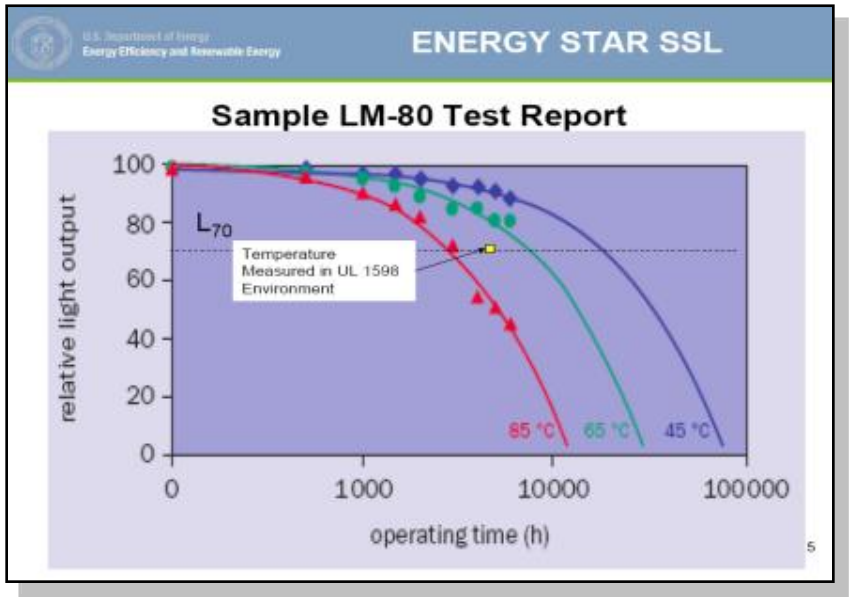
- **Operating Configuration**
  - Ambient Temperature
  - LED Case Temperature
  - LED Operating Current
- **Lumen Maintenance**
  - Out to 6000 hours with variation
- **Chromaticity Shift**
  - Out to 6000 hours
- **Sample size**

6. Case and ambient temperatures (ambient temperature measured 1.5mm above reliability stress board)

The thermal characterization results are summarized in the table below. In all cases, both T_S and T_A meet or exceed the IES LM-80-08 limits (i.e. $T_S \geq 55°C$ or 85°C, and that $T_A \geq T_S - 5°C$).

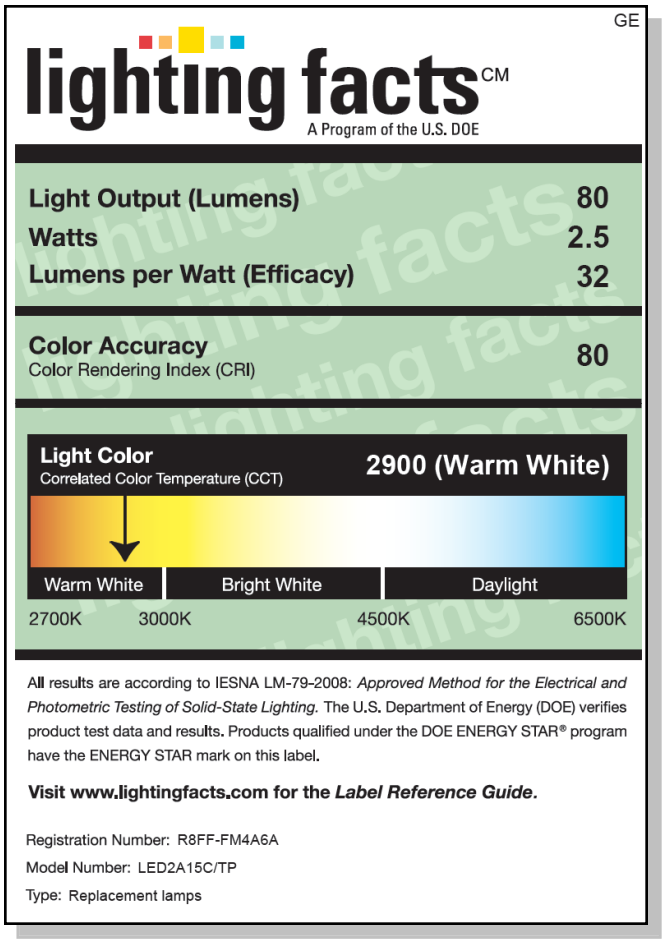
		LM-80 Tests				
Required LM-80 Test Temperature	I_F	Actual T_S	Actual T_A	Actual $\Delta[T_A - T_S]$	Actual Relative Humidity	Average lumen output at 6,000 hours
55°C	350 mA	60°C	64°C	+4°C	18%	0.992
85°C	350 mA	85°C	84°C	-1°C	7%	0.962
108°C *	350 mA	128°C	103°C	-25°C	TBD	0.979

