U.S. Department of Energy
Energy Efficiency and Renewable Energy

What's New in Solid State Lighting

Energy 2006 Conference

August 8, 2006

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Federal Energy Management Program (FEMP)

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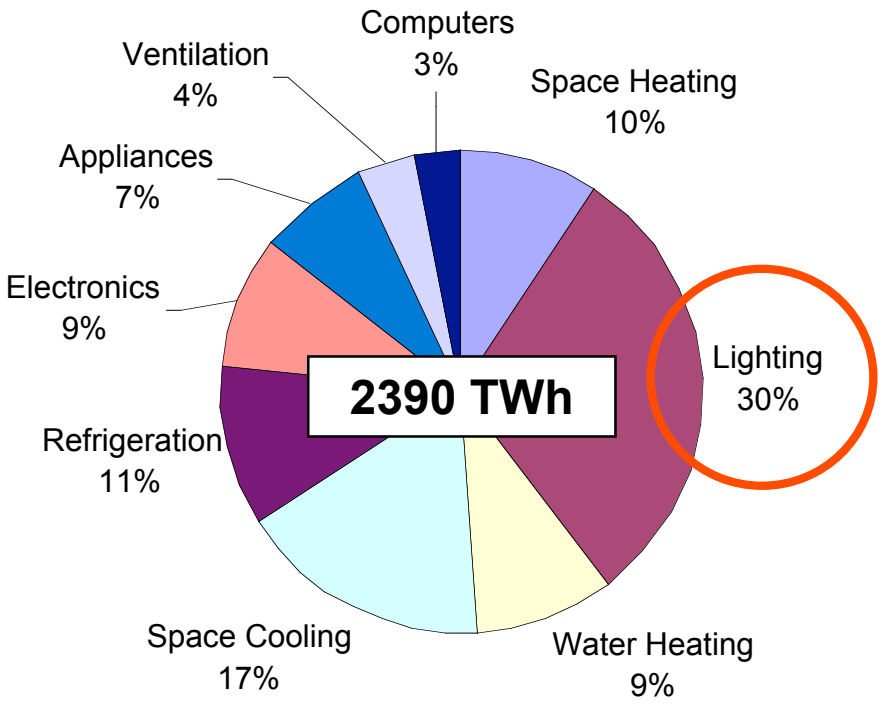
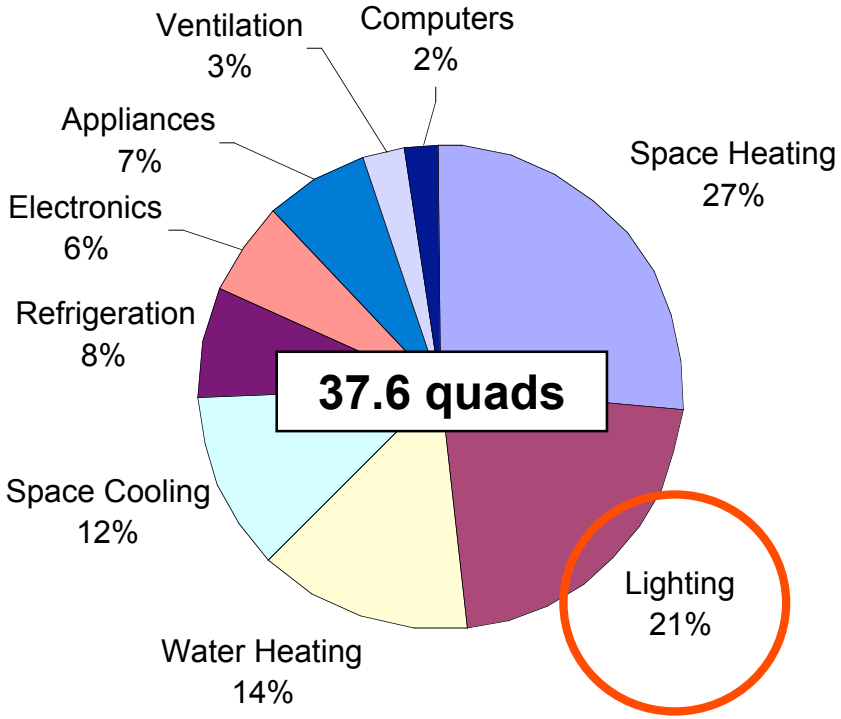
U.S. Buildings Energy End-Use Breakdown, 2001

