DOE's SSL Commercialization Support

Marc Ledbetter

Pacific Northwest National Laboratory

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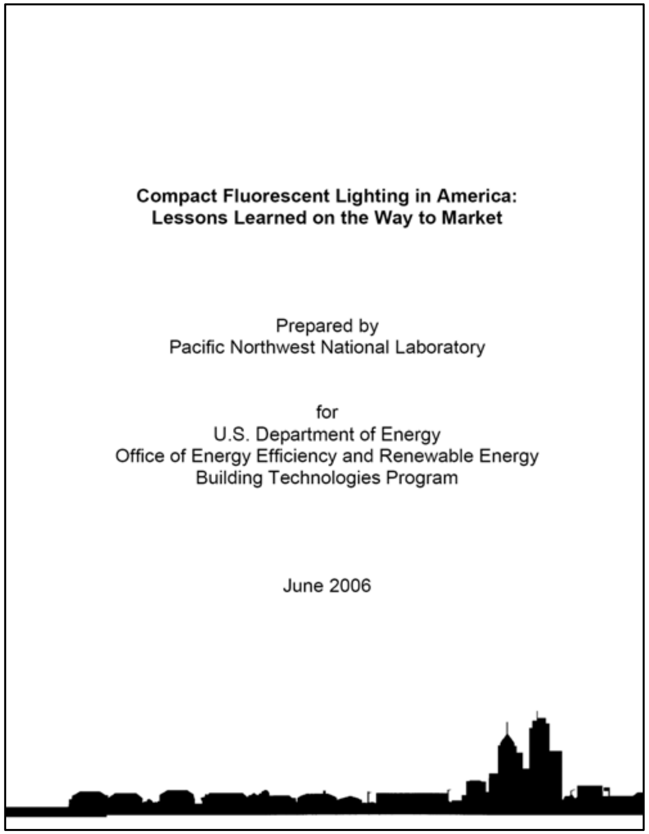
2007 DOE SSL Workshop

Phoenix

SSL Lessons from CFL Market Introduction?

- Compact Fluorescent Lighting in America: Lessons Learned on the Way to Market
  - Prepared for U.S. DOE by PNNL
  - LJ Sandahl, et al.
  - June 2006
  - http://www.netl.doe.gov/ssl/publications.html


Compact Fluorescent Lighting in America: Lessons Learned on the Way to Market

Prepared by
Pacific Northwest National Laboratory

for
U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Building Technologies Program

June 2006

Early fluorescent lamp days (Pre-CFL)

- Green tint due to use of halophosphors
- Harsh, unattractive
- Reputation persists
- Carried over to CFLs

"Harsh fluorescent lighting, linoleum floors and regular plaster walls are not ideal surroundings for neonatal intensive care units." – Google Search.

Early CFLs

- Too big
- Too heavy
- Buzz and flicker
- Poor cold weather performance
- Poor color quality (high CCT, low CRI)
- High prices ($25 - $35 in 1980s)

CFL Marketing Mistakes

- Exaggerated life claims
- Inconsistent incandescent equivalency claims
- Consumer awareness hindered by lack of common name (CFL, CFB, SL-lamps, etc.)
- Weren't available where people buy bulbs
- Retailers didn't understand the product

Lessons Learned (Examples from Report)

- Know and admit technology limitations
  - Life
  - Incandescent equivalency
  - Inappropriate lighting applications

Lessons Learned (Examples from Report)

- Manufacturers and energy-efficiency groups should coordinate to establish minimum performance requirements
  - Wide disparity of program specifications caused confusion & complication

Lessons Learned (Examples from Report)

- Work toward consistent, industry-wide terminology. Identify and avoid terms with negative connotations
  - “Fluorescent” was probably a mistake
  - “Compact Fluorescent Lamp” was complicated

Key Take Away from CFL Experience

- Early consumer experience with fluorescent lamps and CFLs still defines attitudes towards CFLs, even though the technology has greatly improved since its introduction

DOE SSL Commercialization Support Program Elements

- Technical Information
- Commercial Product Testing Program
- Technology Demonstrations
- Standards and Test Procedures Support
- Buyer/User Guidance
- Coordination/Leadership
- Design Competitions