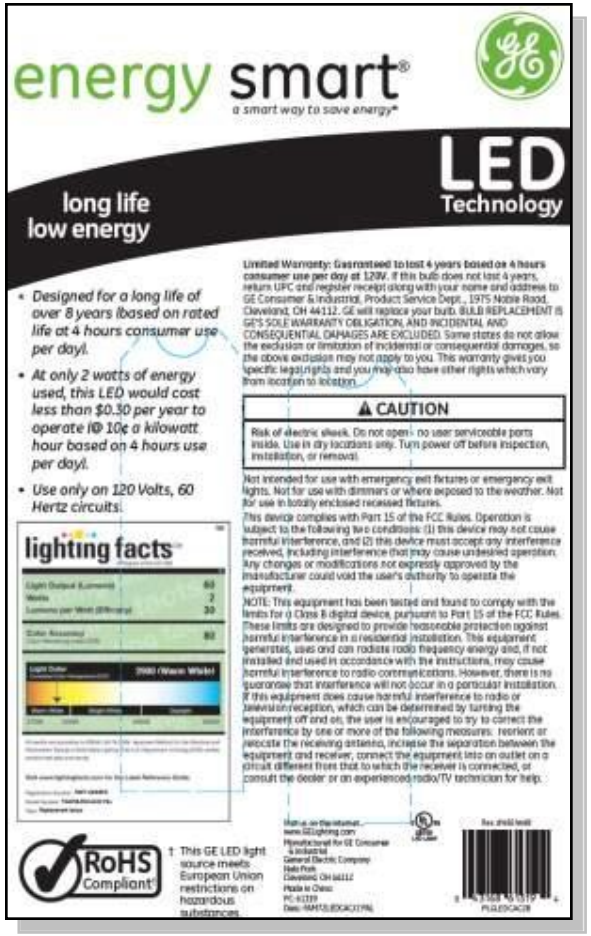
*Third temperature chosen by the manufacturer, and adjusted to meet $-5°C\ T_A - T_S$ requirement.



