DOE's 5-Year SSL Commercialization Support Plan

Marc Ledbetter

Pacific Northwest National Laboratory

April 23-24, 2007

Voices for SSL Efficiency,

DOE Solid-State Lighting Workshop

Pasadena, CA

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

Plan Purpose

1. *Affect the types* of products adopted by the market
2. *Accelerate commercial adoption* of products
3. Support applications that *maximize energy savings*

Plan Scope

FY08 to FY12 ♦ general Illumination SSL luminaires

Goals: By FY12

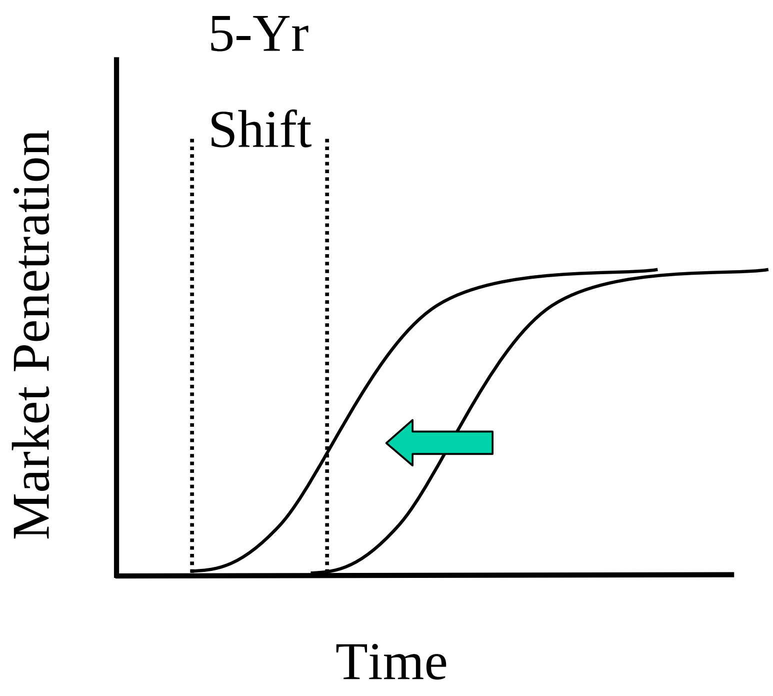
1. **Products Brought to Market**:

   Warm White Products
   1. 68 lm/W luminaire efficacy
   2. 85 CRI (or similar for revised metric)
   3. 3500 CCT or less

   Cool White Products
   1. 88 lm/W luminaire efficacy
   2. 70 CRI (or similar for revised metric)
   3. 6500 CCT or less
2. **Market Adoption**: 5 million units/year (ENERGY STAR)
3. **Energy Savings**: 19 TWh per year (includes savings from R&D)

Energy Savings Goal Methodology

- For complete DOE SSL program (includes R&D, and contributions from program partners)
- Based on savings estimates prepared by Navigant Consulting
- Assumes market adoption curve is advanced 5 years
- Consistent with findings of NRC 2001 evaluation of DOE BT investment in electronic ballasts and low-e windows



Desired End State
(Point at Which DOE Ceases Effort)

- **Products Brought to Market**:
  - *Warm* White: at least ten 100+ lm/W luminaire efficacy
  - *Cool White:* at least ten 120+ lm/W luminaire efficacy
  - Offered for sale by major fixture manufactures in each of following categories:
    - *Warm* White: residential recessed downlights, commercial recessed downlights, commercial office overhead ambient
    - *Cool White*: pole-mounted roadway luminaires, high bay luminaires
- **Market Adoption**: High performance (ENERGY STAR) comprise 10% of annual sales in above product categories
- **Energy Savings**: 50 TWh/year electricity

Primary Market Barriers

- High costs
- Lack of industry standards and test procedures
- Lack of information

Note: *Barriers do not address technical barriers, which are being addressed in R&D program.*

Market Needs (to address Barriers)

