

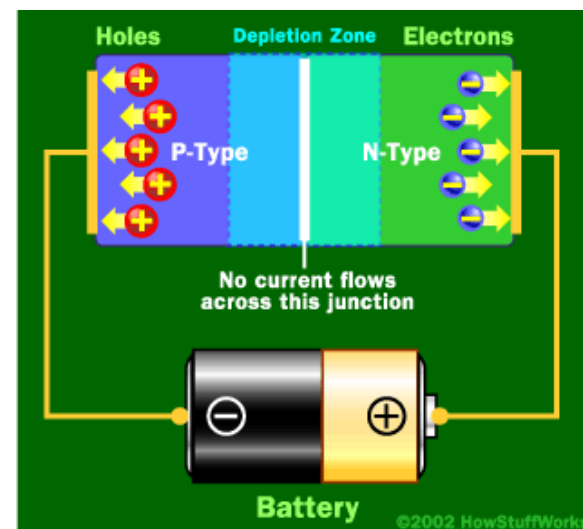
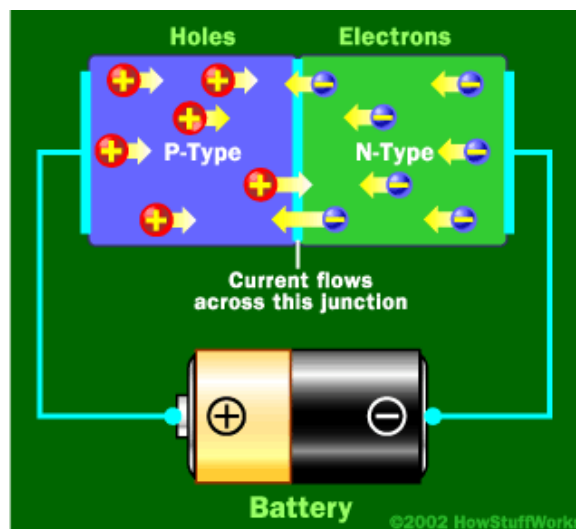
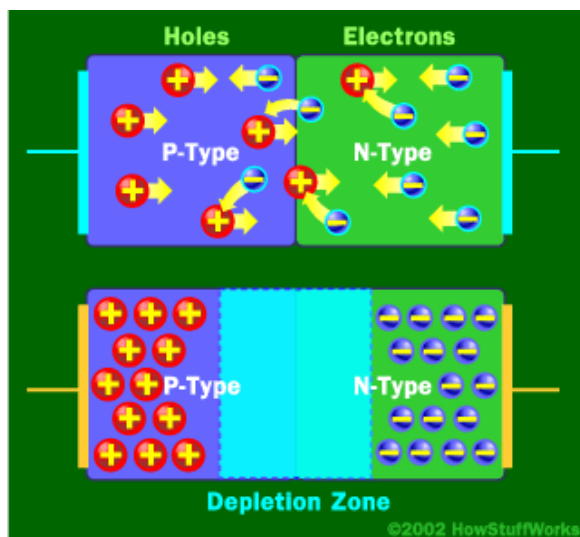
SSL 101: Understanding LED Technology

GreenBuild 2011
Toronto, Canada

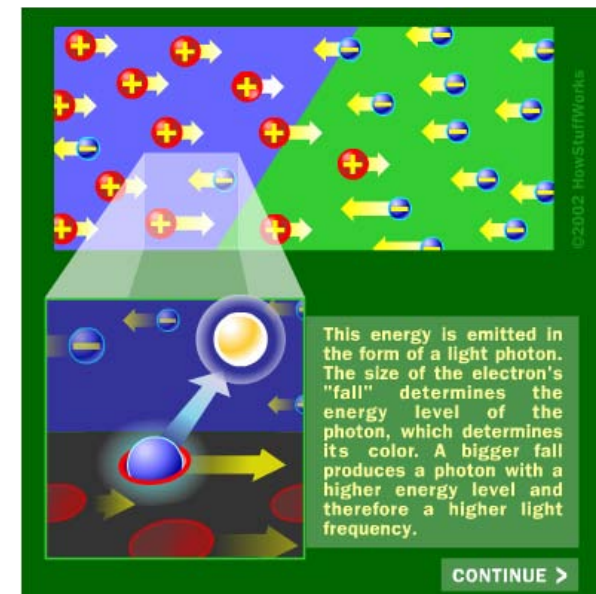
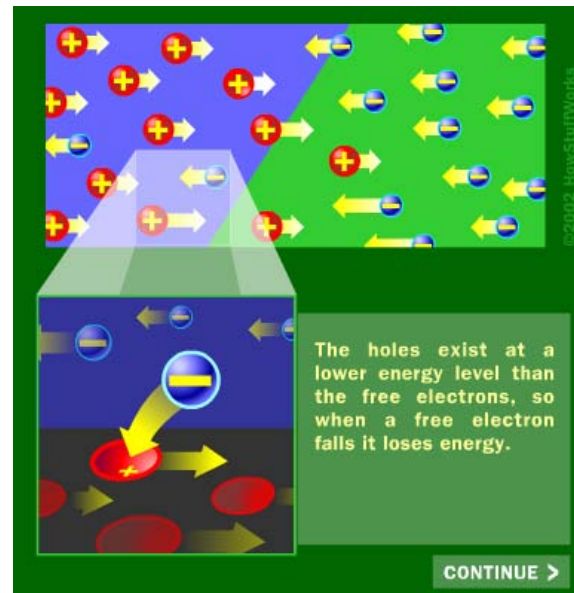
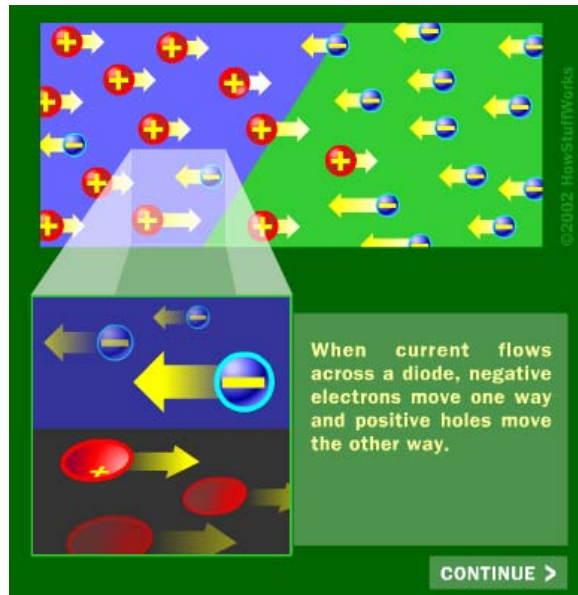
Jeff McCullough, LC
Pacific Northwest National Laboratory