Site Electricity Consumption



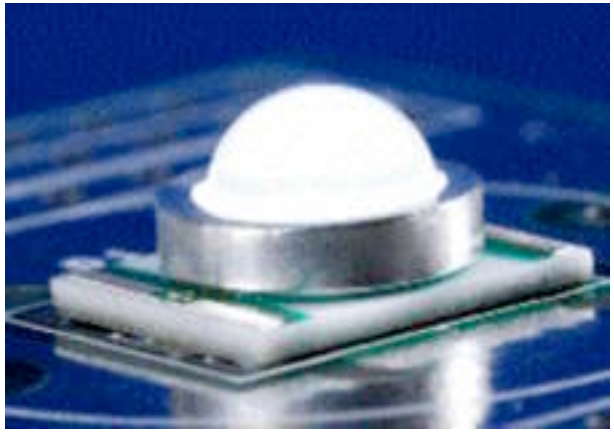
Total Primary Energy (all fuels)



Source: Building Technology Program Core Databook, August 2003. http://buildingsdatabook.eren.doe.gov/frame.asp?p=tableview.asp&TableID=509&t=xls

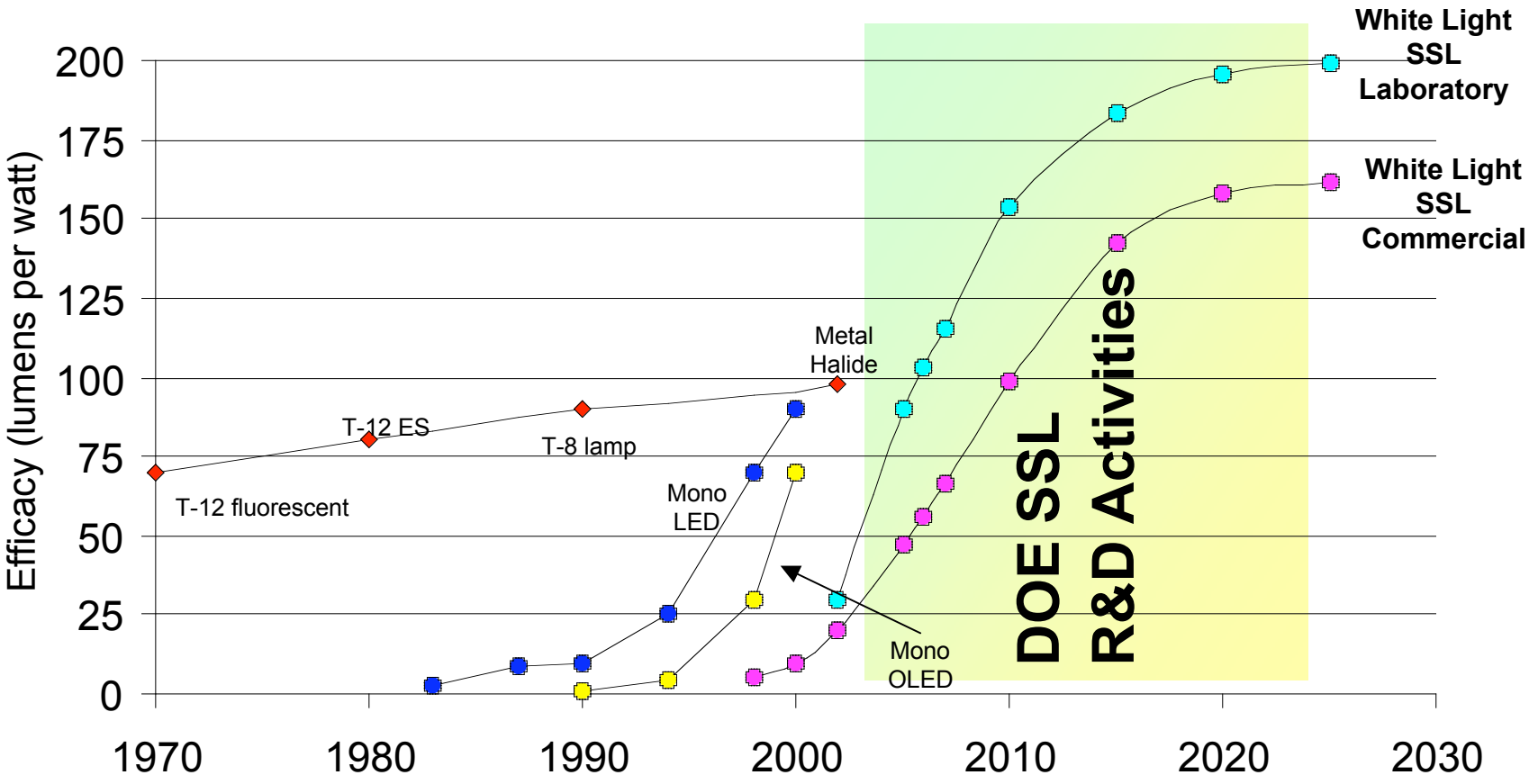
