SSL Workshop: Technology and Market Inputs to Efficiency Program Design

October 14, 2008

Loews New Orleans Hotel

CEE

Working Together, Advancing Efficiency

Agenda Review

- ✓ Introductions
- Technology Overview
- (Lunch)
- CALiPER
- Manufacturer Panel
- (Break)
- Efficiency Program Panel

Ground Rules

- We will:
  - Comply with CEE Meeting Guidelines
  - Use Parking Lot for New Questions
    - Look for ways to continue the conversation
  - Volunteer resources for everyone's benefit
  - Identify name when making comments
  - Value all perspectives
    - All questions are sought
  - Take a learning posture
  - Seek product/manufacturer neutral solutions

SSL Technology Overview

Rebecca Foster, CEE

October 14, 2008

Not Your Typical Presentation

- Five key questions
- Steps
  1. Group activity
     - Talk about each question in your groups - use resources!
     - Develop an answer - everyone in your group should agree
  2. Share your group's answer
     - Uncover myths and get new information
     - Review "Answer" slides with details on each question
     - Debrief and dig deeper

Question 1

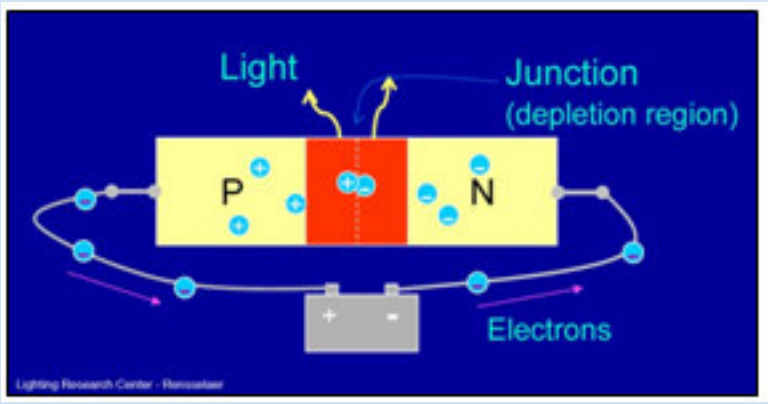
What is Solid State Lighting?

What is SSL?

- Lighting that uses semi-conducting materials to convert electricity into light
- SSL is an umbrella term encompassing different technologies, e.g. LEDs and OLEDs
  - All LED lighting systems are therefore solid state lighting systems as well

What is an LED?

- Electrical device that produces light through movement of electrons in a semiconductor material
- Several layers of semi-conductor material
- Light is generated in the PN junction when a current is applied



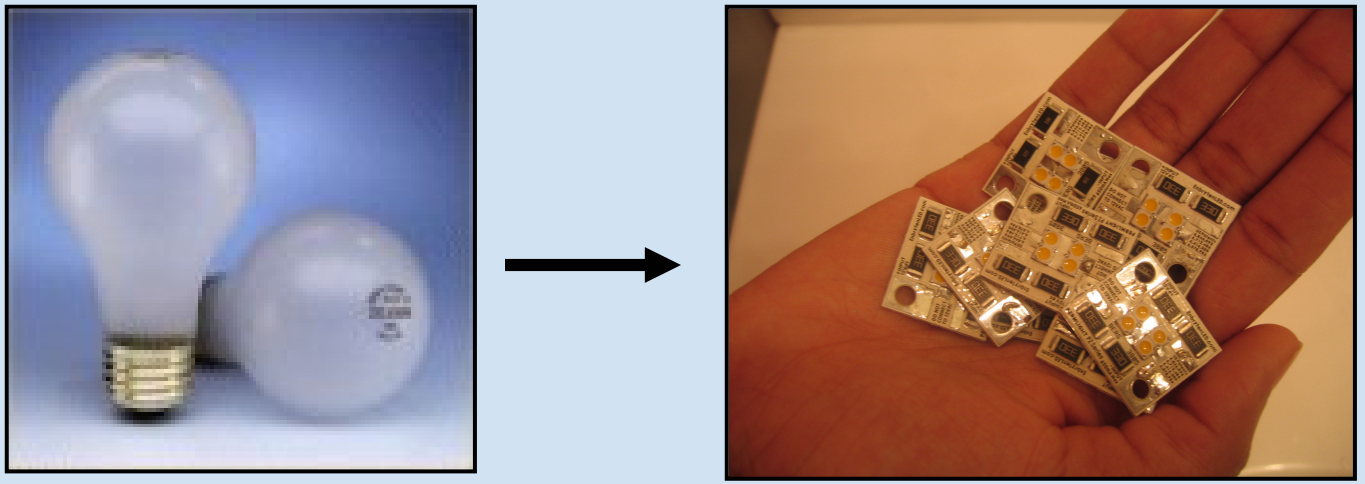
Stephen DenBaars

Question 2

How is SSL different from other light sources?