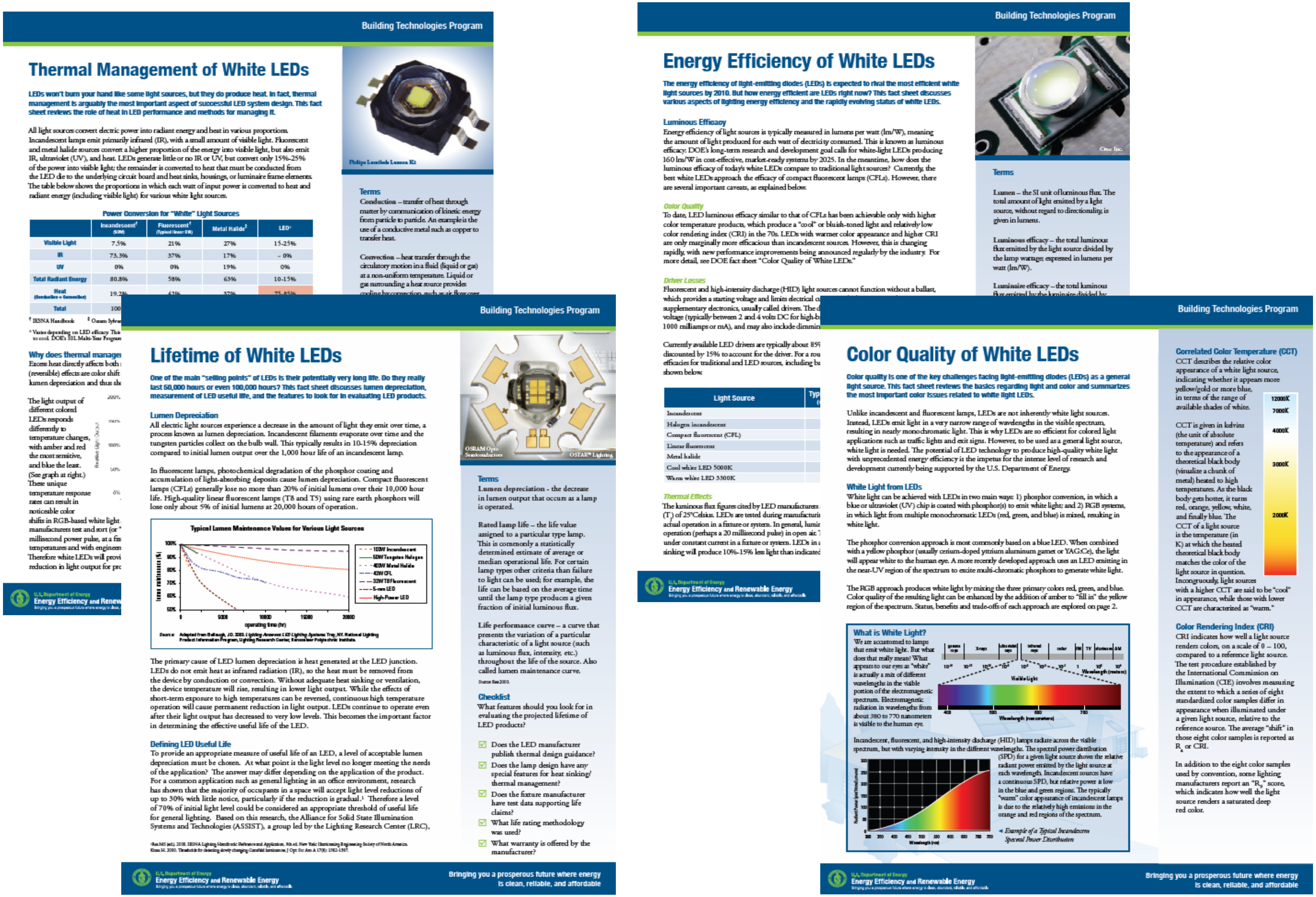
All activities aimed at SSL general illumination applications.