Helps understand System LED Entitlement

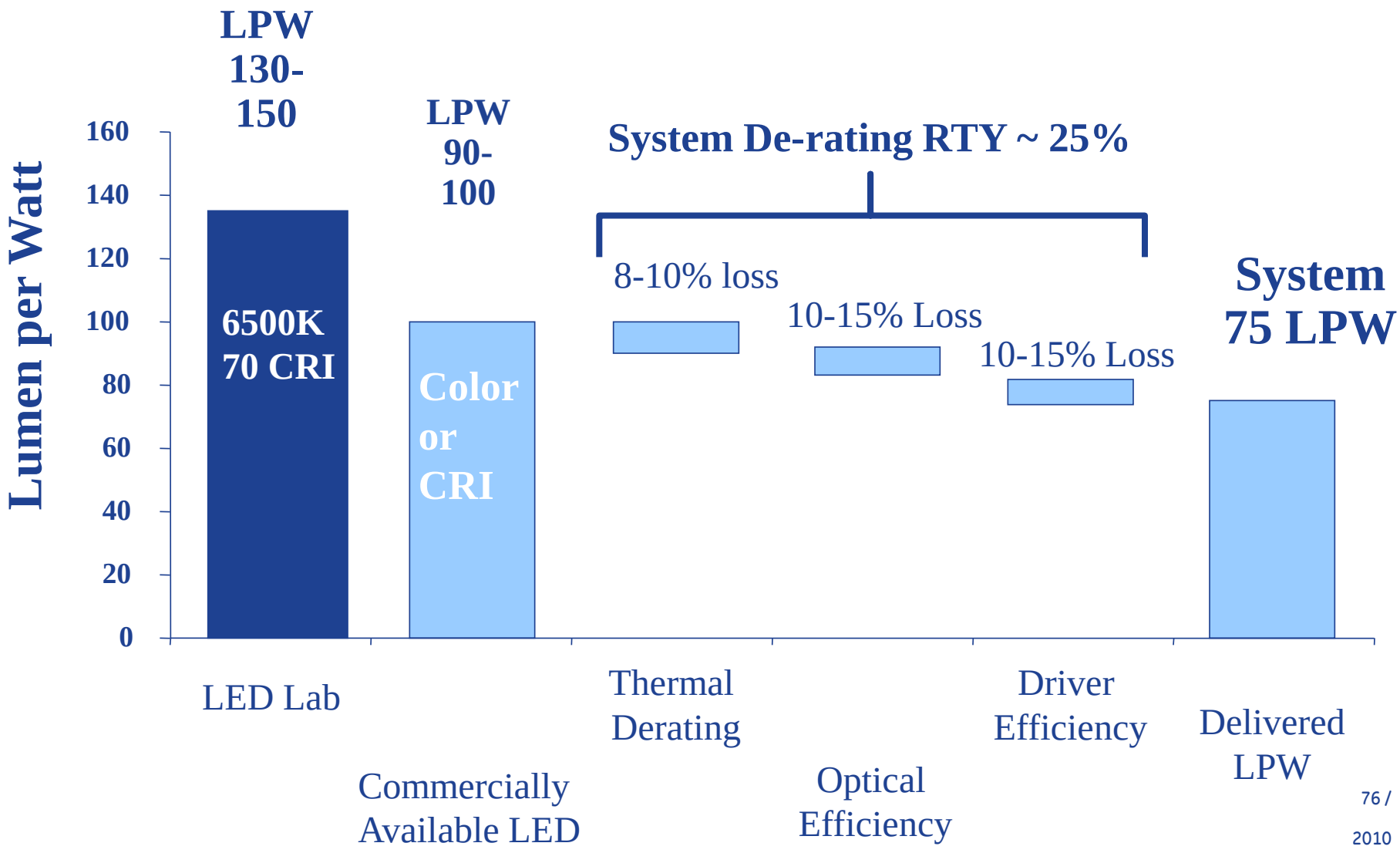
DOE Lighting Facts Label





Simplifies Lighting Parameters for Consumers…

Chip vs System Rating Waterfall



LED Lamp Life Ratings

Generic LED Ratings

Uses LED manufacturers life claim qualification without consideration of system losses

Does not perform proper testing

Uses catastrophic Life rating only with no reference to lumen depreciation

High Quality LED systems

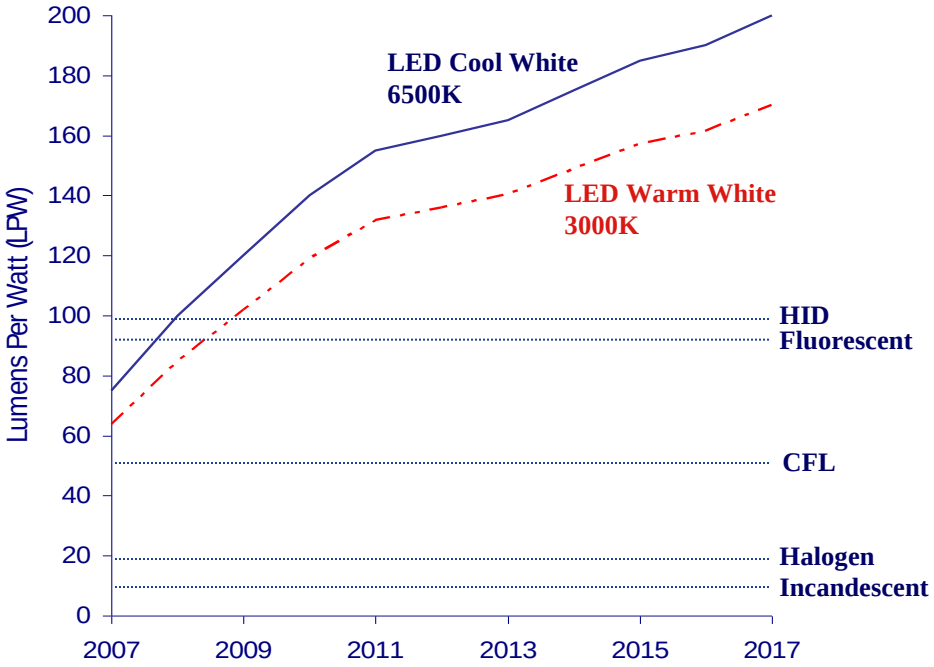
Independently test LEDs for long term at multiple temperatures and currents

Performs accelerated life testing at 85C/85% RH and rack testing up to several thousand hours

Uses LEDs that were tested to the LM80 requirements and bases final rating on L70 or L50 (application dependant)

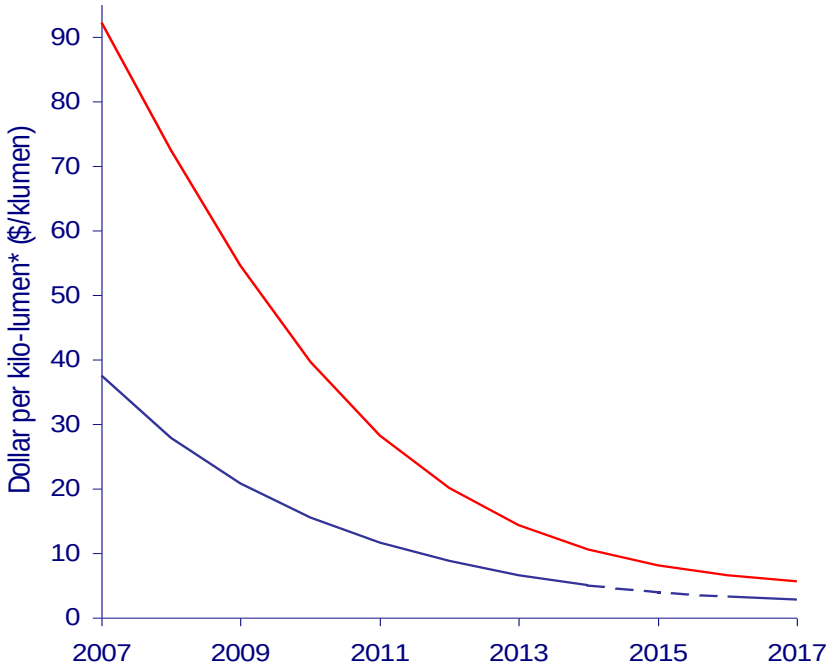
Efficiency Gains & Lower Price

LED Efficiency Evolution



DOE SSL Multi-Year Program Plan – January, 2009 Cool White Efficacy Projection Warm white estimated @ 85% of Cool White