What is the significance of those differences?

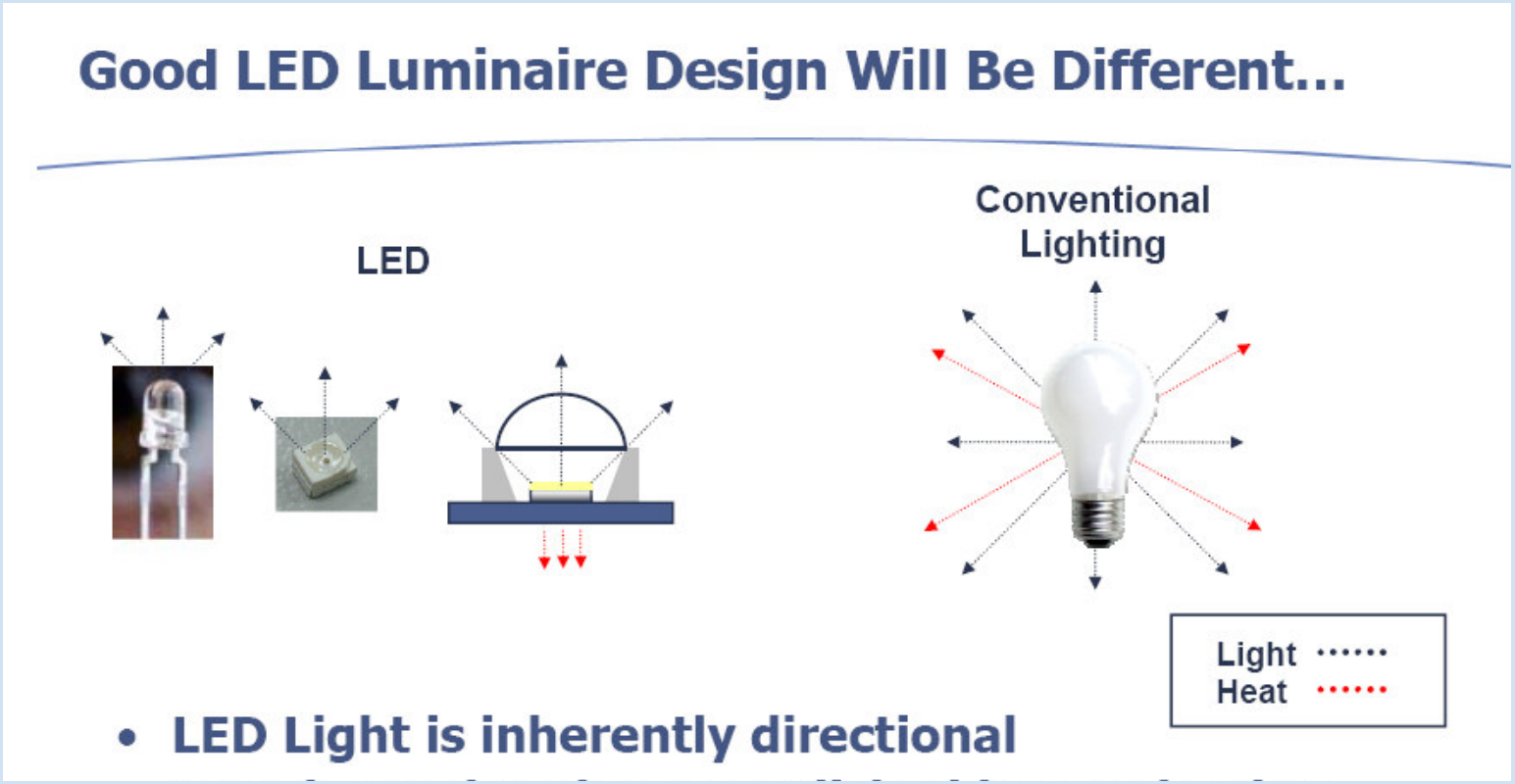
Not the Same Old Light Bulb



Major Differences in…

- Directionality
- Heat Management
- Lifetime
- Color
- Efficiency
  - (Will save this for next question)