Market Needs Addressed by DOE SSL Commercialization Support

- Objective, widely available technical information
- Independent performance test results
- High-profile examples of model applications of SSL
- Industry standards and test procedures
- Guidance for purchasing and proper application
- Coordination of local and regional commercialization activities
- High visibility for state of the art products and designs

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

Technical Information



Technical Information

Building Technologies Program

LED Application Series:

Recessed Downlights

Recessed downlights are very common in both residential and commercial buildings. Is this a good application for LEDs? This fact sheet explores issues unique to this type of luminaire, and the potential for use of LEDs in downlights.

Recessed downlights are the most common installed luminaire type in residential new construction. Downlights are used for general ambient lighting in kitchens, hallways, bathrooms, and other areas of the home. Downlights with small apertures and more directional lensing and baffling are also used for wall-washing and accent lighting. In commercial settings, a wide variety of downlight types, sizes, and finishes are used in lobbies, perimeter areas, hallways, and restrooms.

The light output of a recessed downlight is a function of the lumens produced by the lamp and the luminaire efficiency. Reflector-style lamps are specially shaped and coated to emit light in a defined cone, while "A" style incandescent lamps and CFLs emit light in all directions, leading to significant light loss within the luminaire. Downlights using non-reflector lamps are typically only 50% efficient, meaning about half the light produced by the lamp is wasted inside the fixture. LEDs are more directional, but can they provide enough light? For comparison, the table below shows typical light output and efficiency of residential-style fluorescent and incandescent recessed downlights and an LED downlight.

Examples of Recessed Downlight Performance Using Different Light Sources

		Fluorescent*		Incandescent*		LED**
		26W pin-based CFL	15W R-30 CFL Edison base	65W R-30	100W A-19	LED 15W Downlight
LAMP	Rated lamp lumens	1800	750	755	1700	unknown
LAMP	Lamp wattage (nominal W)	26	15	65	100	9 x 1W LEDs
LAMP	Lamp efficacy (lm/W)	70	50	12	17	45
LUMINAIRE	Luminaire efficiency	50%	90%	90%	50%	unknown
LUMINAIRE	Delivered light output (lumens), initial	900	675	680	850	300
LUMINAIRE	Luminaire wattage (nominal W)	27	15	65	100	15
LUMINAIRE	Luminaire efficacy (lm/W)	33	45	10	9	20

*Based on photometric data for commonly available products. Actual product performance depends on reflectors, trims, lamp positioning, and other factors. Assumptions available from PNNL.
**Based on one commercially-available product tested. Other LED-based downlights may differ. Lamp efficacy for the LED product refers to the manufacturer listed "typical luminous flux" of the LEDs used. Luminous flux of the 9-LED array is not known.

Even though the 26W CFL is the most efficacious light source listed, the 15W reflector CFL provides higher luminaire efficacy, i.e., total lumens out of the fixture per watt consumed. The 15W LED downlight provides less than half the delivered light output of the 15W reflector CFL. As LED technology matures, this performance is expected to improve.

Source: PNNL

Terms

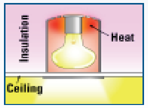
Luminaire – a complete lighting unit including lamp(s), ballast(s) (when applicable), and the parts designed to distribute the light, position and protect the lamps, and connect to the power supply.

Luminaire (fixture) efficiency – the ratio of luminous flux (lumens) emitted by a luminaire to that emitted by the lamp or lamps used therein; expressed as a percentage.

Luminaire efficacy – total lumens provided by the luminaire divided by the total wattage drawn by the fixture, expressed in lumens per watt (lm/W).

ICAT – stands for "insulated ceiling (or "insulation contact"), air tight" and refers to ratings on recessed downlight luminaires used in residential construction.

Downlights installed on the top floor of a house are immersed in insulation, creating a high-temperature operating environment that is difficult for CFLs and potentially similarly challenging for LEDs. Further, energy codes in most states require downlights installed in the building shell to be rated "air tight" to minimize loss of heating and cooling energy.