LED Cost Trajectory



DOE reference Building Technology Report , December 2006 Navigant

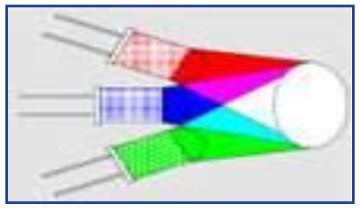
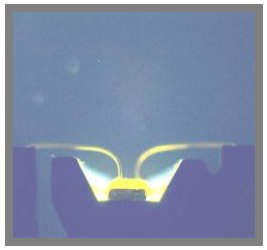
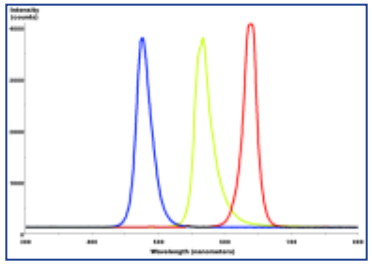
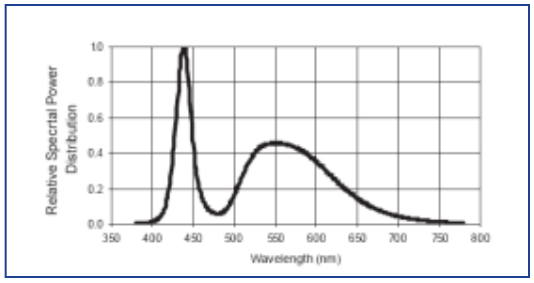
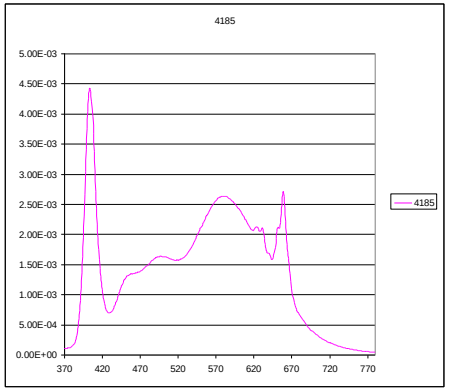
Cool improving faster than warm in both of these areas…Cool White stronger economics

LED Metrics Roadmap 2010

LED Metric	Unit	2009	2010	2012	2015
Efficacy 26-37K. 80-90 CRI	Lm/W	70	88	128	184
Price	$/klm	36	25	11	3
Efficacy 47-70K. 70-80 CRI	Lm/W	113	134	173	215
Price	$/klm	25	13	6	2

http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_manuf-roadmap_july2010.pdf

Technical Approaches to White LEDs

	RGB Tri-chip	Blue Chip + Yellow Phosphor	Violet + Remote Multi-Phosphors
			
Benefits	1. Highest Efficiency "white" source 2. Enables Dynamic white (i.e. color changing)	1. High efficiency (YAG) 2. High Flux density 3. Simple circuitry	1. Highest efficiency @400nm 2. Superior quality of light (CRI) 3. Diffuse source 4. Color consistency
Challenges	1. Color Stability over time 2. Poor CRI 3. Complex circuitry 4. Somewhat limited applications based on optics	1. Color consistency 2. CRI Capability 3. Efficiency @ lower CCT 4. Color Stability (time/DC)	1. Efficiency at higher CCT 2. Source size? 3. Scale/Cost
			

Do you need Uniformity?

Color consistency, CRI & color stability over time limiting Illumination adoption