- A semi-conductor device
 - Therefore they DO get hot... It's just in a different way!
- Most are low voltage direct current (DC), although some are AC
- They are not “white light” by themselves
 - The material composition determines the color
- Inherently directional
- Under “normal” operation they don't burn-out but rather reduce in light output over time
- Require different test procedures (e.g. IESNA LM-79, IESNA LM-80, etc.
- They can be energy efficient in certain applications
- This ain't your Father's lightbulb!

What's an LED you ask?

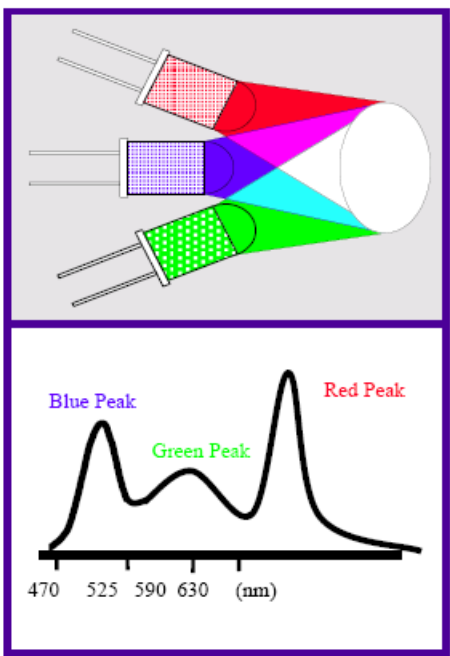


How does an LED make Light?



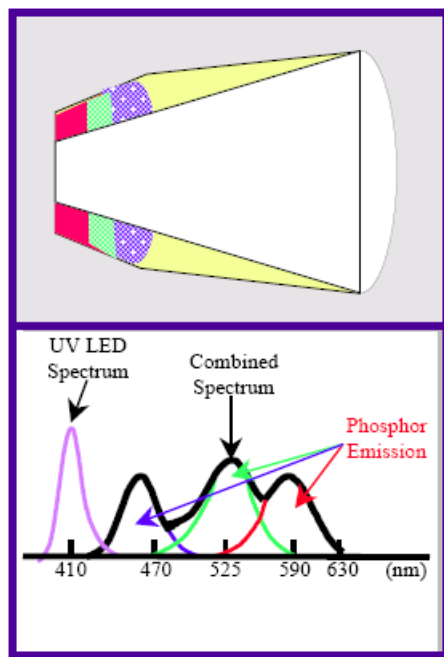
Okay, so if they are “colored” how do they make white light?

Red + Green + Blue LEDs



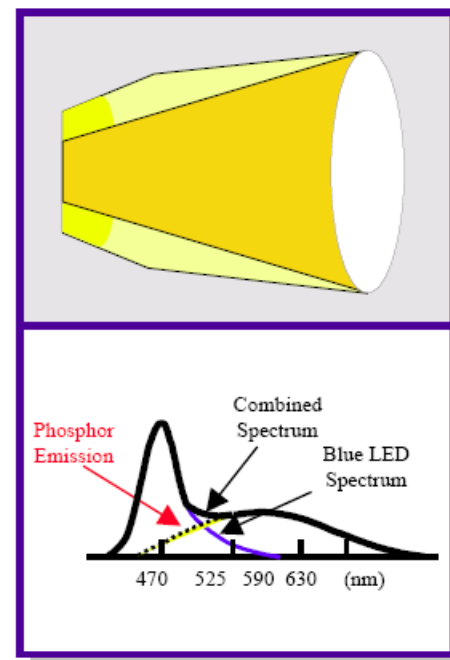
- Dynamic color tuning
- Excellent color rendering
- Large color gamut

