



LED Market Status Update

Mark McClear
mark_mcclear@cree.com

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LEDs Have Come A Long Ways...

- Dramatic improvement over the last two decades in
 - Brightness
 - Energy efficiency
 - Cost reduction
 - Color point stability
 - Lighting applications know-how

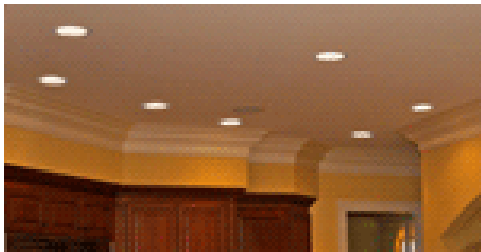


*Courtesy of
Beta
Lighting*



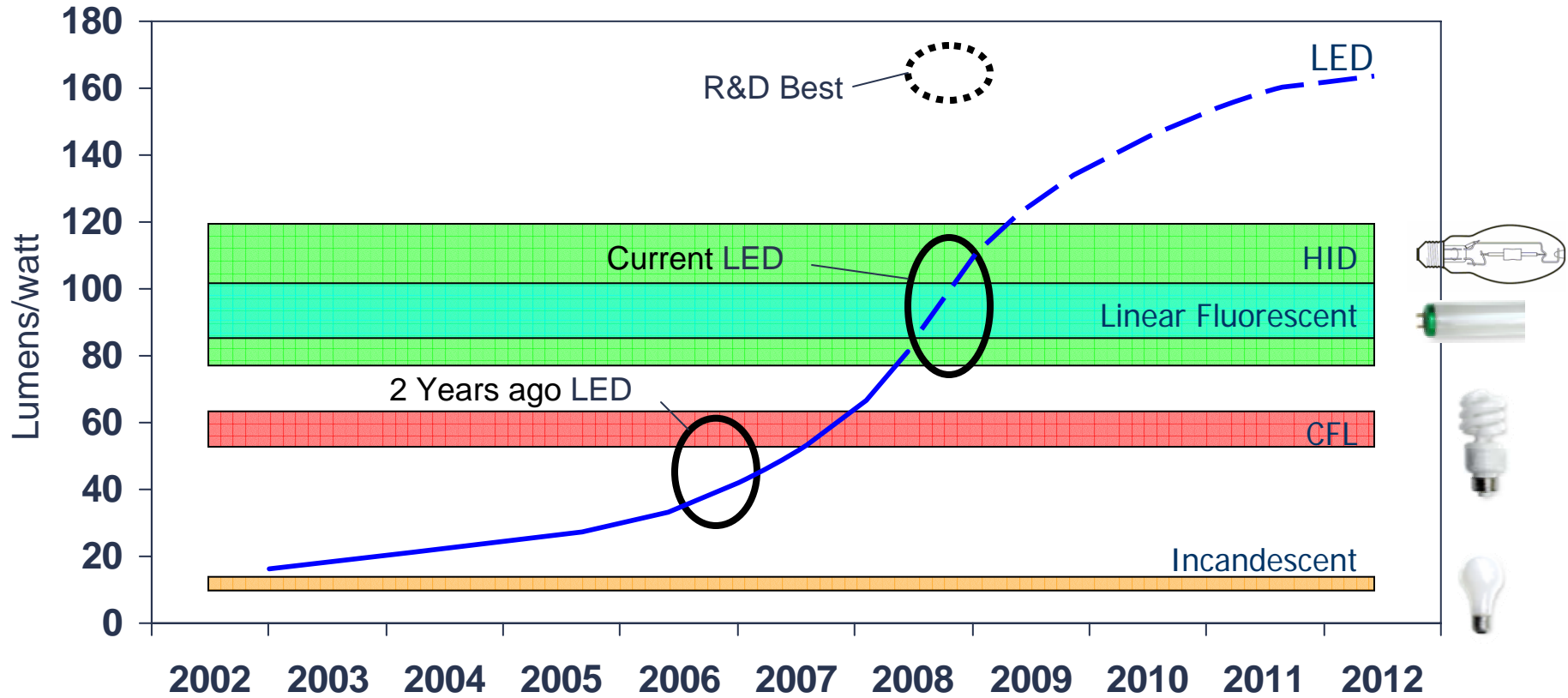
- Cree achieved major tipping point in October, 2006, enabling never-before-possible cool white outdoor lighting applications
- Major warm white LED technical milestone reached March 2007 enabling the same in indoor solid state lighting