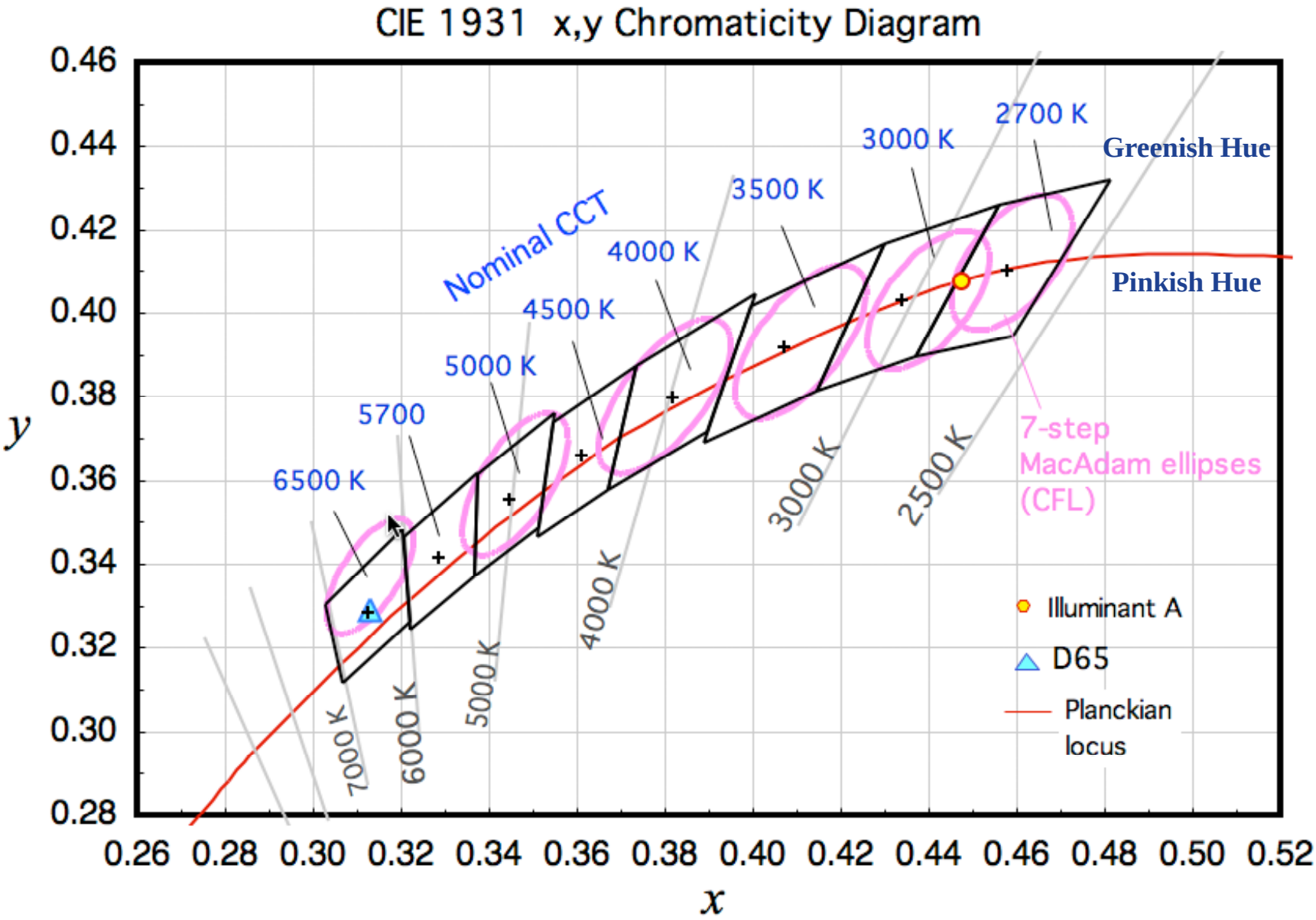
What is Binning?

Wafers are mined for conforming product.
Results are produced with wide variation:

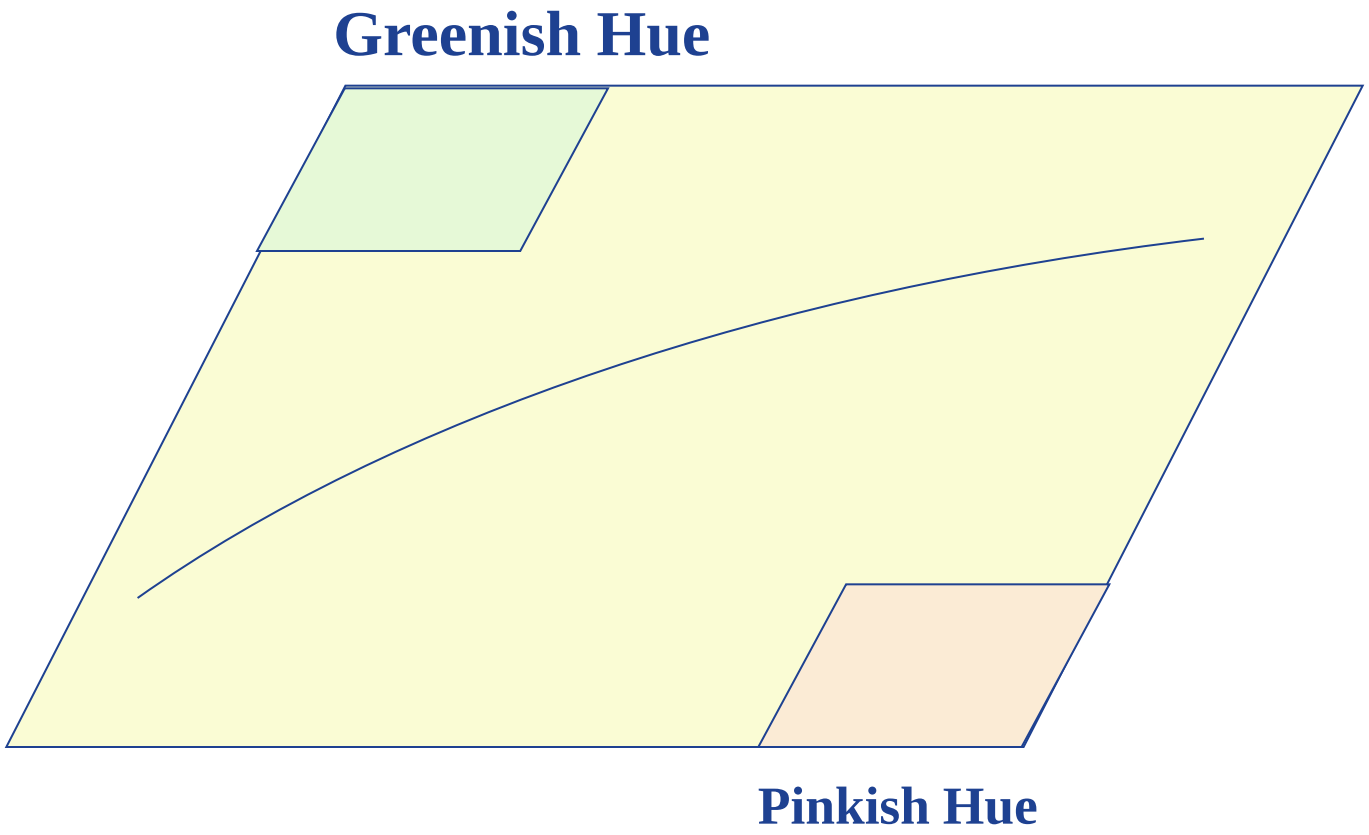
- **Color (wavelength = nm)**
- **Forward voltage (Vf)**
- **Light Output (brightness = luminous flux)**