UV LED + RGB Phosphor



- White point tunable by phosphors
- Excellent color rendering
- Simple to create white

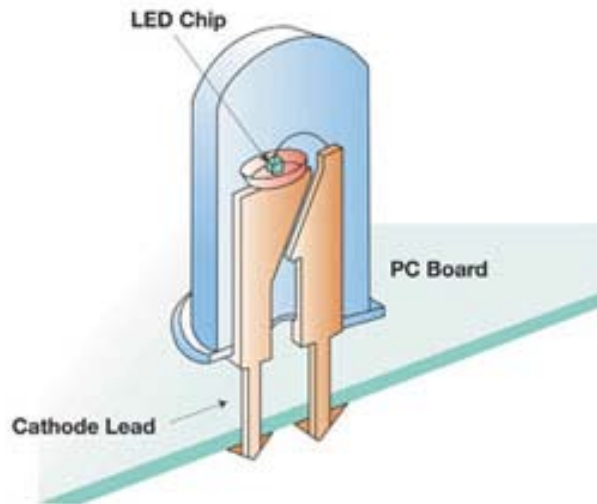
Blue LED + Yellow Phosphor



- Simple to create white
- Good color rendering

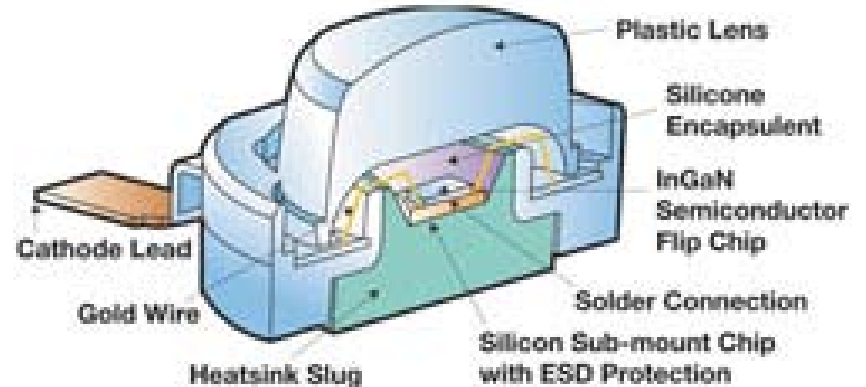
Courtesy: Lumileds

5 mm “Indicator”



Structure of a 5mm type LED.
Source: Lumileds™

High power/flux



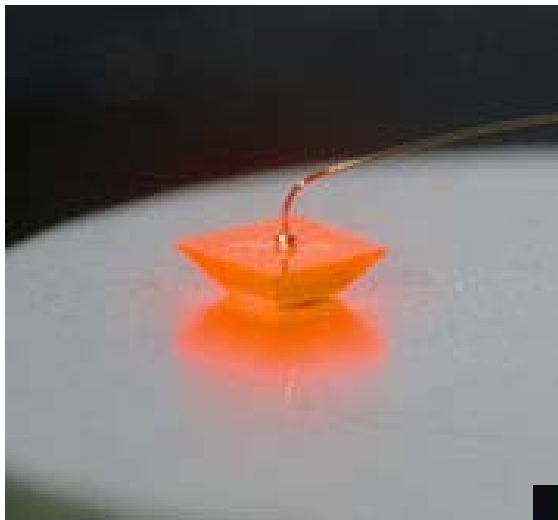
Structure of a high-brightness LED.
Source: Lumileds™