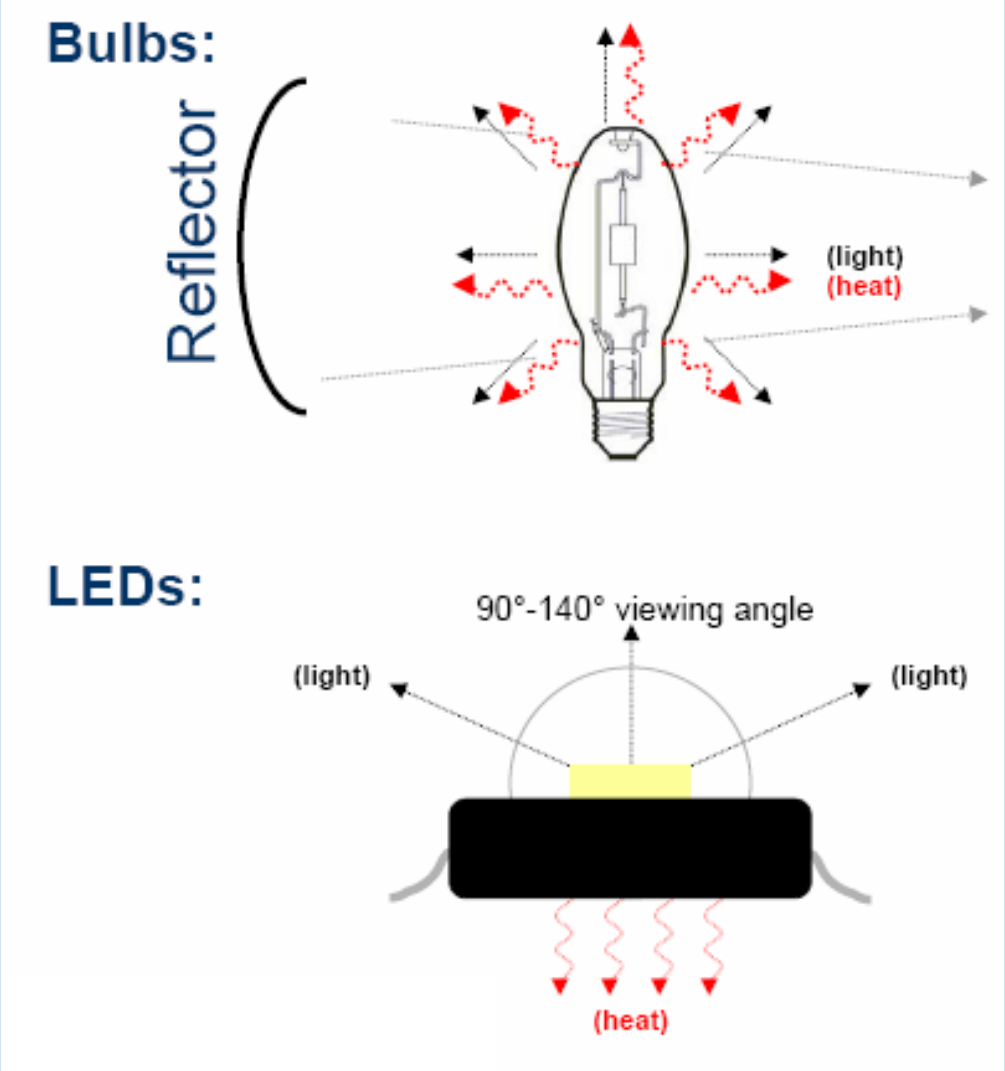
Directional Light



Mark McClear

Heat

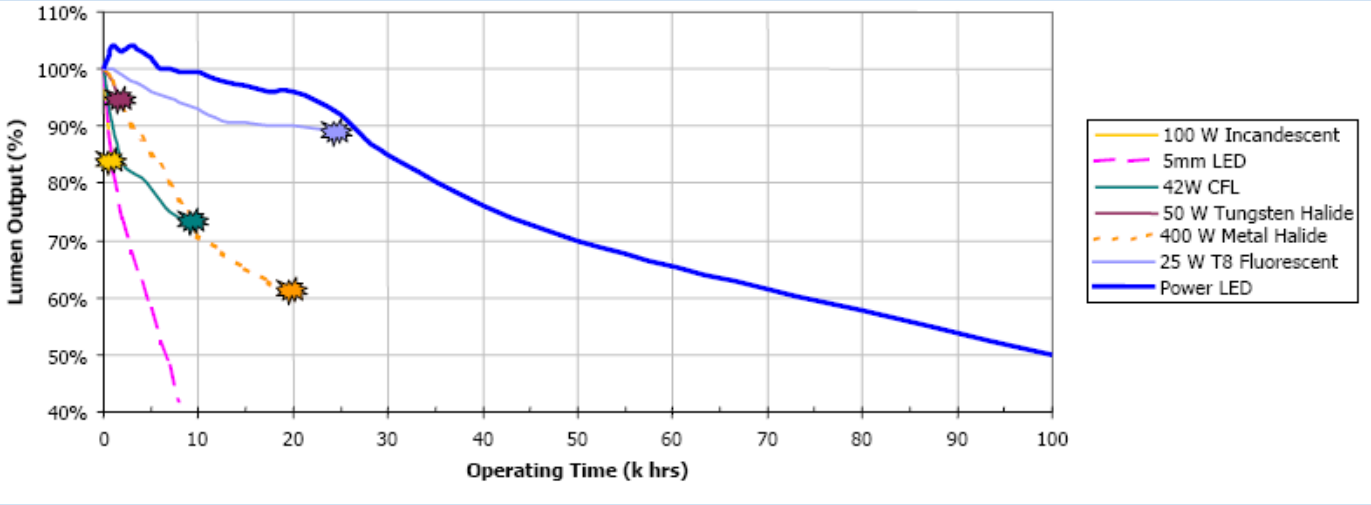
- LEDs transfer heat through conduction, not convection



Mark McClear

Lifetime

- Don’t burn out, but do get dimmer over time
- End of life is when the LED is “too dim” to do the job



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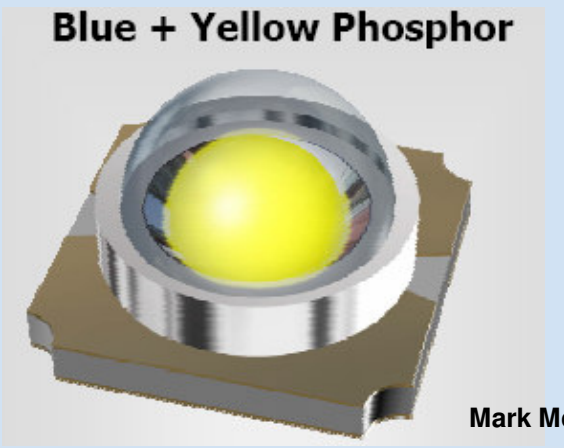
Color

- Unlike an ordinary light bulb which emits a continuous spectrum of light, the LED light is monochromatic
- The color of light depends on the materials
- Two ways to make white light:



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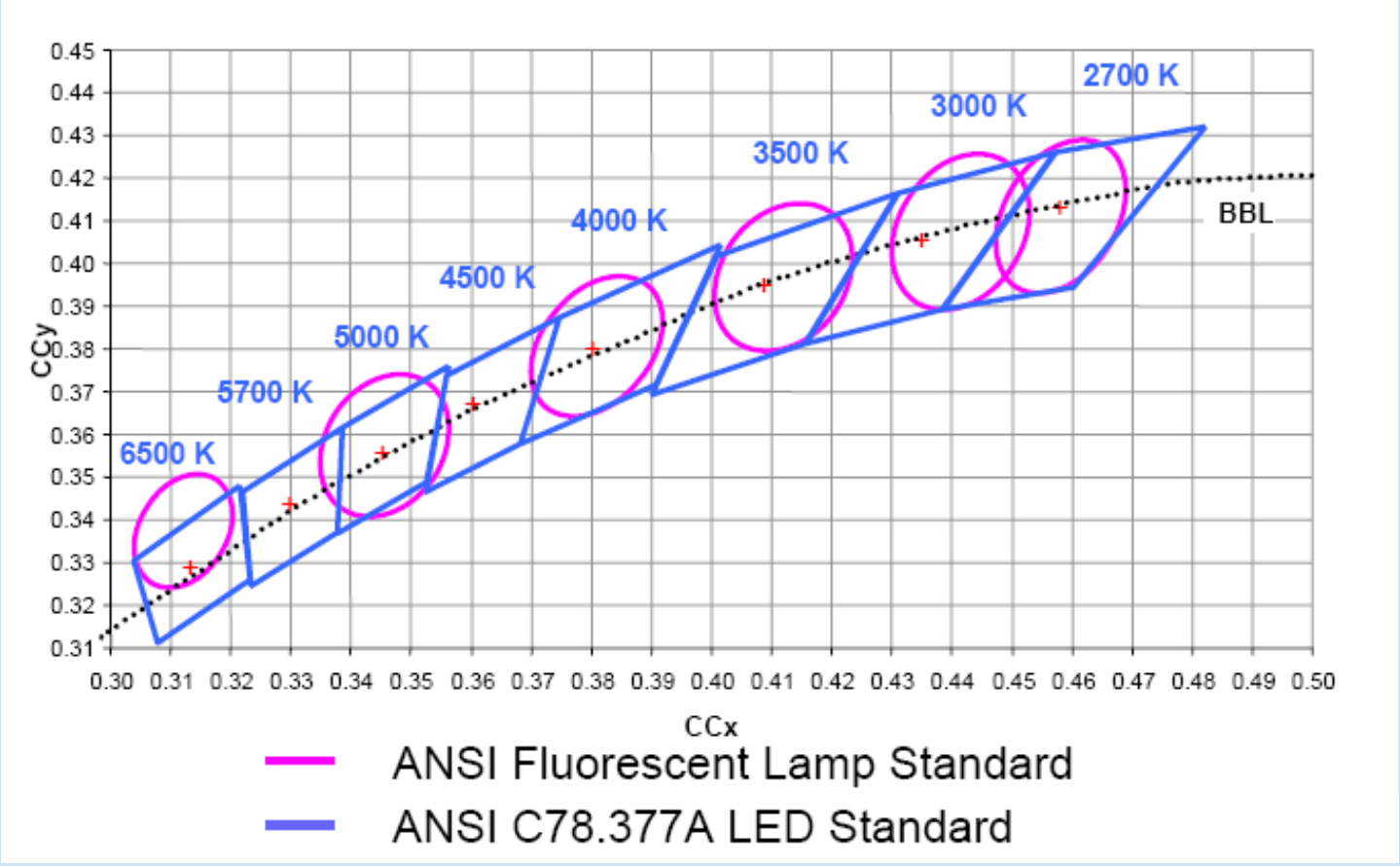
Fluorescent and SSL Color