Potential Benefits of LEDs

- Potential to be highly energy efficient
- Potential to be cost effective
- Potential for very long life
- Impact and vibration resistant
- Small size enables new fixture and system designs
- Directional beam puts light where needed



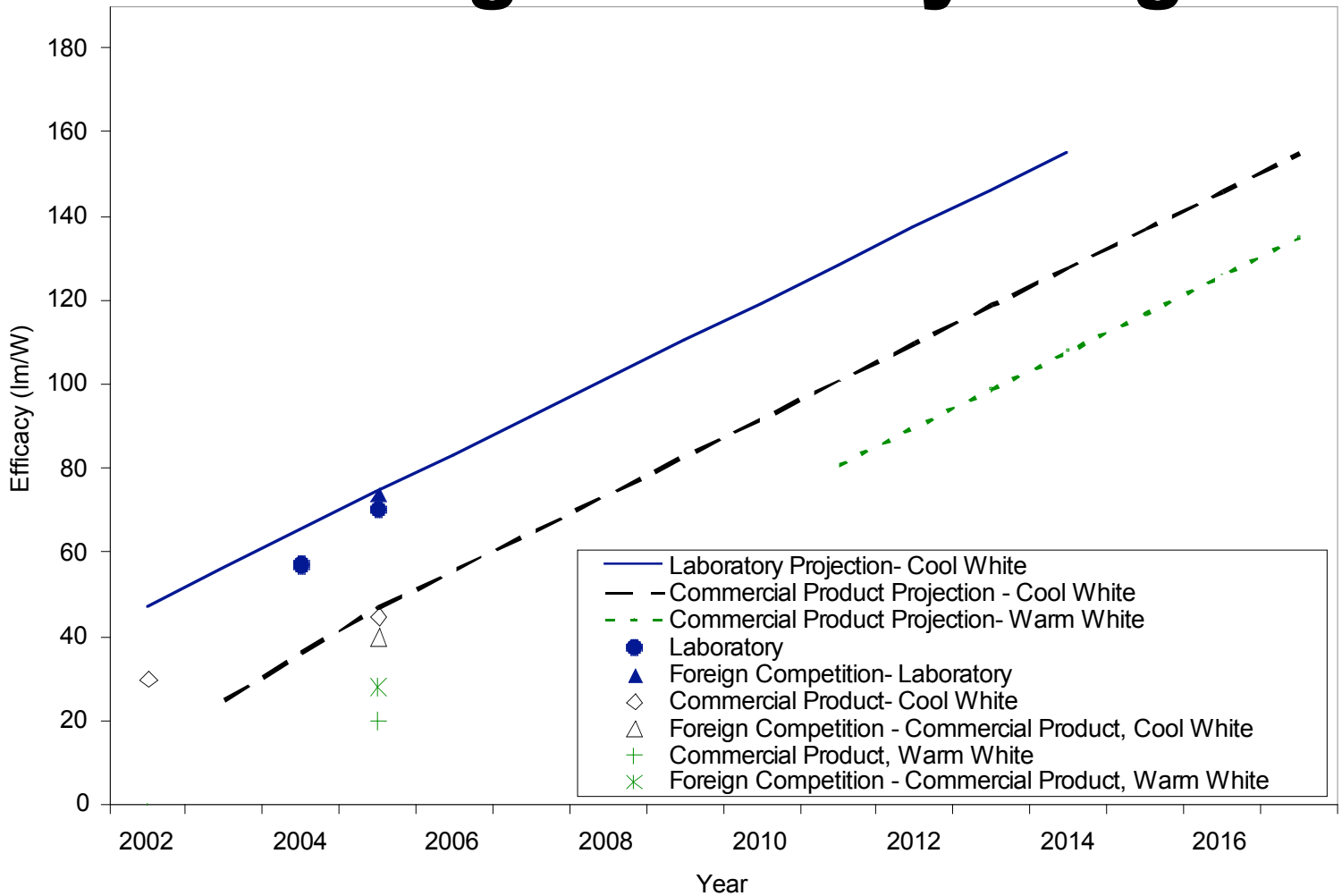
Cree, Inc.