The LED Die

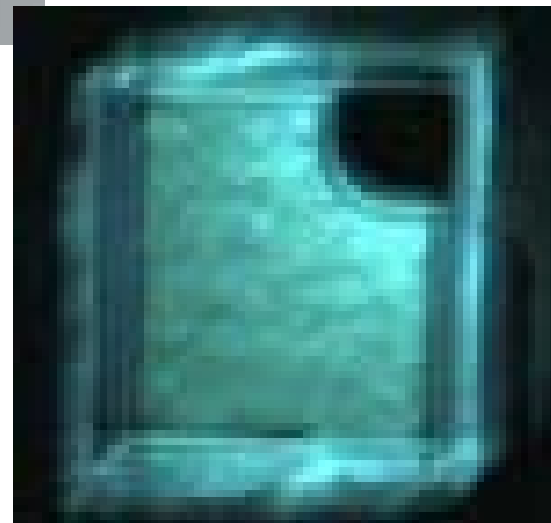
The LED Package or Device

The LED Module or Array

The LED Light Engine



Source: Lumileds



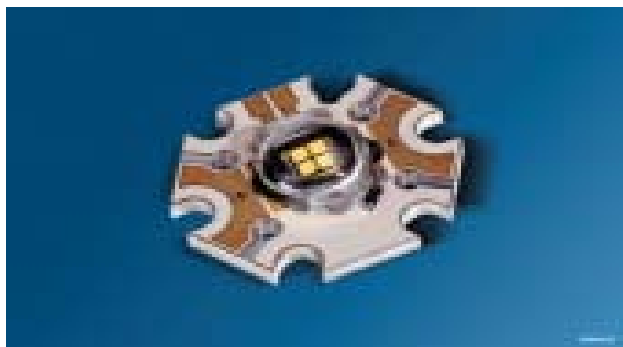
Source: Cree

The LED Die

The LED Package or Device

The LED Module or Array

The LED Light Engine

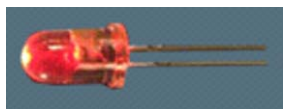


Source: Osram Opto



Source: Lumileds

Die integrated into an assembly



Source: Lamina

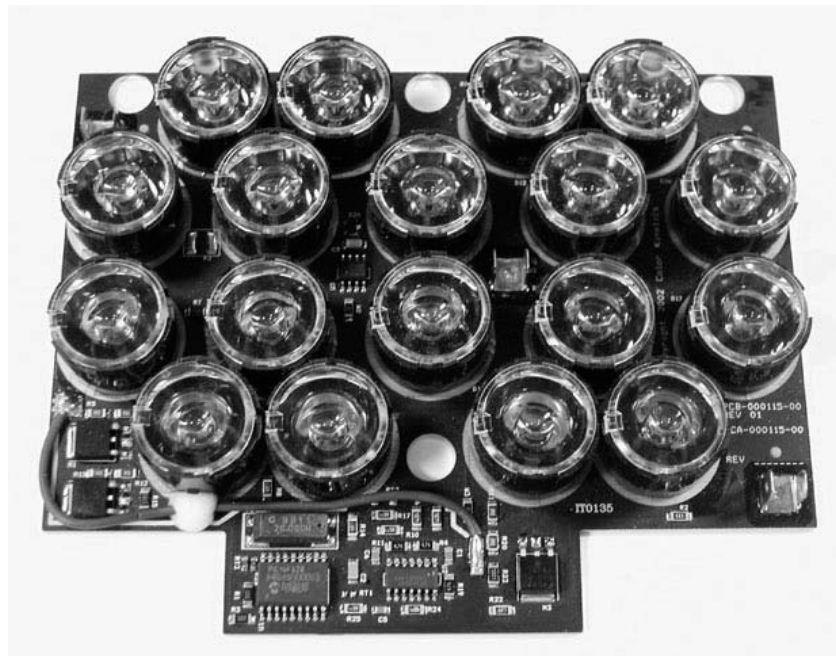
The LED Building Blocks

The LED Die

The LED Package or Device

The LED Module or Array

The LED Light Engine



The LED Building Blocks

The LED Die

The LED Package or Device

The LED Module or Array

The LED Light Engine



Elements of the LED System

Component

Devices that
can not be
self-operated



LED Component, Array, Module, Driver

Subsystem

Devices that can
be self-operated



LED Lamp, Source System, Engine

System

Devices that are
used by the end
user

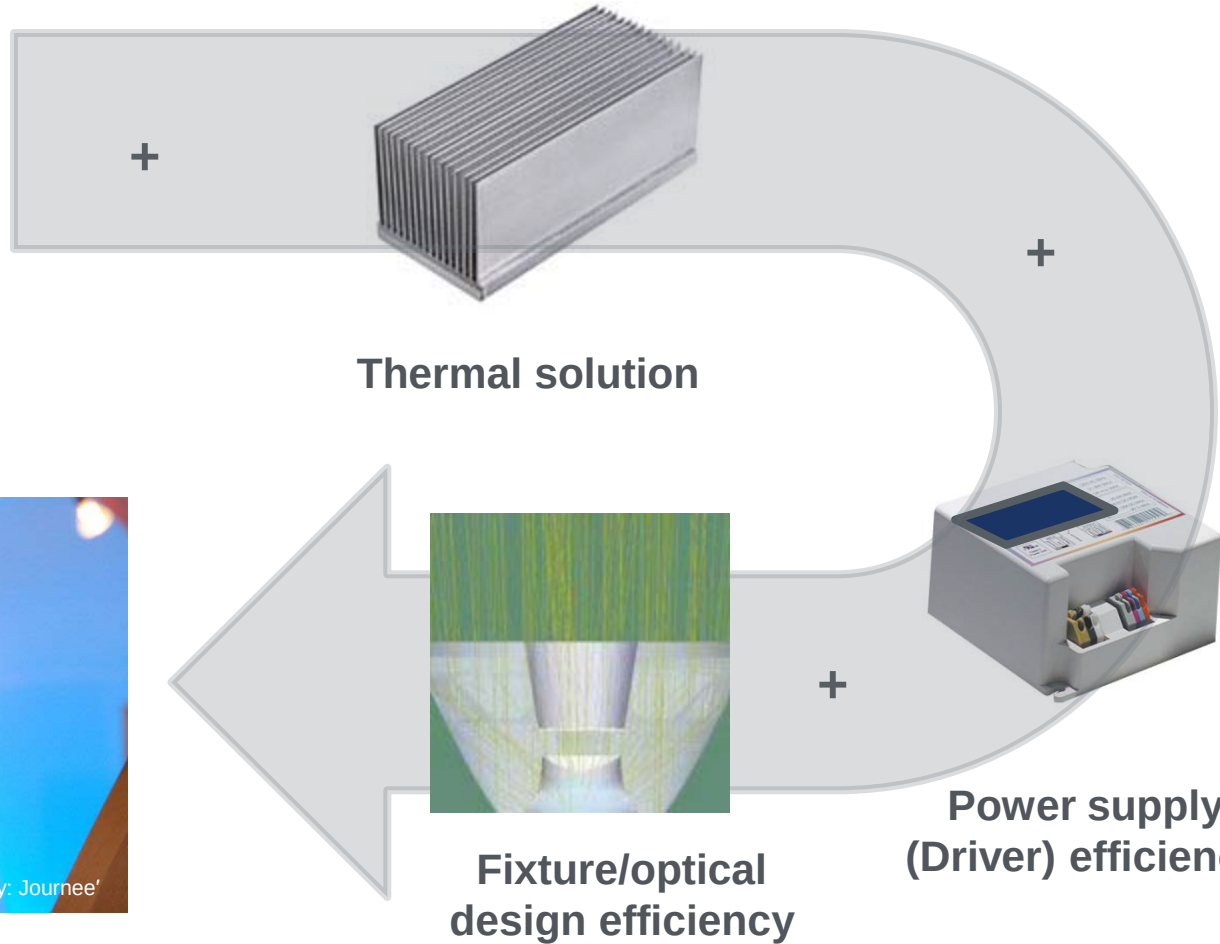


LED Luminaire, Hybrid LED Luminaire

Efficiency is the sum of the parts...