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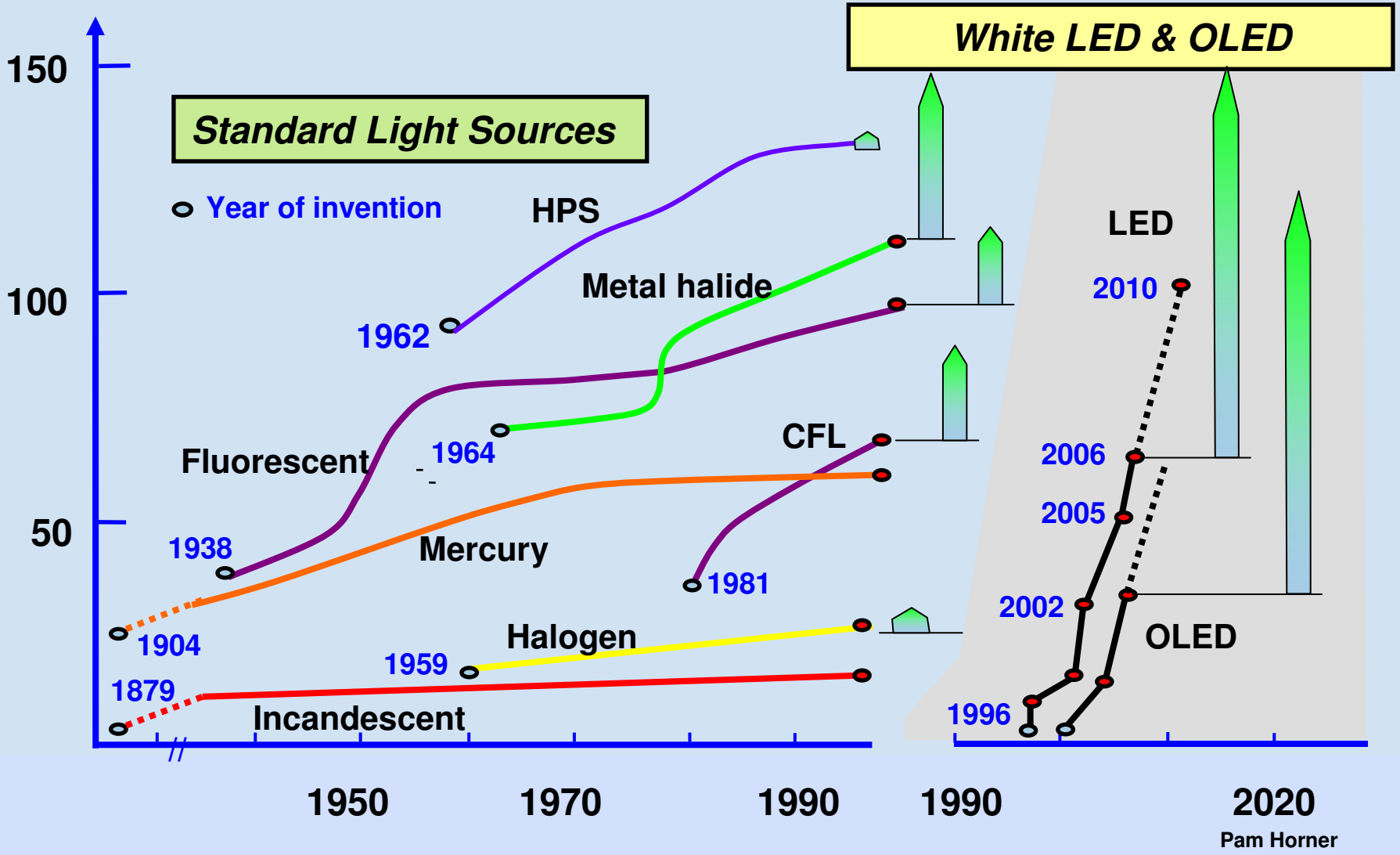
Other Differences