- Effective product purchasing and architectural design guidance
- State of the art products and lighting designs
- Highly visible examples of model SSL general illum. applications
- Independent performance test results on commercial products
- Objective technical information from a credible, source
- Industry standards and test procedures for SSL general illumination products
- Coordination of local, regional, and federal SSL commercialization activities

DOE SSL Commercialization Support Strategy Elements

1. Buyer Guidance
   - ENERGY STAR
   - Design Guidance
2. Design Competitions
   - Lighting for Tomorrow (Residential Fixtures)
   - Commercial Fixture Design Competition
   - Architectural Lighting Design Competition
3. Technology Demonstrations/Procurements
   - Demonstrations of Market Readiness
   - Demonstrations to Test Field Performance

DOE SSL Commercialization Support Strategy Elements (cont.)

4. Commercial Product Testing Program
5. Technical Information
   - Technical Information Development & Dissemination
   - Technical Information Network
6. Standards and Test Procedures Support
7. Coordination and Leadership
   - Facilitating & Coordinating Local and Regional Efforts
   - Federal Government Leadership

1) Buyer Guidance

- Developed draft ENERGY STAR criteria for SSL luminaires for general illumination
- General illumination only
- Residential and commercial products
- Intended to provide early market presence
- 1st draft issued in Dec. 06
- Stakeholder workshop on February 8, 2007 in DC
- 2nd draft issue in April 07

Why ENERGY STAR SSL? Why Now?

- Many new products entering market
- Many appear to have greatly exaggerated performance
- DOE SSL commercial product testing is showing actual performance is much less than claimed

Example: Downlight claimed 40 lm/W; measured luminaire efficacy of 13 lm/W and 193 lumens; less than 1/2 the efficacy of typical CFL downlight, and ~1/3 the lumens.

Why ENERGY STAR SSL? Why Now?

- Meanwhile, LED technology is rapidly improving
- Manufacturers are announcing new performance records almost every month
  - Nichia announced 150 lm/W @ 20 mA in December (lab)
  - Seoul Semiconductor announced 100 lm/W @350 mA in December (commercial)
  - Lumileds announced 115 lm/W @ 350 mA in January (commercial)

Note: the above performance levels are typically done at 25°C for 25 ms with non-standard test; they are not meant to represent actual performance in a luminaire

Why ENERGY STAR SSL? Why Now?

- DOE expects market introduction in 07 and 08 of high performance products

Example: 2700K CCT, 90+ CRI downlight, 60 lm/W (luminaire efficacy); twice the efficacy of a CFL downlight expected 2nd Q 07.

Design Guidance

- Develop SSL design guidance in cooperation with IESNA
- Purpose: provide lighting designers with key information on SSL technology & characteristics to be considered in designs
- Project in development

2) Design Competitions

- Lighting for Tomorrow
  - Partnership with ALA and CEE approved through 2008
    - Niche applications
    - Cutting edge design
    - Residential products only
    - Recently expanded to include SSL
  - Expert judges
  - Publicity, visibility for winners

Design Competitions (cont.)