LED package efficacy

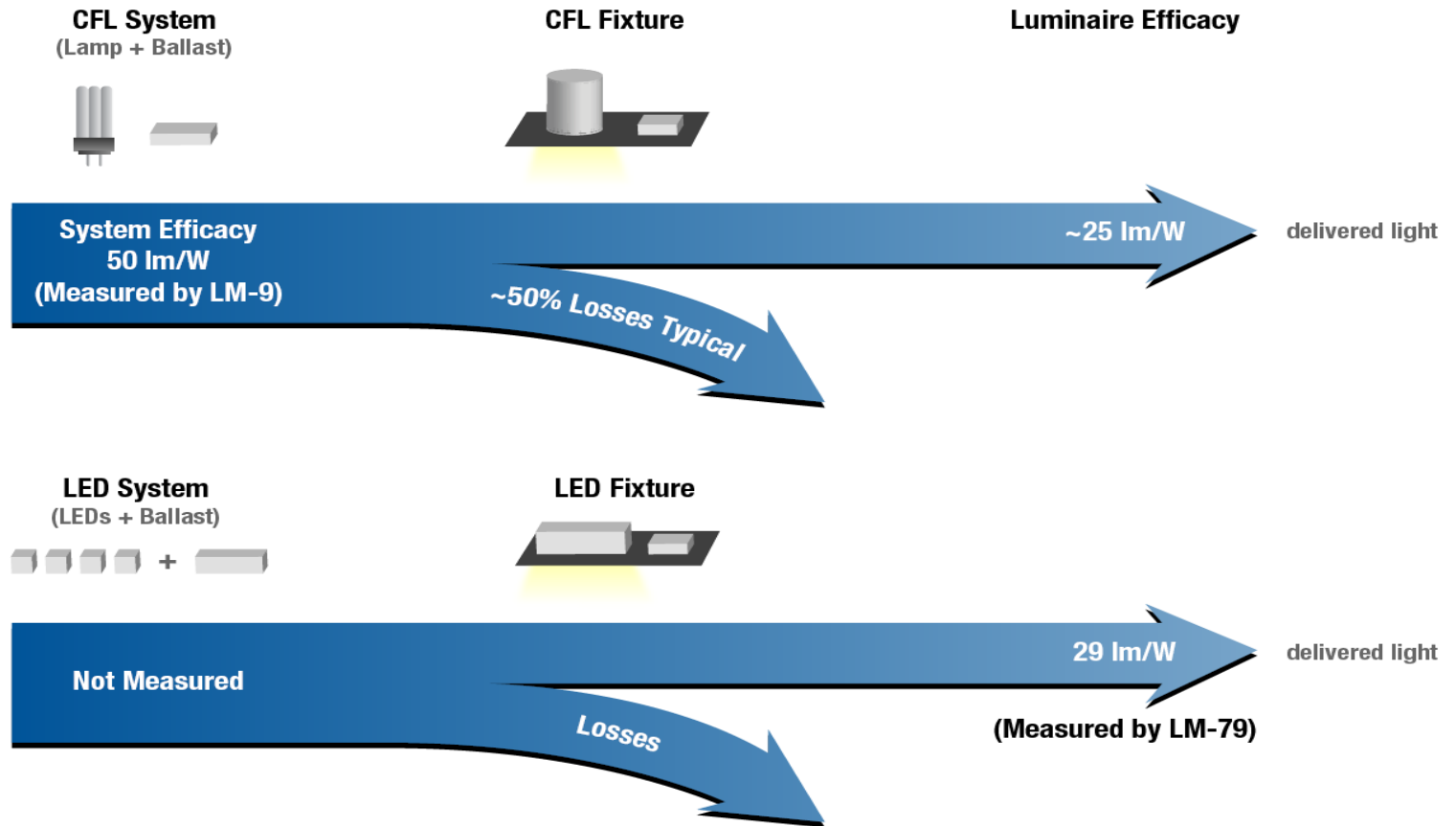


Resultant Luminaire efficacy

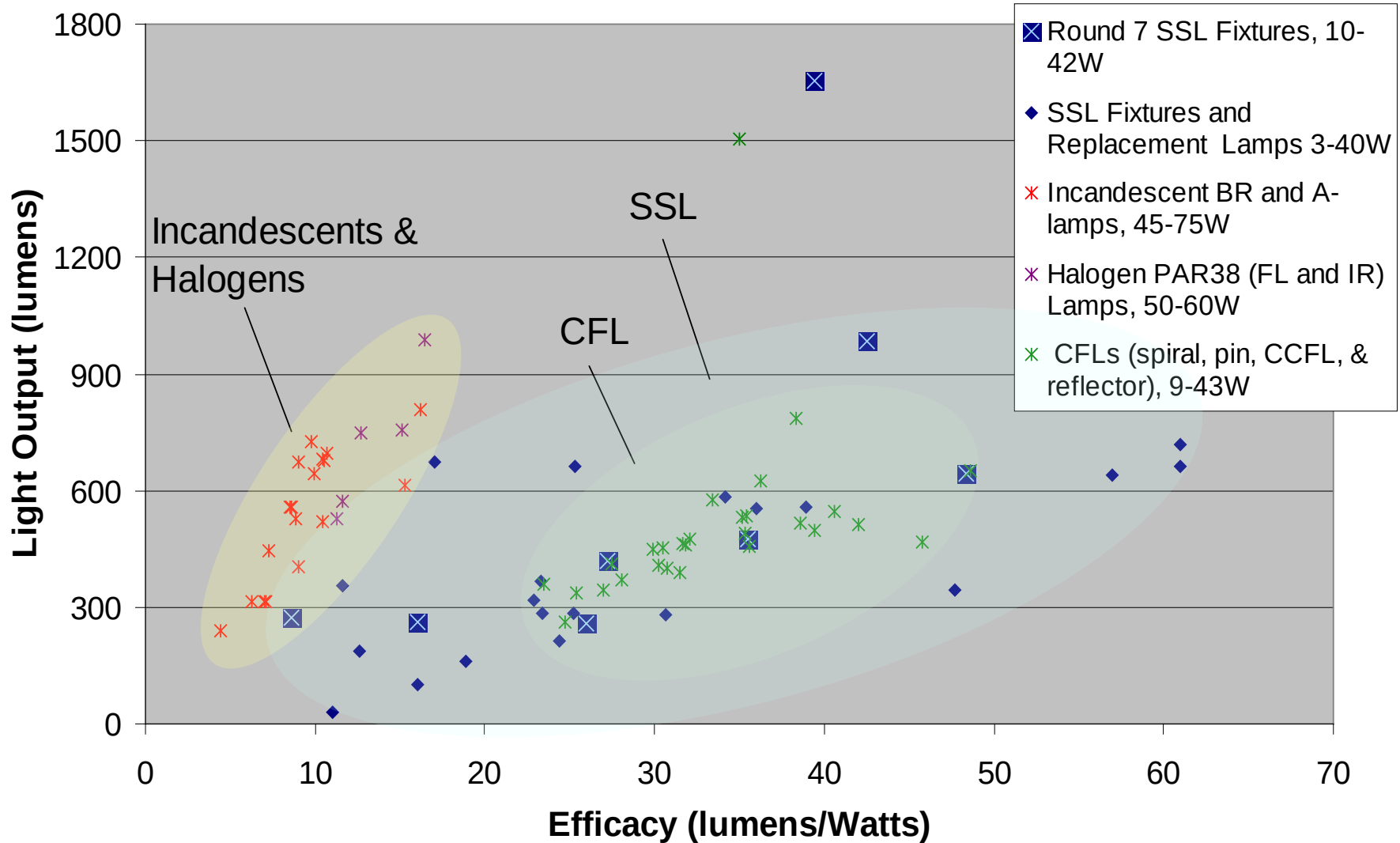
How many Efficacies are there?

- Efficacy = Lumens/Input Power
- The type of efficacy depends on the technology, under what conditions it operated and where power is measured
- Input Power measured at the:
 - lamp/source but does not include ballasts, drivers or power conversion = **Lamp Efficacy**
 - AC power source (includes ballasts, drivers or power conversion) = **Source/System Efficacy***
 - AC power source but lumens are measured net of the luminaire = **Luminaire Efficacy**
 - AC power source but only lumens contributing to a specific application are measured = **Application Efficacy**
- Mean what you say and say what you mean!

System Efficacy Vs. Luminaire Efficacy (Recessed Downlights Example)



So how do LEDs Compare?