Binning provides consistency in color, brightness, efficiency, and electrical loading.

LED Color Quality and Binning



4000K Detailed Binning



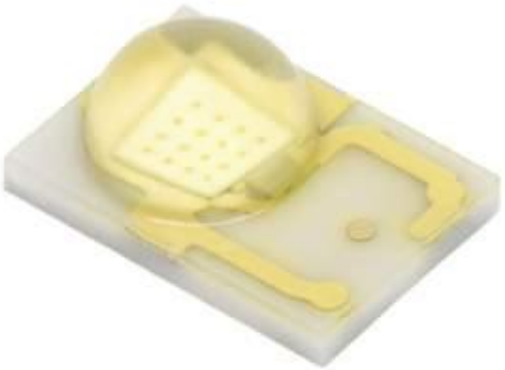
Closer to the Black Body Curve is best.

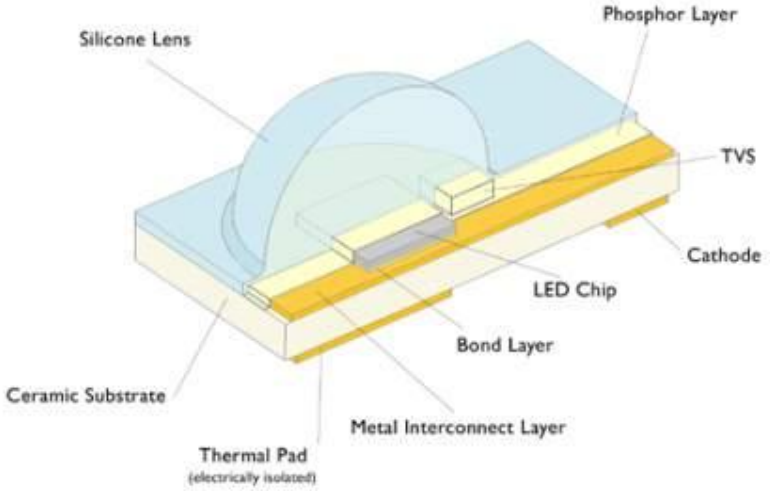
4 Thermals

Why worry about the Thermals?