Accelerated R&D for White Light SSL



SSL Laboratory and Commercial Curves, revised September 2004

White Light Efficacy Targets

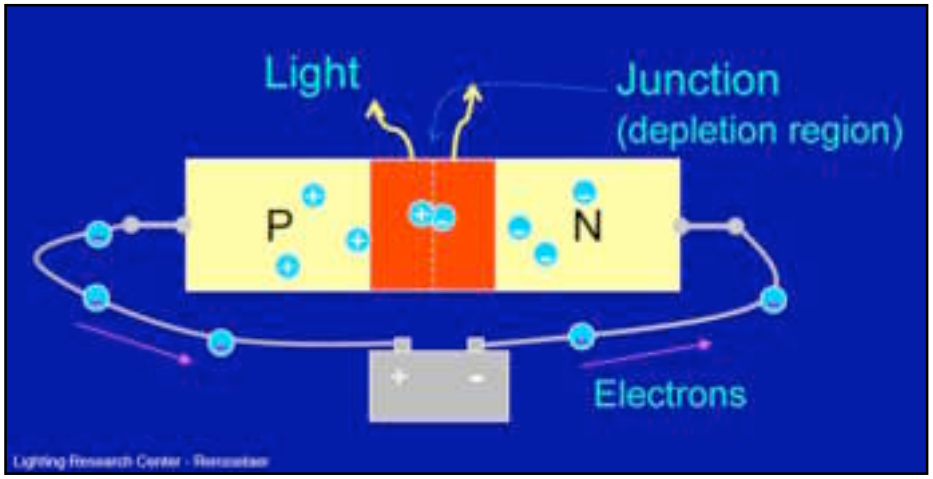


Note: Efficacy projections assume CRI=70 _ 80, Color temperature = 5000-6000°K, 350ma drive current, and lamp-level specification only (driver/luminaire not included), reasonable lamp life.

Source: DOE SSL Multi-Year Program Plan, March 2006

What is an LED?

- Uses layers of semi-conducting materials
- Emits photons (light) when electric current is applied



Why Are We Hearing So Much About LEDs Today?

- LED technology available since 1960s (low power indicator applications)
- Higher-output colored LEDs already save energy in exit signs, traffic signals, and other indicator applications
- White LEDs available for niche applications now: aircraft, automobiles, back-lighting, display cases
- White LEDs for energy-efficient general illumination are several years away