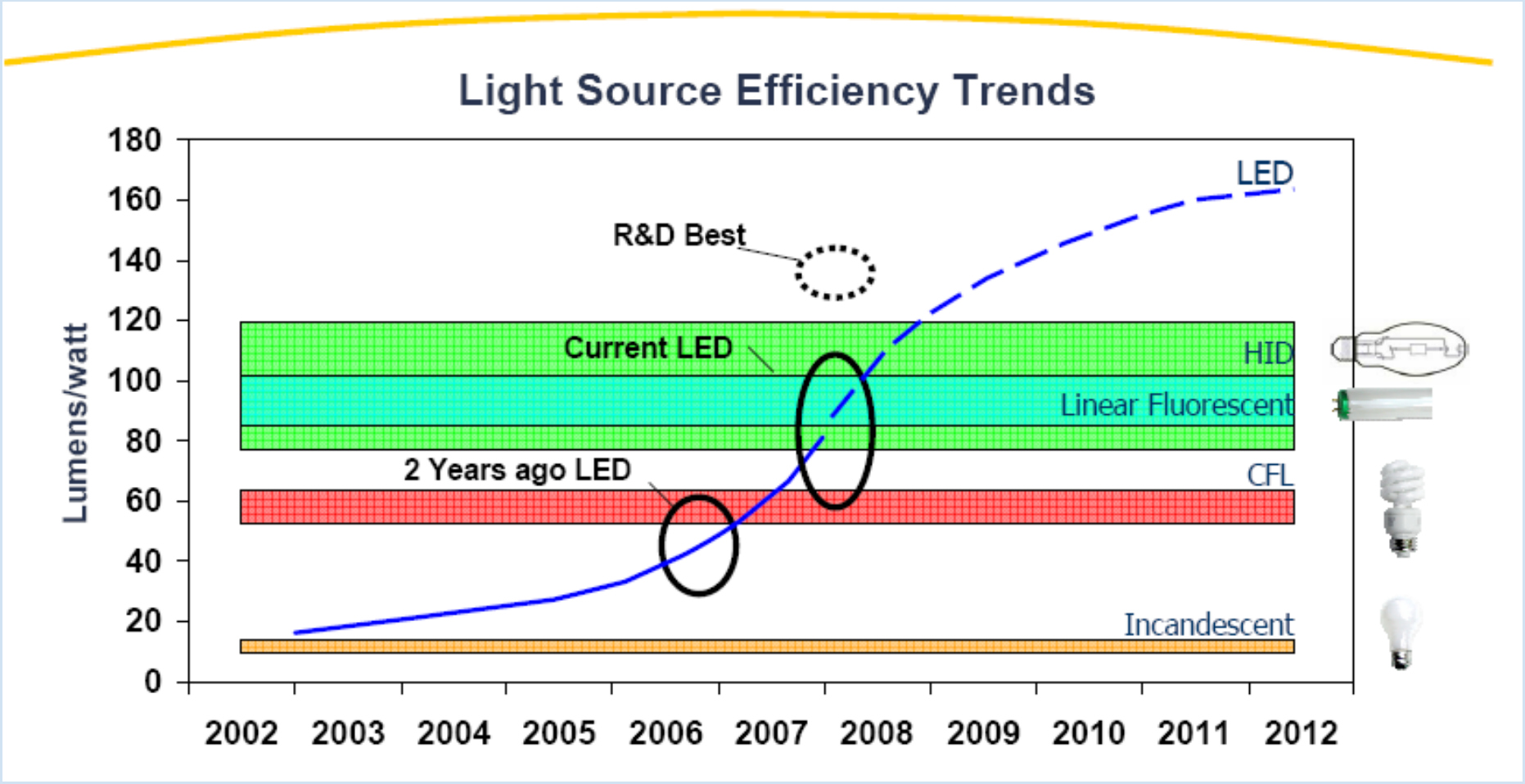
- Controllable
- Tolerant of cold temperatures
- Rugged (no filament to break)
- Mercury-free
- Instant on
- Compact size
- Industry (semiconductor, not light bulb)

Question 3

Why is SSL important for energy efficiency?

Efficiency Over Time





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Question 4

How is SSL performance measured?