Performance, Reliability, Life…

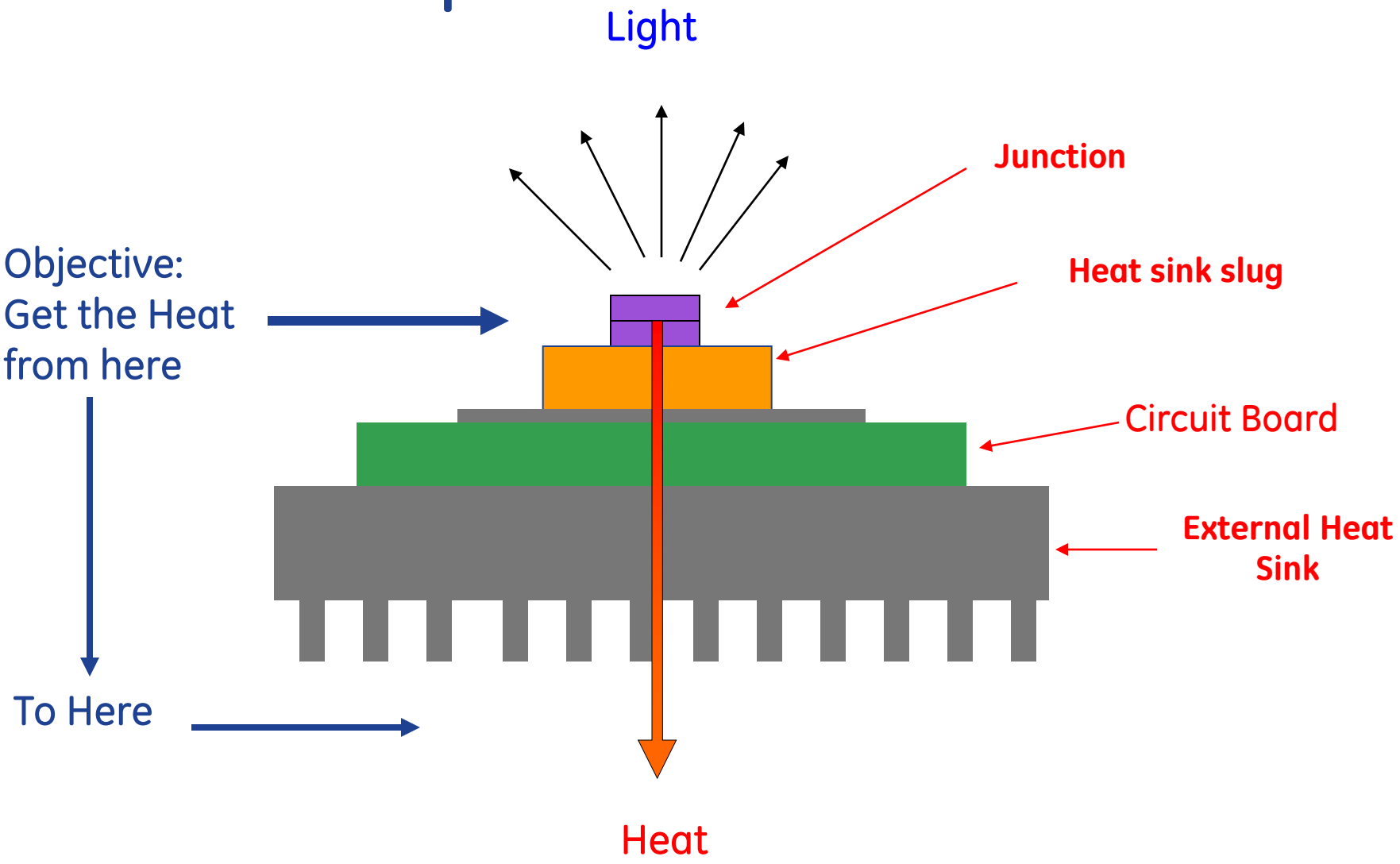
Junction Temperature is King!





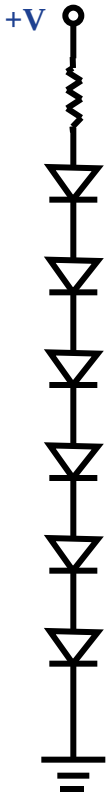
All life ratings are based on a max junction temperature. -Typically max 150C T_j