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- Application series:
  - Recessed downlights
  - Undercabinet
  - Portable desk/task
- Other:
  - Compare/contrast LED and traditional light sources
  - Cost/economics
- Measurement series:
  - Luminaire efficacy

Technical Information Network

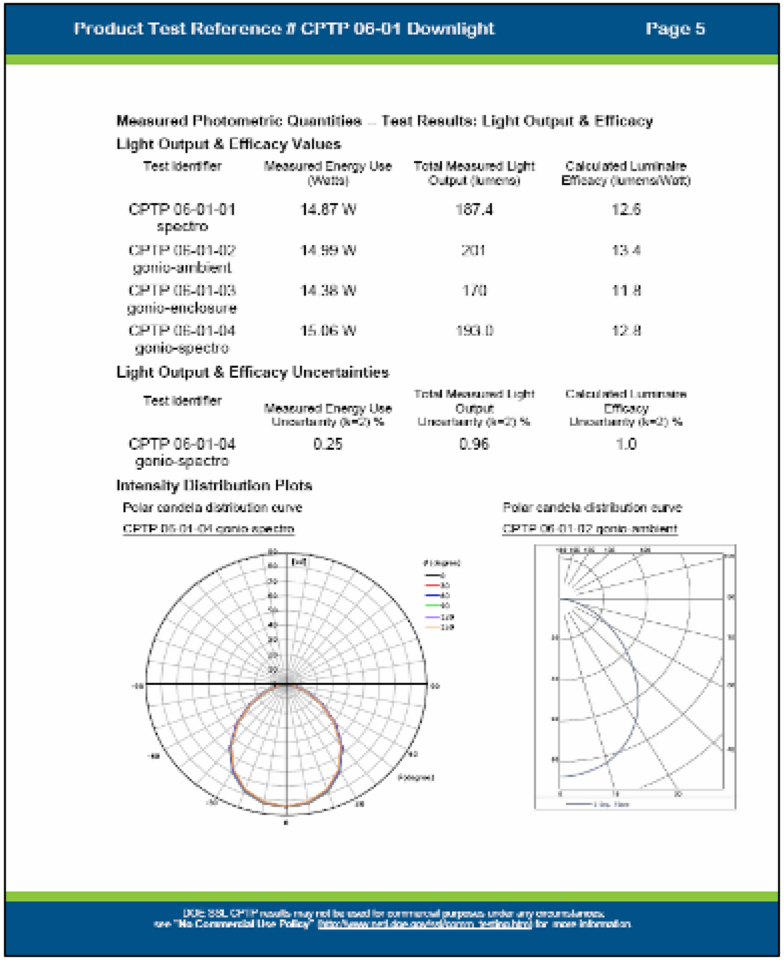
- Cooperative agreements to be awarded soon to selected partners
- Outreach to efficiency orgs, utilities, and their contractors
- Leverage existing programs & contacts
- Quarterly meetings
- Disseminate information to:
  - Retailers
  - Builders
  - Consumers
  - Others

Commercial Product Testing

- Testing of commercially-available LED products
- Early stages of program rollout
- Purposes
  - Input to DOE planning
  - Provide objective performance information to public
  - Input for test procedure development/refinement

Commercial Product Testing

- Arranging for multiple test labs (via solicitation)
- Completed pilot testing & public workshop
- Round 1 testing underway for 11 products
  - Undercabinet, portable task, outdoor area, step lights, etc.
- Summary and detailed test reports available via DOE SSL website
- "No commercial use" policy



Product Test Reference # CPTP 06-01 Downlight — Page 5

Measured Photometric Quantities – Test Results: Light Output & Efficacy

Light Output & Efficacy Values

Test Identifier	Measured Energy Use (Watts)	Total Measured Light Output (lumens)	Calculated Luminaire Efficacy (lumens/Watt)
CPTP 06-01-01 spectro	14.87 W	187.4	12.6
CPTP 06-01-02 gonio-ambient	14.99 W	201	13.4
CPTP 06-01-03 gonio-enclosure	14.38 W	170	11.8
CPTP 06-01-04 gonio-spectro	15.06 W	193.0	12.8