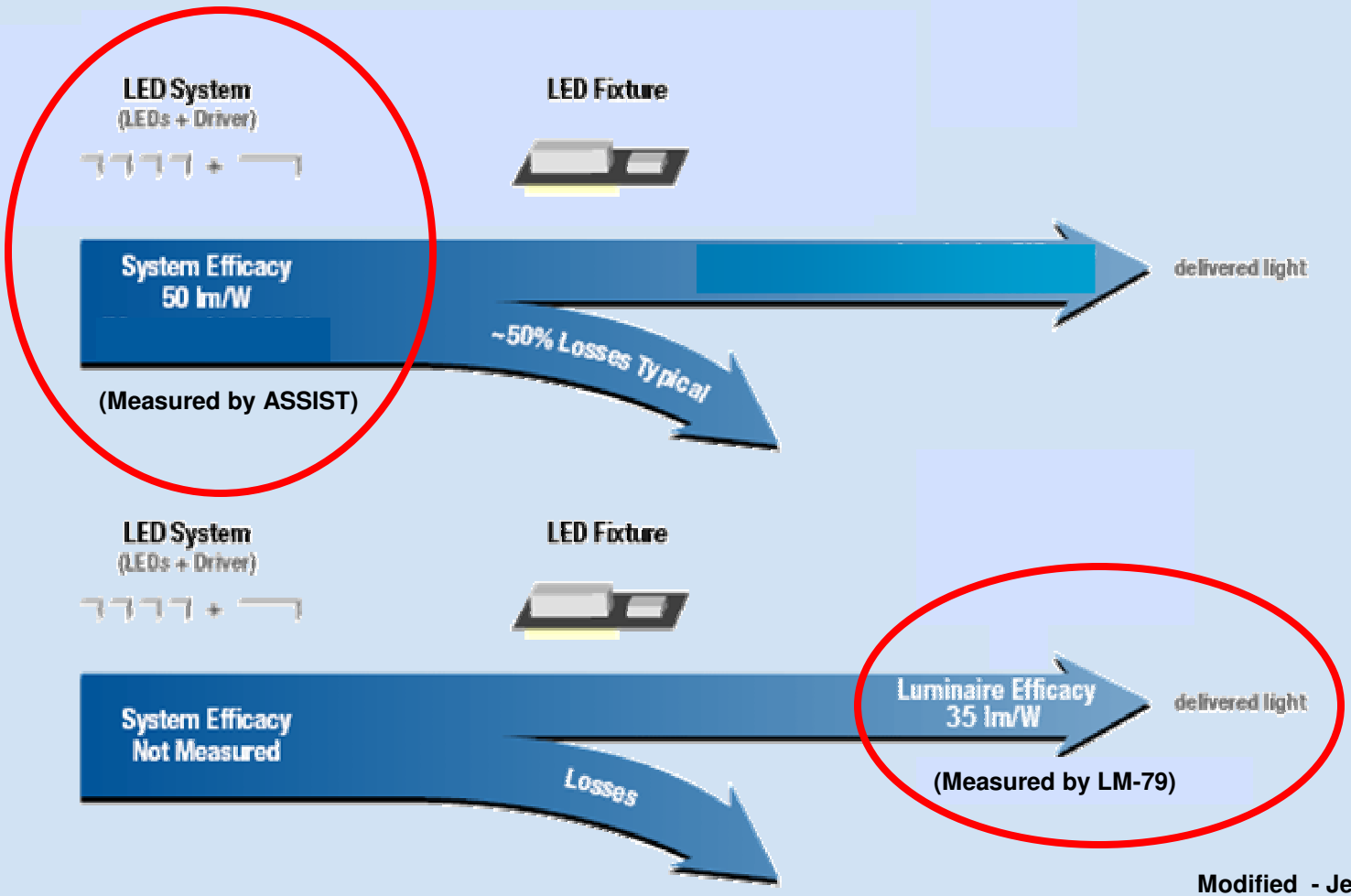
- **Efficiency**
- **Lifetime**

Efficacy

- Efficacy = Lumens / Wattage
- Can define the inputs differently
  - Luminaire efficacy uses lumens *delivered* by the luminaire
    - DOE approach
    - Measured by LM-79
  - Light engine or source efficacy uses lumens *generated* by the LED
    - EPA approach
    - Measured by *ASSIST* Recommends

System Efficacy Vs. Luminaire Efficacy

(Recessed Downlights Example)



Modified - Jeff McCullough

LM-79

- LM-79 is an industry standard
- Provides a consistent and repeatable method
  - Results are compiled in detailed reports and summary reports
    - Luminaire light output
    - Luminaire efficacy
    - Color
    - Distribution
    - Electrical characteristics

ASSIST Recommends

- *ASSIST* for Light Engines is a testing recommendation developed at LRC
- Currently not an industry standard; may be used as a starting point for an IES standard
- Tests at three temperatures (Ts) to help create a better estimate of actual performance in situ
  - 40%, 60%, and 80% of Tj max

Lifetime

- Because LEDs “fade away” need to test them to the end of their useful life
  - 70% of initial lumens, L70, for general illumination
- LM-80 standard
  - Run for 1,000 hours
  - Measure initial lumens
  - Run for 5,000 hours
  - Measure lumens again and compare to initial

What happens after 5,000 hours?

- IES is developing TM-21
  - Would explain the process for extrapolating L70 from the data generated in LM-80
  - Not a standard, but a test method
- DOE ENERGY STAR
  - Has created a pass/fail threshold
  - For 25,000 hour applications, must be >91.8%
  - For 35,000 hour applications, must be >94.1%

Question 5

How will SSL change residential and commercial lighting?

- **In 2010?**
- **In 2012?**
- **In 2015?**

LED Device Performance Projections

Metric	2007	2010	2012	2015
Efficacy-Lab (lm/W)	120	160	176	200
Efficacy-Commercial Cool White (lm/W)	84	147	164	188
Efficacy-Commercial Warm White (lm/W)	59	122	139	163
OEM Lamp Price-Product ($/klm)	25	10	5	2

US DOE SSL R&D MYPP, March 2008, table 4-2.