- Provide objective, high quality performance information of market available LED products
 - To support R & D planning
 - To support development of programs
- Provide independent testing data for use in industry test procedures and standards development
- Discourage low quality products
- Reduce SSL market risk due to buyer dissatisfaction from products that do not perform as claimed:

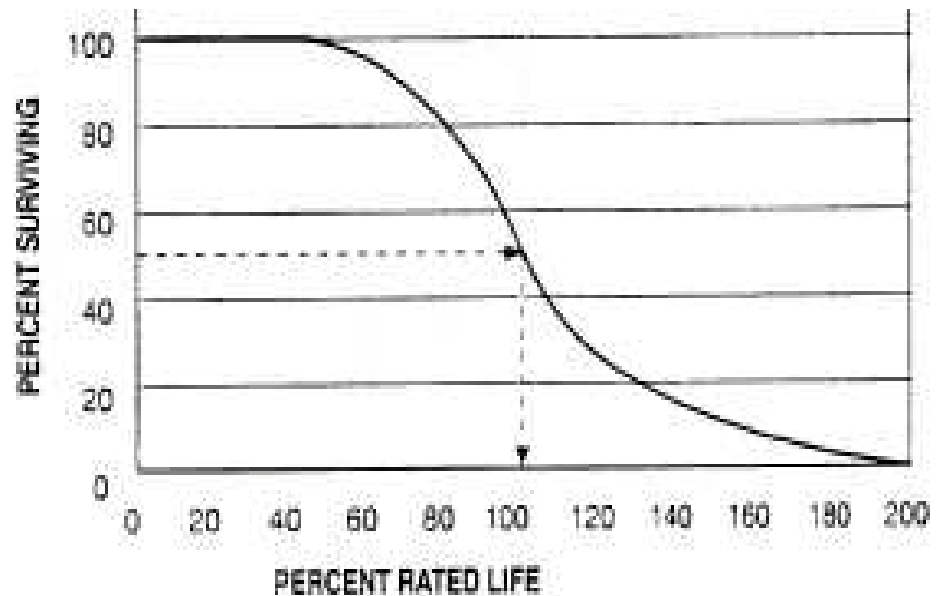
**“LEDs Produce
No Heat”**

**“LEDs last
forever”**

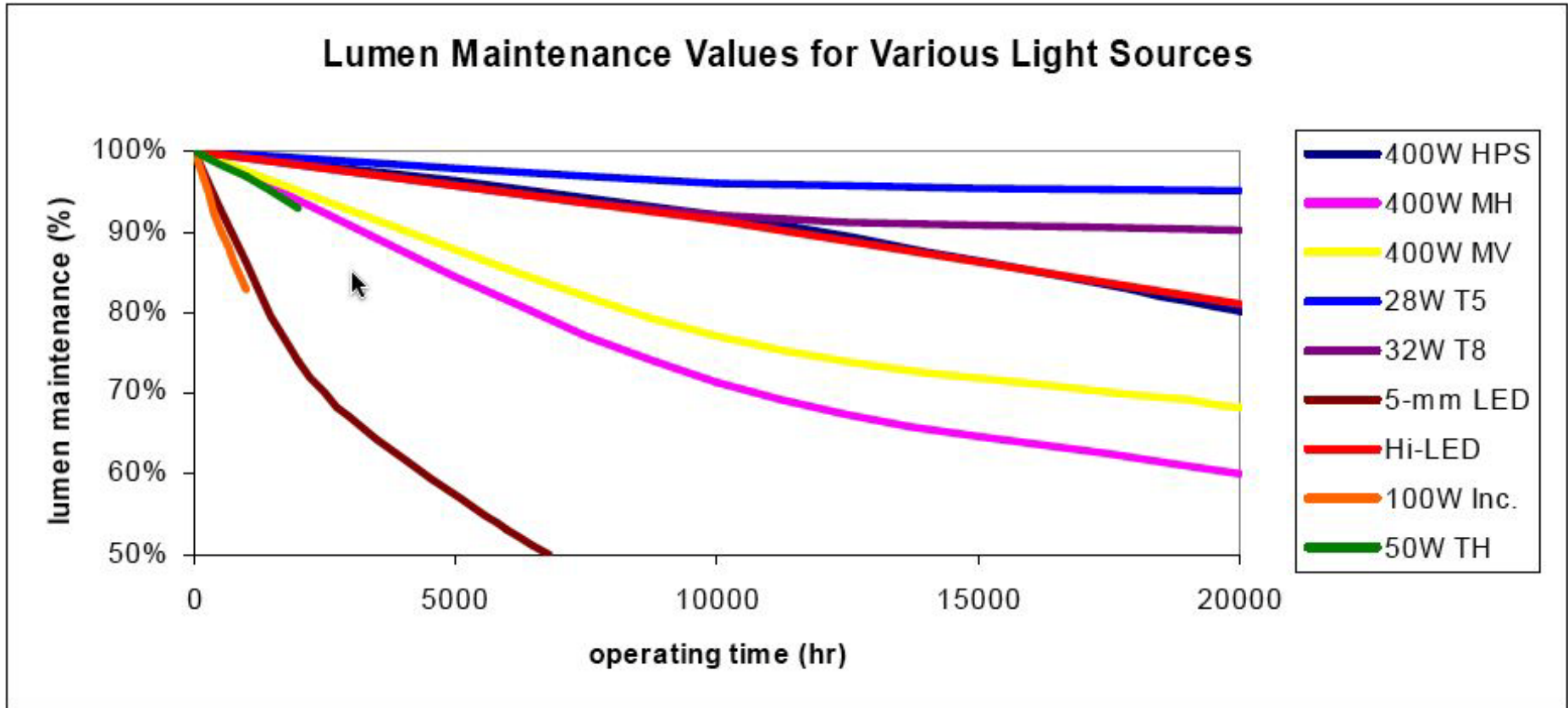
**“LEDs are VERY
efficient”**

- Lumen depreciation vs. catastrophic failure
- Definition of rated life for traditional light sources
 - 50% of a large sample “still going...”
- LEDs use L_{70} for general illumination