Light Output & Efficacy Uncertainties

Test Identifier	Measured Energy Use Uncertainty (k=2) %	Total Measured Light Output Uncertainty (k=2) %	Calculated Luminaire Efficacy Uncertainty (k=2) %
CPTP 06-01-04 gonio-spectro	0.25	0.96	1.0

Intensity Distribution Plots

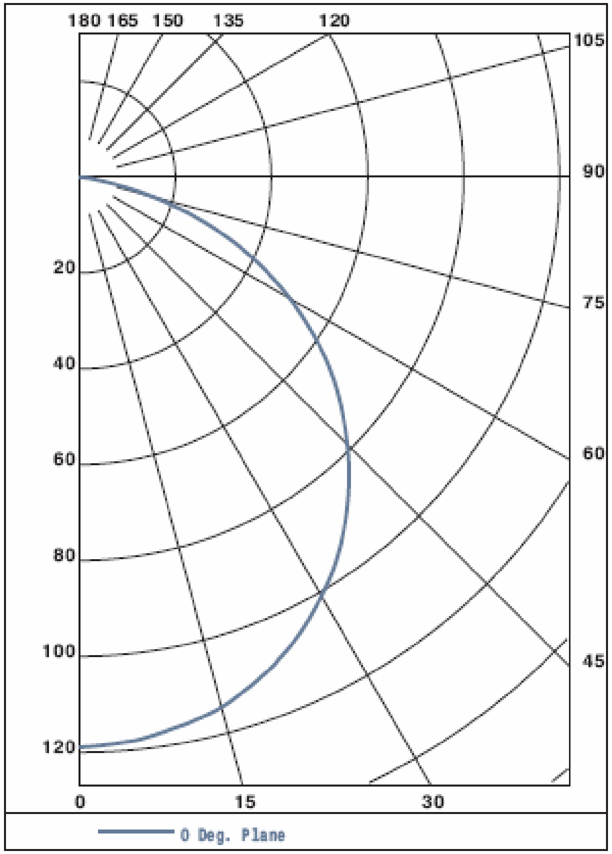
Polar candela distribution curve
CPTP 06-01-04 gonio-spectro

Polar candela distribution curve
CPTP 06-01-02 gonio-ambient

DOE SSL CPTP results may not be used for commercial purposes under any circumstances.
see "No Commercial Use Policy" (http://www.netl.doe.gov/ssl/comm_testing.html) for more information.

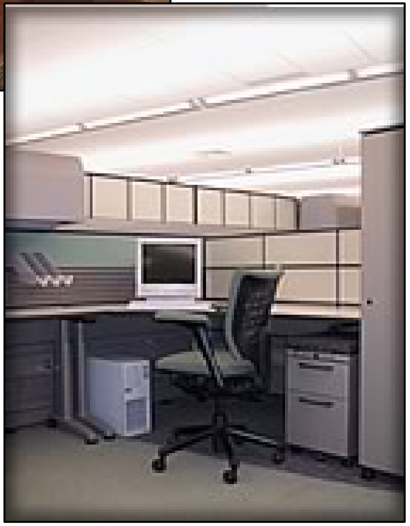
Commercial Product Testing

- Testing for
  – Luminaire light output, efficacy
  – Power characteristics
  – Beam and intensity
  – Spectral power distribution, CCT, CRI
- Findings to date
  – Tested performance << claimed performance
  – Tested products under-performed CFLs and some incandescents
- SSL Design Industry News editorial