*Courtesy
of LLF,
Inc.*



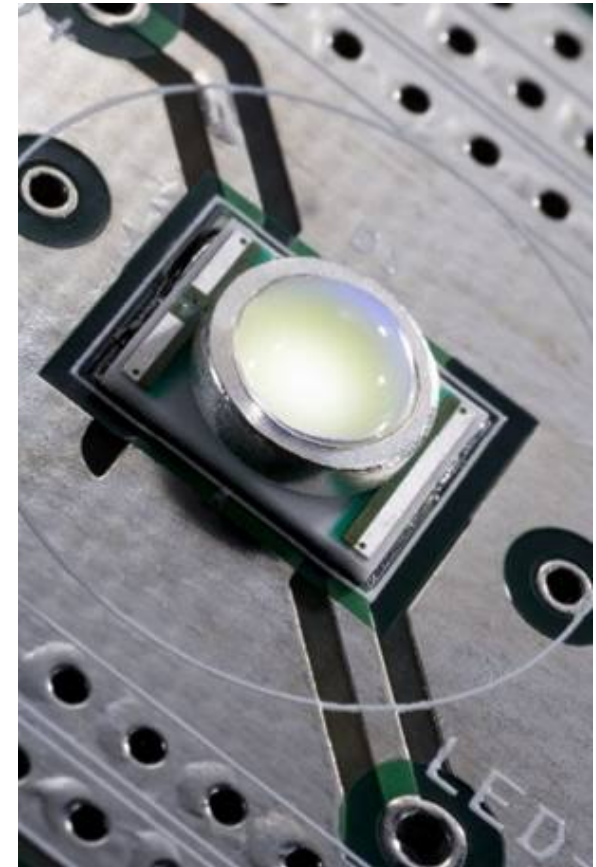
LED Performance vs. Traditional Light Sources