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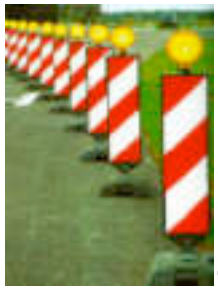
Examples of SSL Applications Today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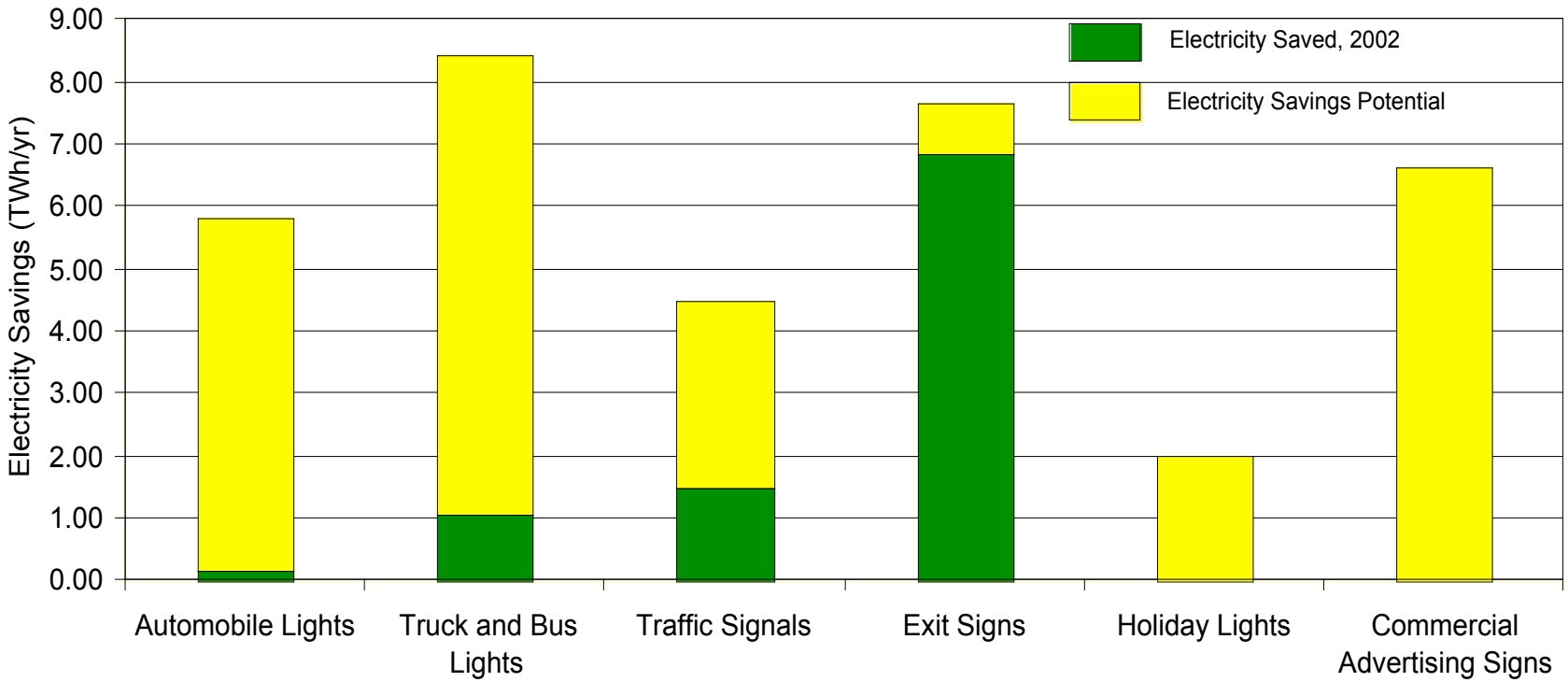
Color LED Applications

- Cost-effective now
- Used for exit signs, traffic signals, advertising signs, airport taxiway lights
- Mandated efficiency and performance levels for exit signs and traffic signals in 4 states (CA, CT, MD, NJ) best met with LEDs
- Legislation pending in ~10 other states

Current and Potential Electricity Savings from LEDs



Source: Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications, Navigant Consulting, November 2003; www.netl.doe.gov/ssl/.

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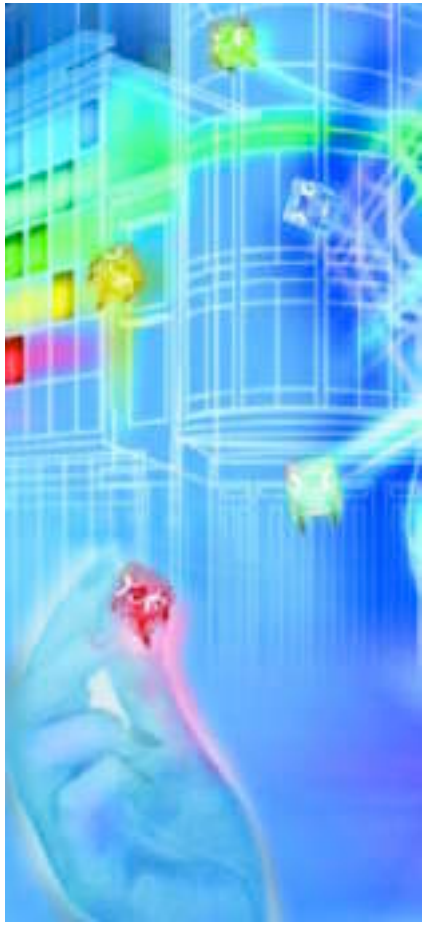
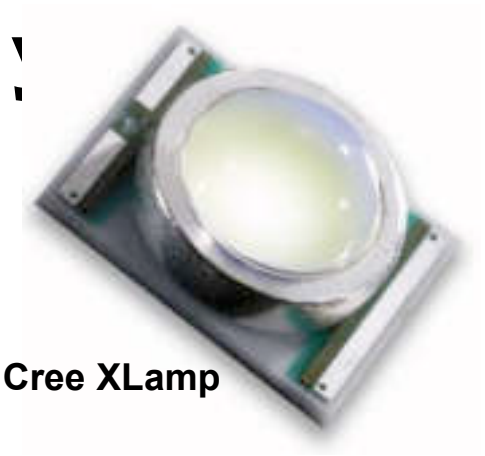
White Light SSL Challenges