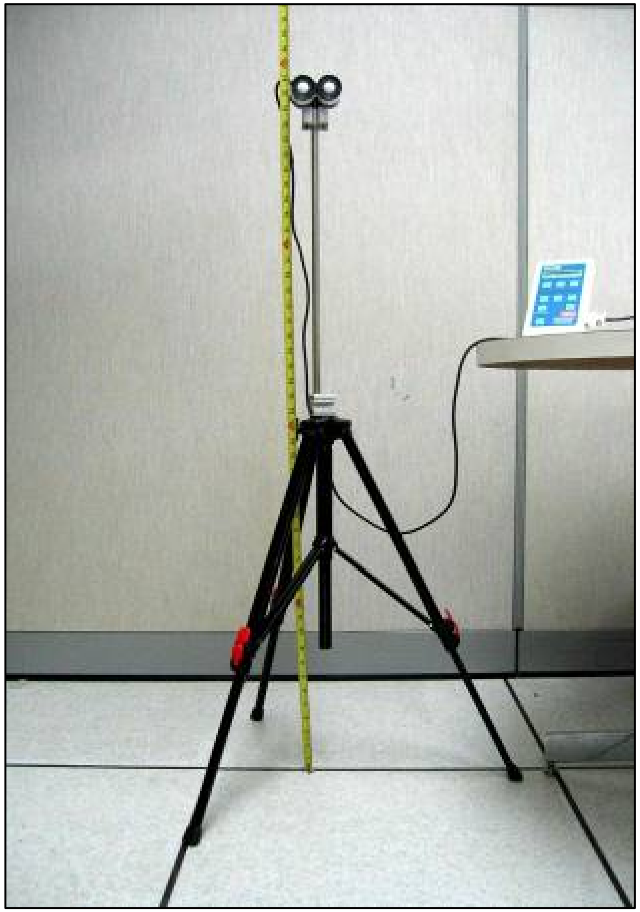
Technology Demonstrations

- Purpose: field demo advanced technology in general illumination applications; leverage demo with closely linked promotional effort
- Downlights anticipated but open to others via competitive solicitation



Technology Demonstrations

- Manufacturers provide equipment
- DOE finds partners & host sites, conducts testing, publicizes results and helps promote follow-up sales
- Evaluations to focus on light quality, occupant responses
- RFP to be issued to manufacturers in February

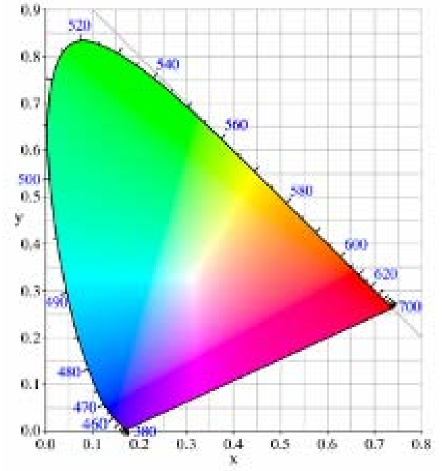


Other Technology Demonstrations

- Solar Decathlon
- DOE Showcase

Standards & Test Procedures Support

Key Measurement Issues



- Measurement of luminous flux
  - Luminous efficacy
  - Luminaire efficacy
- Chromaticity and color rendering
- Electrical characteristics
- Drivers
- Life rating (lumen depreciation)
- Definitions and nomenclature

Standards and Test Procedures Support

American National Standards Institute

Underwriters Laboratories Inc.

CSA INTERNATIONAL

IES 100 1906-2006

NIST National Institute of Standards and Technology

- DOE workshops in Mar & Oct 2006
- In process:
  - Photometric Measurement (LM-79)
  - Lumen Depreciation (LM-80)
  - Chromaticity (ANSI C78.377A)
  - Electrical performance (ANSI C78.XX3)
  - SSL-LED power supply (ANSI C82.XX1)
  - Definitions/nomenclature (IESNA RP-16)
- New standards expected June 2007

User/Buyer Guidance

- Developed draft ENERGY STAR criteria for SSL luminaires for general illumination
- Publicly issued on Dec 20, 2006
- Stakeholder workshop on February 8, 2007 in DC

Coordination & Leadership

- Federal government is largest U.S. energy consumer
  - Working with FEMP to identify opportunities for early SSL applications
- Organize workshops, joint projects for key partners, including
  - Efficiency organizations, utilities
  - Lighting industry professionals
  - Fixture manufacturers
  - DC Workshop planned for April (Date to be announced soon)

Design Competitions

- Lighting for Tomorrow
- Partnership with ALA and CEE approved through 2008
  - Niche applications
  - Cutting edge design
- Expert judges
- Publicity
- New lighting design (not fixture) competition being considered