Light Source Efficiency Trends

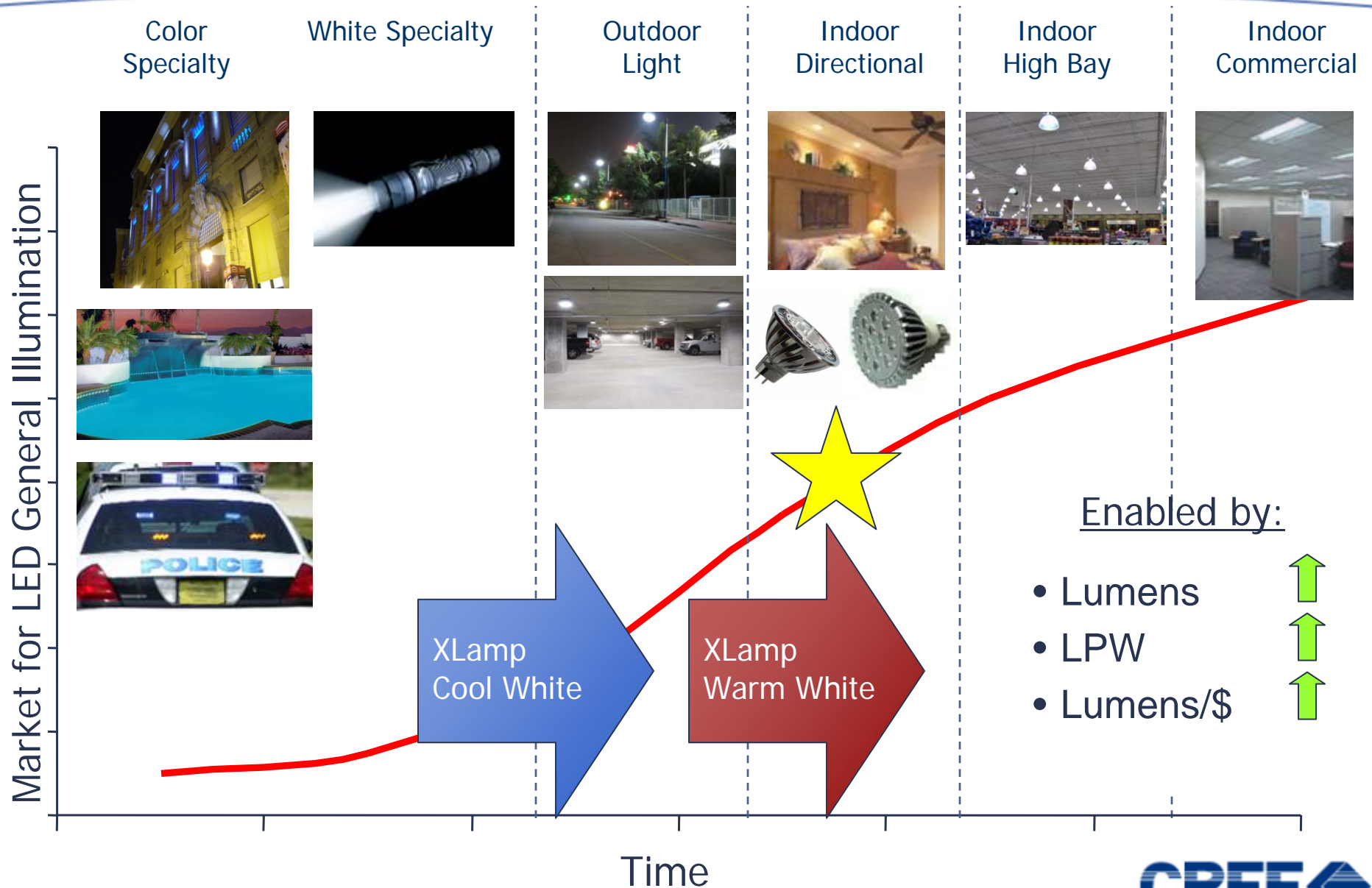


Basic Advantages of LED Light

- LEDs are...very **energy** efficient → >100LPW (near-term roadmap to >150LPW...)
- Are **directional** → No wasted light, any pattern possible
- Have very **long lifetime** → >50,000 hours to 70% Lumen Maintenance (L70)
- Are inherently **rugged** → No filament to break
- **Start instantly** → nanoseconds vs. > 10 min re-strike (HID)
- Are **environmentally sound** → no Hg, Pb, heavy metals
- Are **infinitely dimmable, controllable** → New lighting features, power savings
- Love cold temperatures → **No cold starting issues**



LEDs Deliver Value Segment-by-Segment



Making the Business Case Work



Initial applications will be driven by maintenance avoidance & energy savings

- Street & Parking lot lighting
- Parking garages
- Atrium
- Tunnels
- Hazardous work areas

Anchorage, AK



- Replacing 16,000 streetlights
- Initial installation of 4,000 streetlights saves \$360,000 a year.
- Total installation saves >\$1.5 million a year.



Courtesy of BetaLED



80% Energy Savings
Bi-level Outdoor Lighting

Raleigh, NC



New Raleigh Convention Center



49% less energy than HID
Payback in just over 3 years
Estimated \$636k savings over 15 years