Typical lamp mortality curve



Lumen Maintenance of Traditional Sources



- IESNA - A difference in illuminance of about 1/3 is a perceptible difference.
- General illumination is often about maintaining a norm - consistency
- 30% down is a reasonable basis
- Some existing sources exhibit similar L values
- L_{50} can be used for decorative lighting but not for general illumination
- Emergency lighting values outside scope

What's in a label?

Light Output/Lumens

Measures light output. The higher the number, the more light is emitted.

Reported as "Total Integrated Flux (Lumens)" on LM-79 test report.

Watts

Measures energy required to light the product. The lower the wattage, the less energy used.

Reported as "Input Power (Watts)" on LM-79 report.

Lumens per Watt/Efficacy

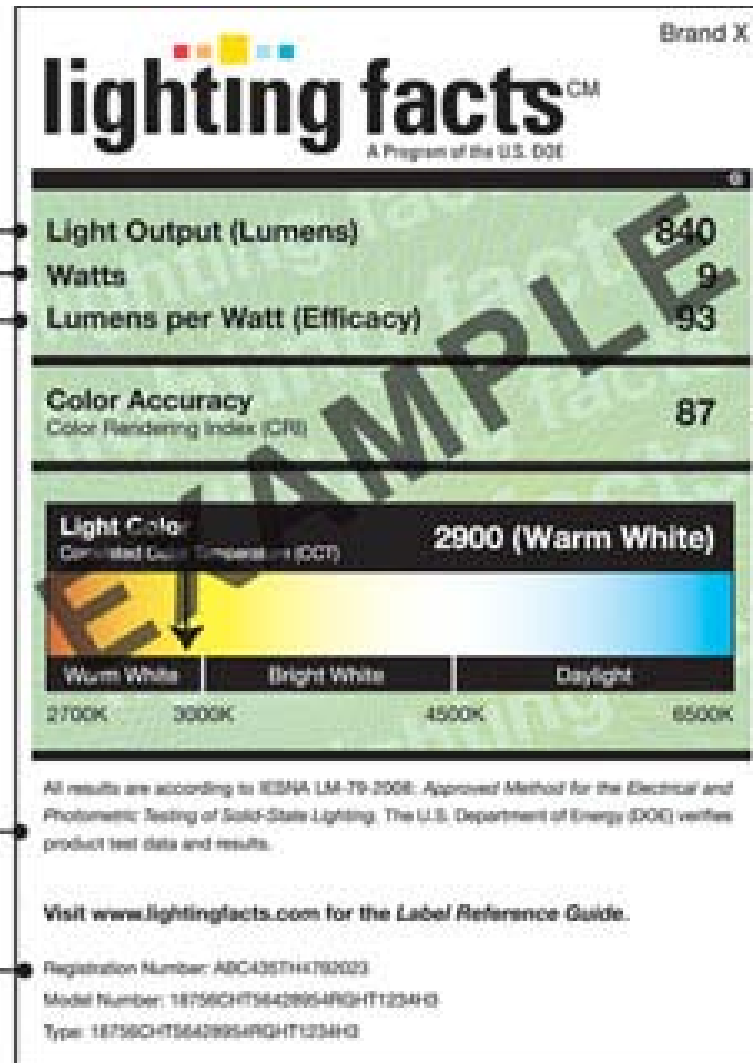
Measures efficiency. The higher the number, the more efficient the product.

Reported as "Efficacy" on LM-79 test report.

IESNA LM-79-2008

Industry standardized test procedure that measures performance qualities of LED luminaires and integral lamps. It allows for a true comparison of luminaires regardless of the light source.

Registration Number Model Number Type



Brand X

Brand

Color Rendering Index (CRI)

Measures color accuracy.

Color rendition is the effect of the lamp's light spectrum on the color appearance of objects.

Correlated Color Temperature (CCT)

Measures light color.

"Cool" colors have higher Kelvin temperatures (3600–5500 K); "warm" colors have lower color temperatures (2700–3500 K). Color temperatures higher than 6500 are outside of the defined region for white light, but may be appropriate for outdoor applications.

- Stick around... there's lot more coming in the DOE booth!
- Fact Sheets... behind you!
- Main DOE website: www.ssl.energy.gov
- DOE's Commercially Available LED Product Evaluation and Reporting program (CALiPER):
www.ssl.energy.gov/caliper.html
- Look for the "Lighting Facts": www.lightingfacts.com
- ENERGY STAR®: www.energystar.gov
- IESNA Standards and Guidelines: www.iesna.org