- Lifetime – lumen maintenance, heat management
- Efficacy – improving rapidly
- Color Quality
- Luminous Flux
- Cost
- Need testing/reporting standards
- Ready or Not

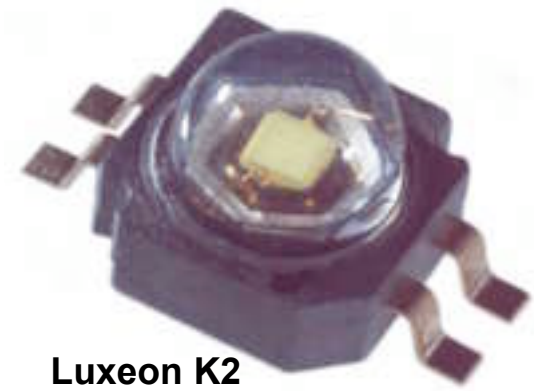


White LED Efficacy Advancing Quickly

- Cree XLamp 7090
  - 33-56 lm/W
- Lumileds K2 Luxeon
  - 38-50 lm/W



Cree XLamp



Luxeon K2

LED Efficacy Caveats

- Data sheets report laboratory performance
  - Tested at 25 degrees C junction temperature with an instantaneous pulse
  - Continuous current operation results in 65-90 degrees C and 10-15% less light output
- High efficacy LEDs typically have high CCT
  - Luxeon K2 is 6500 K
  - Luxeon "warm white" with high CRI is 20 lpw

Efficiency and Cost of White Light Sources

Source efficacy (2005)

- Incandescent (75W) ~13 lpw
- Fluorescent (T8) ~83 lpw
- HID (Metal Halide) ~100 lpw
- SSL (White LED) ~45 lpw

Normalized retail lamp price (2005)

- Incandescent (75W) ~0.60 $/klm
- Fluorescent (T8) ~0.73 $/klm
- HID (Metal Halide) ~1.27 $/klm
- SSL (White LED) ~50.00 $/klm

*manufacturer data

Research is improving SSL efficacy while decreasing price

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Near-Term White LED Applications

- Airplane reading lights
- Down lights, focused light applications
- Task lights, desk lights
- Under cabinet
- Display cases, including refrigerated
- Elevators – vibration resistant, long life
- Architectural (hard to reach locations) – durability

ENERGY STAR® for SSL

- DOE developing ENERGY STAR criteria
- Promote high quality, energy-efficient products
- Establish performance targets for:
  - Interim niche applications
  - Longer range general illumination applications