Courtesy of BetaLED

Arezzo, Italy

High Pressure Sodium



LED



61% Energy Savings
< 3 year Payback

Courtesy of BetaLED

Thorntons Gas Station – Edgewood, KY



62% Energy Savings
Will use in 13 properties

Courtesy of BetaLED

Notre Dame University



STERNBERG
LIGHTING
Lighting up America Since 1923



U.S. DOE Gateway Project



Rayley's Supermarket, Chino, CA



346W Metal Halide

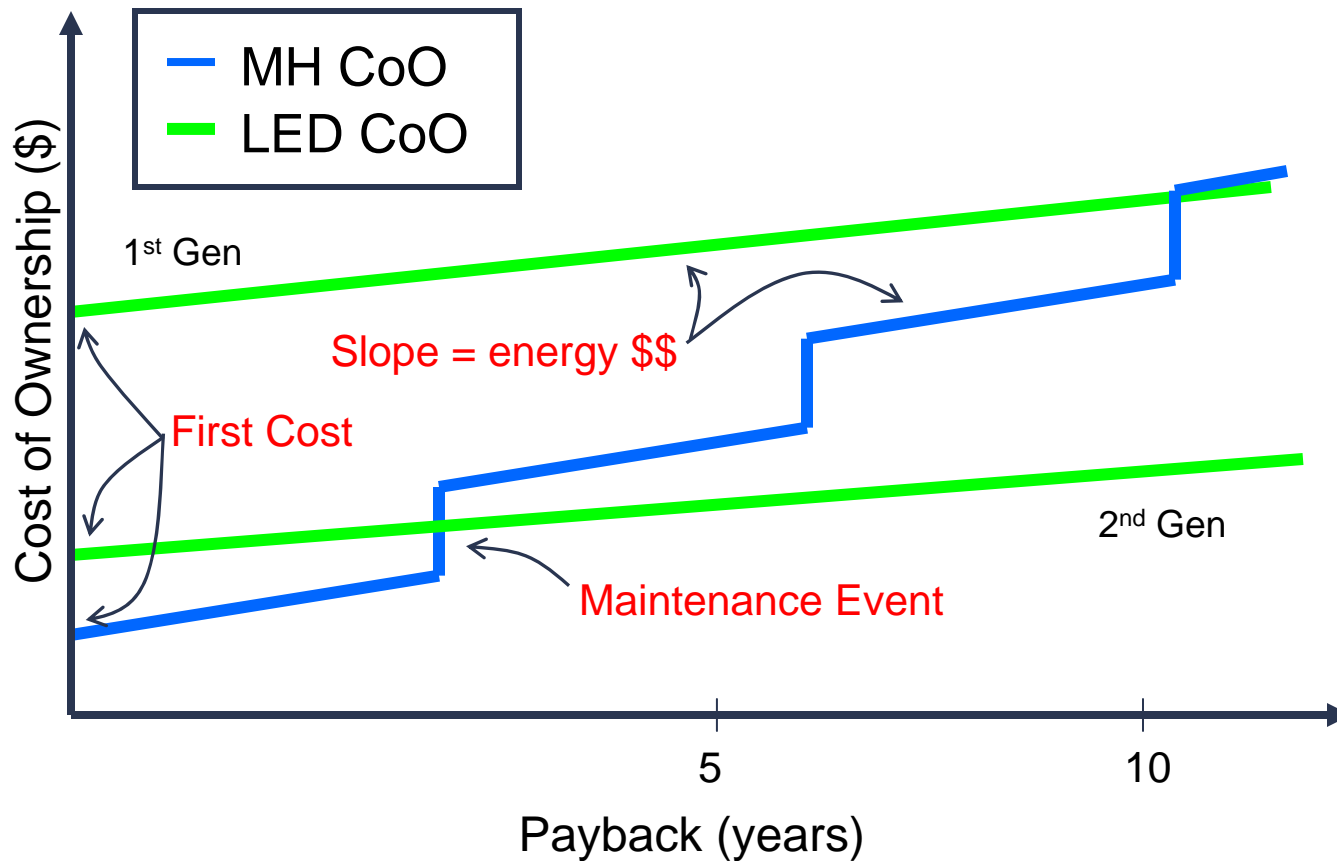


149/52W Bi-level LED System

- 70% Energy Savings
- 3.3/4.7 year simple payback (new construction/retrofit)

http://www1.eere.energy.gov/buildings/ssl/gatewaydemos_results.html

Generic Outdoor SSL Economics



1st Gen BetaLED



2nd Gen BetaLED



SSL fixture technology improvement will have at least as much impact as LED Technology



BEFORE

Incandescent 65W BR30 - Total Power = 5,135W



AFTER

Cree LR6 - Total Power = 948W

Indoor Residential Applications



Cree LR6



Indoor: Restaurants



- 80% Energy Savings
- Excellent Color Rendering (CRI >92)

Cree LR6

Restaurants (MR16 Retrofit)



LED:

- 0.6kw
- no UV, IR
- CRI ~90



Halogen:

- 2.5kw
- CRI ~99

NC State University Student Housing



Cree LR6



U.S. Pentagon



After – 288W = 33% Savings

Retail



Cree LED Lighting LRP38 – **Total Wattage = 36W**

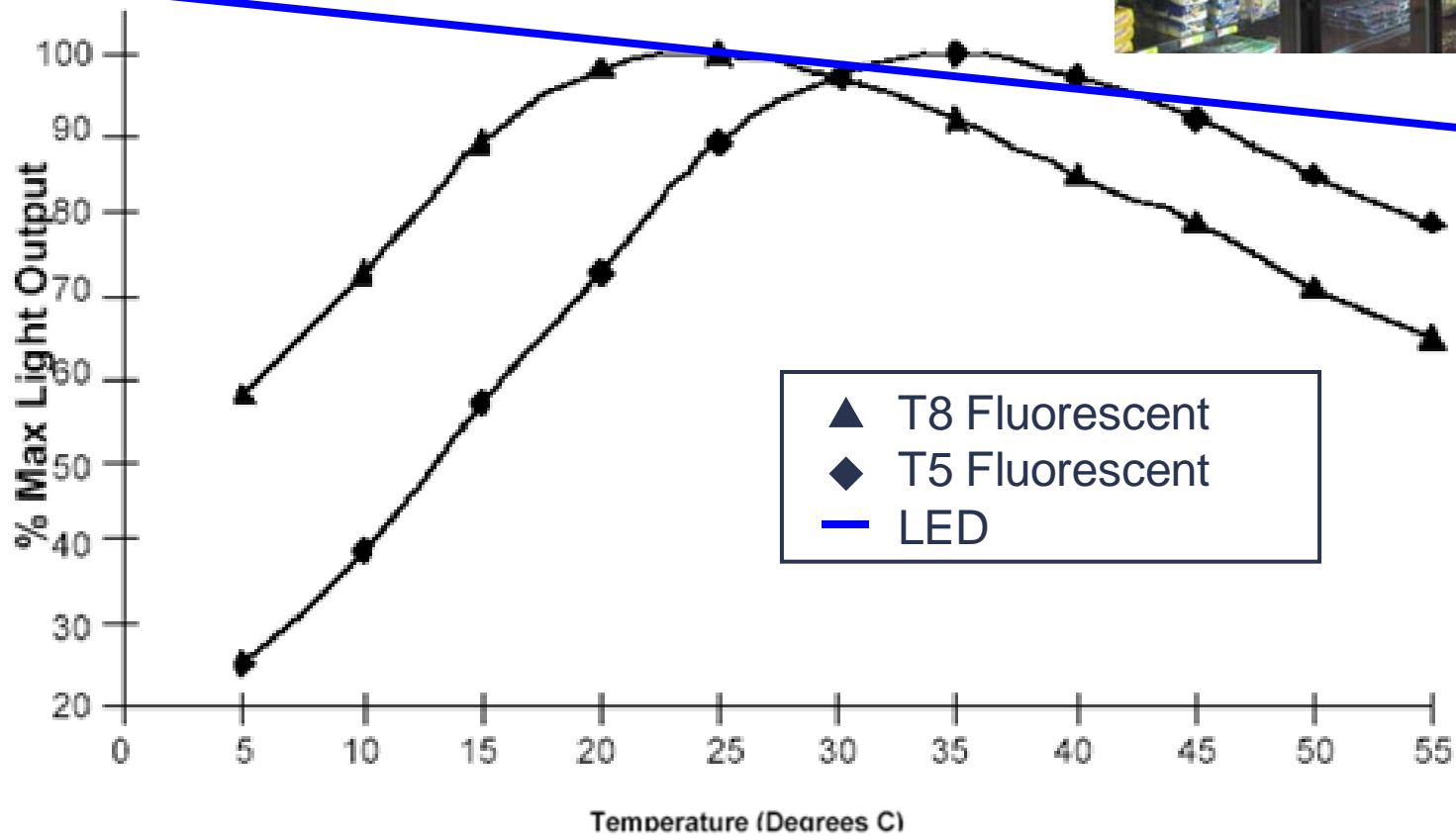


Ceramic Metal Halide – **Total Wattage ~ 158 to 237W**

Cold Temperature Performance



Typical Fixture Ambient Temperature Range



Source: Lighting Research Center, RPI

Next Big Potential Application



BEFORE
295W HPS



Below – 5.2fc
Vertical – 2.1fc

AFTER
160W LED



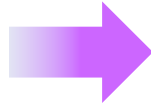
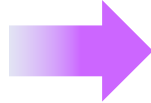
Below – 18.0fc
Vertical – 5.0fc

- 30'
- -26°C
- 45% energy savings
- Higher light levels

LED Myth vs. Reality

Myth

- “Lasts Forever”
- “No Heat”
- “Bad Color”
- “Green”
- “No standards”



Reality

- Not True. Between 10 minutes and 100 years can be predicted...
- Not True. No radiated heat; heat in LED fixtures is conducted...
- ...depends on when you bought & from whom...
- True...but has not yet been fully and quantitatively substantiated
- Not True...anymore...changing rapidly (like most things in LED...)