Thermals equate to Life

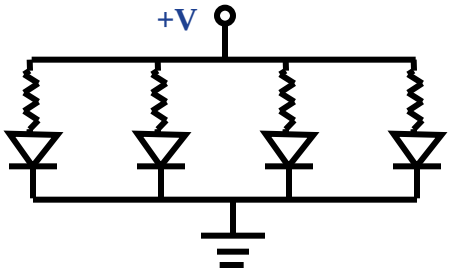


LED Array Electrical Configurations

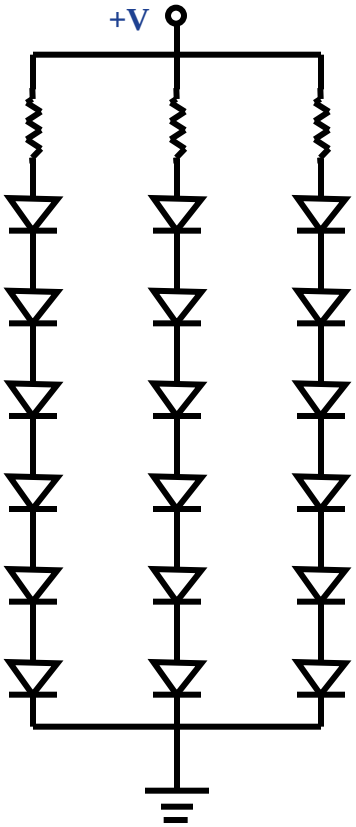
Serial



Parallel



Series-Parallel



9 Watt GE energy smart® LED A19 General Purpose Bulb

77% energy savings vs. 40-watt incandescent

ENERGY STAR® qualified**

40-Watt incandescent replacement

High light output - 450 lumens

L70 Life: 25,000-hour rated life. 10 Year Warranty

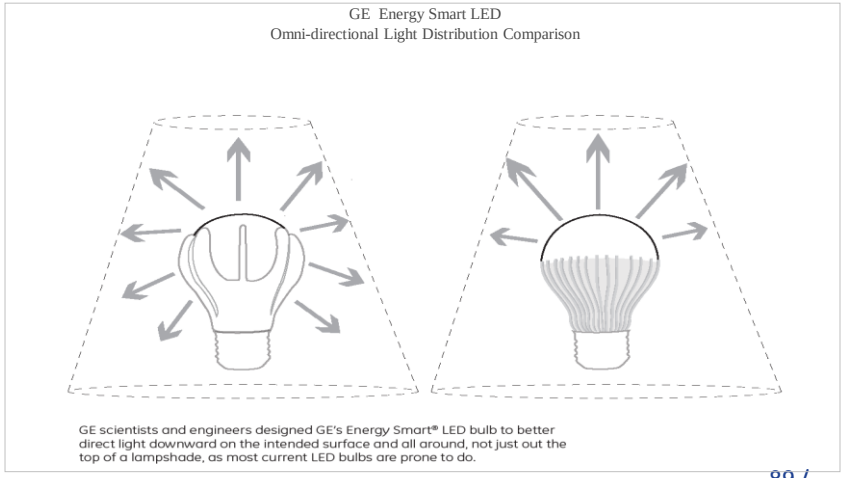
Instant full brightness of an incandescent or halogen bulb

Omni-directional light distribution

Color Temperature (3000K)

RoHS compliant

Suggested Re-sale ~$50



** Target certification by end Nov 2010

LED Lighting that shines all around the competition

9W GE energy smart®

LED Omni-Directional A19 Lighting

Compare The Light - See The GE OMNI-DIRECTIONAL Difference!

GE LED **Other**

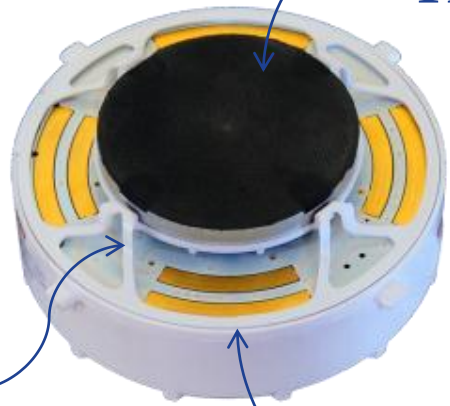
Field Replaceable LED Lamp

The Industry's first consumer-friendly field-replaceable LED Lamp Module

Integrated 24 Volt LED Driver with AC to DC Converter

Integrated high-efficiency secondary optics

Compression-loaded Thermal pad



Spring-ribs

WattageAdjust® Switch

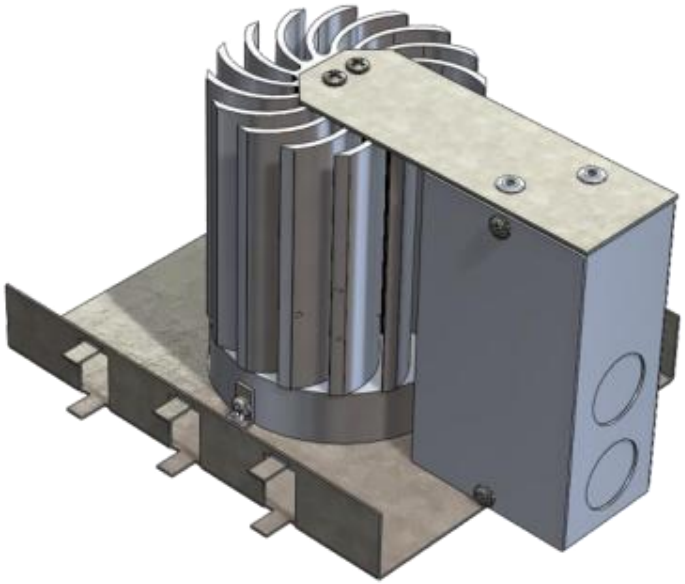
Electrical contacts for input power

Track Lighting Luminaire

LED Driver + LED Chip + Optics are all integrated within the Infusion™ Housing (Luminaire housing has no internal electronics)

Heat Dissipating Housing

Downlight Luminaire



What is the future?

OLEDS?

Bringing OLEDs to Life

- **Looking at market needs, current technical weaknesses and OLED capabilities**

- **Achieved roll-to-roll manufacturing capability**
  - **Enables low-cost manufacturing**
  - **Allows design flexibility vs. stiff glass panel**

- **Tapping GE's ultra-high barrier coatings experienc**
  - **Allows use of low-cost flexible substrate that protects OLED material throughout its life**

- **Validating attributes: flexible and thin**

Envisioning OLEDs Applications

These images were created to illustrate concepts of potential future applications

Illuminated Safety Outerwear

Advertising Signage

Concealed Under-Shelf

Decorative Wall Peel

Illuminated Stairs

Portable and Flexible Lamp

Working with The Cleveland Institute of Art, Case Western Reserve University, Architects, Lighting Designers, etc…

Questions?