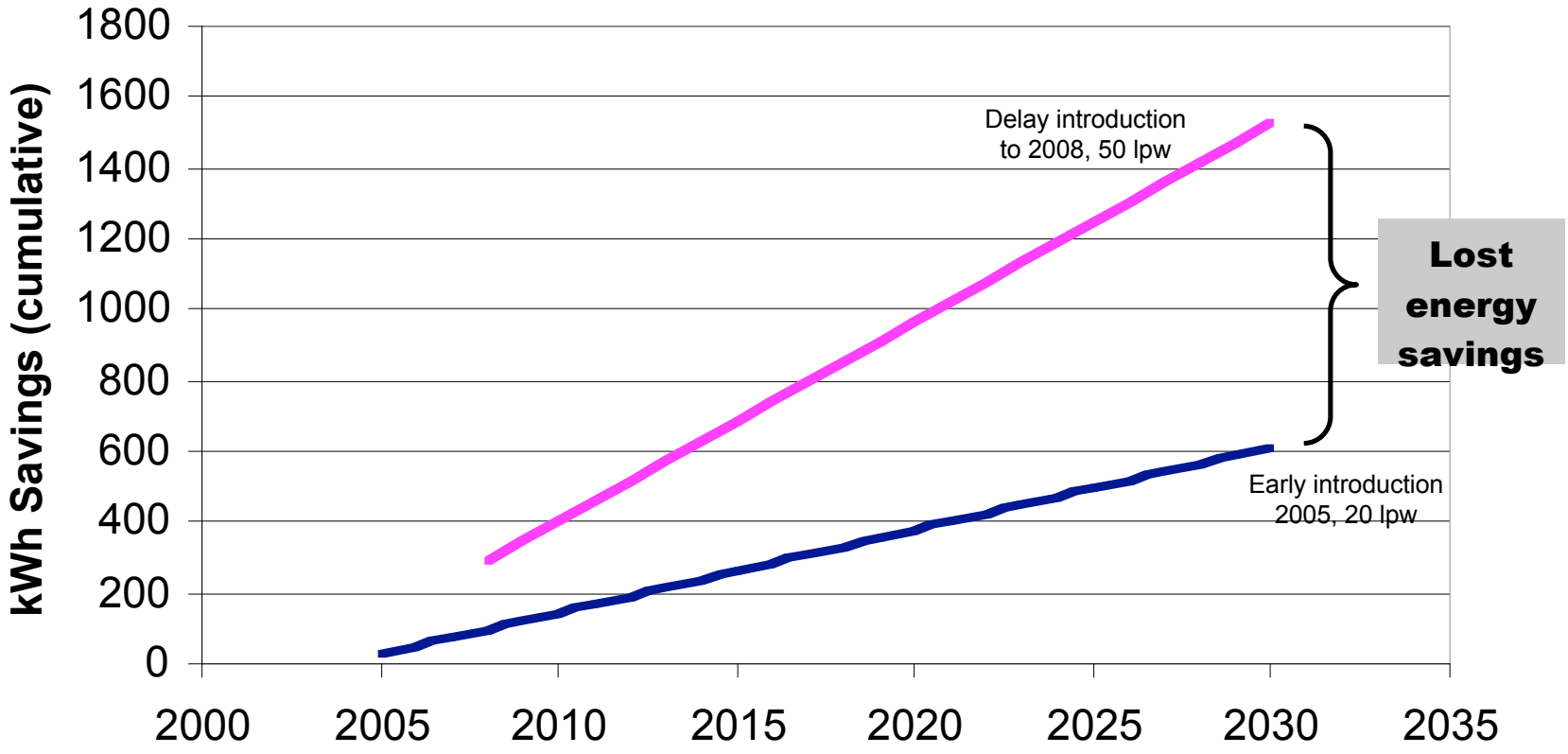
CHANGE FOR THE BETTER WITH ENERGY STAR

Evaluating LED Products

Compare with most energy efficient lighting available for the application

- **Verify lumens per watt**
  - **Incandescent:** 12-15 lpw
  - **CFL:** 50 lpw
  - **LEDs:** 20-45 lpw depending on specific LEDs used
- **Verify total light output**
  - Manufacturers often don't report it
  - Will the fixture/system provide the needed amount of light on the task?
- **Calculate cost**
  - Conventional (fluor., incand.): $1/1000 lumens (klm)
  - LEDs: $50/klm
  - LEDs on 24/7 or in hard to reach areas: potential cost savings on maintenance
- **Assess need for special LED features (durability, accessibility)**
- **Check color**
  - Bluer tones than fluorescents
  - Warmer tones less efficient
- **Obtain a sample**

Importance of Strategic Timing
Hypothetical LED Installation



Note: SSL replacing 14 LPW halogen sockets generating 1000 lumens for 3 hours per day. Replacement in 2005 with 20 lumens per watt white-light LED or delayed to 2008 with 50 lumens per watt. Efficacies held constant over time.

Sources of Information

- http://www.netl.doe.gov/ssl/faqs.htm
- Request to be on e-mail list for periodic updates:

  http://www.netl.doe.gov/ssl/index.html
- Brad.Gustafson@EE.DOE.GOV