The Real Problem With LEDs – Education

You may not [YET] know how to tell on SSL...



- You know extravagant marketing claims on this are not realistic
- You know what you are getting when you buy one
- You expect top quality, know how to tell when you are getting it, and are willing to pay for it

LED Status Summary

- **Major pieces of the puzzle are coming into place:**
 - Standards
 - Performance
 - LED Fixture design learning curve
- **LEDs save real energy and make good economic sense in many important applications now:**
 - Parking decks, canopies
 - Hazardous work areas
 - Pedestrian, bollards, etc.
 - Lower wattage street lights
 - Indoor down lights
 - Freezer cases/displays
- **Still some work to be done on others (0-3 years):**
 - Higher wattage roadway
 - Replacement bulbs
 - Indoor hibay
 - Indoor fluorescent
- **Caveat emptor: Many poor quality products as well as hyper-inflated marketing claims – education is key**
 - DOE Energy Star and other quality programs will help

LED Fixture Quality Check List (“12 Questions”)

	Question	One Good Answer
<input type="checkbox"/>	Who is your LED supplier?	Cree, Nichia, Osram, Philips. Stay with top suppliers to guarantee quality, reliability, and IP. Don't accept "that's proprietary" for an answer. You have a right to know how much technical and legal risk you are running with this purchase.
<input type="checkbox"/>	Did they provide an IESNA LM-80 test report for the LEDs?	Yes. If not, RUN! Any good LED manufacturer will supply this to the fixture maker; any that does not or can not is a huge red flag...
<input type="checkbox"/>	What is the max operating temp and max T_j ?	The answer the fixture maker gives should make sense for the application. The LED junction temperature (T_j) should not be more than 80-90°C over the entire expected operating range of the fixture.
<input type="checkbox"/>	What's the expected L_{70} fixture lifetime?	Everybody says 50k hrs, but 1k to 100k are possible as well. Make him convince you he knows the number, and WHY. Don't forget to ask about the driver lifetime as well.
<input type="checkbox"/>	Can you supply an IESNA LM-79 test report? .ies files?	Yes. If not, RUN! This is fundamental and essential for any LED fixture. There are more than a dozen accredited labs in the US and the cost is only a few hundred dollars. Don't accept no for an answer on this one.
<input type="checkbox"/>	What are the delivered lumens and LPW of the fixture?	Unlike traditional lamps, LEDs are a directional light source so raw lamp lumens are much less important with LED. Make sure the light DELIVERED in the application meets your requirements (FC/lux).
<input type="checkbox"/>	Is the chromaticity in the ANSI C78.377A color space and is it stable over time?	Yes. If not, RUN! The ANSI standard for LED is a rough approximation for the ANSI CFL standard. Lamps outside of this could look tinted blue, green, or red.
<input type="checkbox"/>	How much does the color vary from fixture to fixture?	7-step MacAdams ellipse should be acceptable for most applications, 4-step if you are picky, but many/most LED fixtures can not currently not meet this (ref: ANSI CFL is 7-step). What is important is that he speaks this language, understands question, and has a well-grounded answer.
<input type="checkbox"/>	What is the Power Factor of your fixture?	Energy Star is 0.7 and 0.9 for residential and commercial applications respectively. There is no reason a well designed driver can not deliver 0.9 – or much better – today.
<input type="checkbox"/>	Have you applied for DOE Energy Star? Why/why not?	The DOE Energy Star criteria is another way to screen out bad quality product. He should have a good answer for not applying for this.
<input type="checkbox"/>	Is your fixture RoHS compliant? Mercury free?	Yes. If not, RUN! This is a key question on sustainability and there is no reason that these regulations can not be met with commonly available electronic manufacturing.
<input type="checkbox"/>	What is your warranty?	DOE Energy Star requires 3yrs. Some manufacturers have longer. Point again is to make sure he understands the reliability of his system and is willing – and able – to stand behind it.



PORTABLE



RESIDENTIAL



OFFICE



RETAIL



ARCHITECTURAL



OUTDOOR



LED lighting: Energy efficient & planet friendly.

Cree. Leading the LED lighting revolution.

Join Cree's LED lighting revolution. We invite you to see how our high-performance, high-efficiency LEDs are lighting up the world.