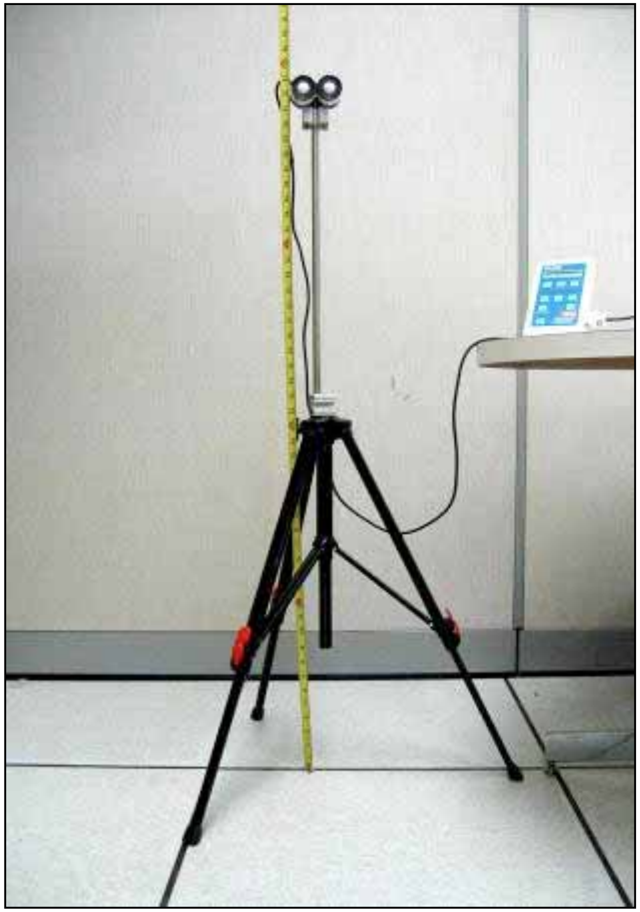
- Two new design competitions being considered
  - Commercial luminaires
  - Architectural lighting designs
- New competitions being discussed with IES and NEMA

3) Technology Demonstrations/ Procurements

- **Purpose:** Demonstrate advanced technology in general illumination applications for visibility & improved understanding
- Leverage demos with closely linked promotional/procurement effort
- Two types of demos:
  - Market readiness
  - Field test

Technology Demonstrations

- 1st Round started
- Invitation issued to manufacturers in March
- DOE finds partners & host sites, conducts testing, publicizes results and helps promote follow-up sales
- Evaluations to focus on light quality, occupant responses
- Next round likely before FY end



Other Technology Demonstrations

- Solar Decathlon
- DOE SSL Showcase

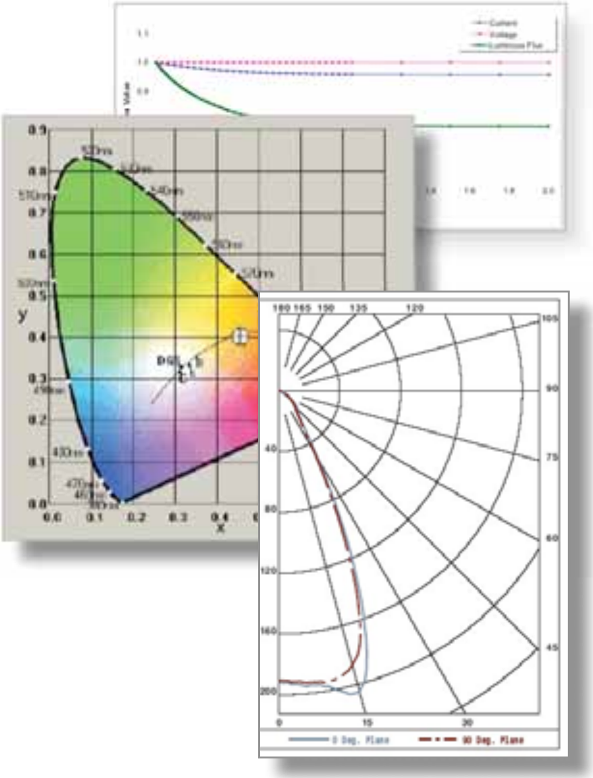
4) Commercial Product Testing Program

Purposes:

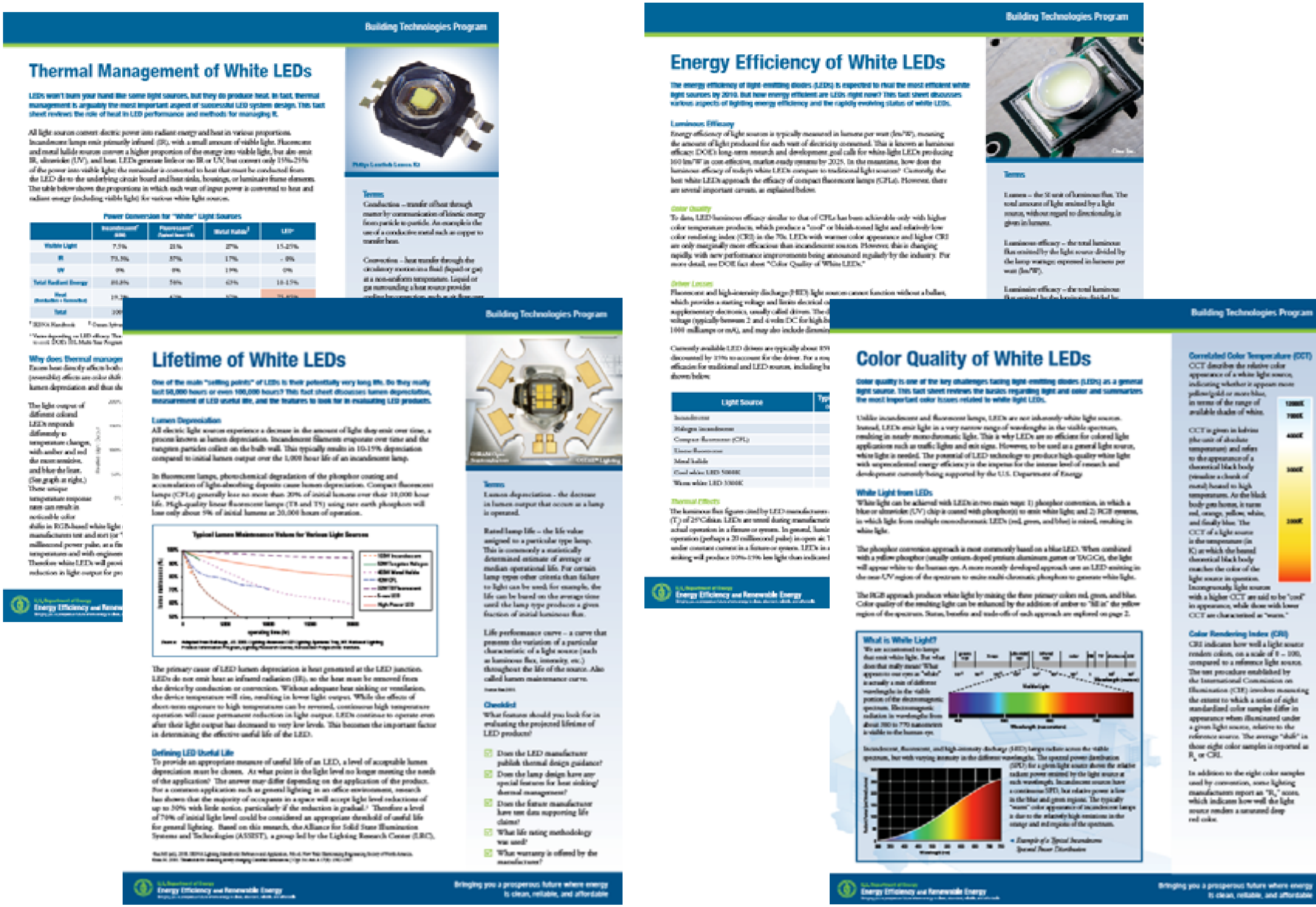
- Provide objective, high quality performance information
- Know performance of market available products
  - To support R & D planning
  - To support ENERGY STAR
- Inform industry test procedures and standards development
- Discourage low quality products
- Reduce SSL market risks to buyers

Testing Program Scope

- Commercially-available SSL products for the general illumination market
  - Luminaires (white light)
  - Indoor and outdoor
  - Residential and commercial
- Testing for
  - Luminaire light output, efficacy
  - Power, thermal characteristics
  - Beam and intensity
  - Lumen depreciation
  - Spectral power distribution, CCT, CRI
  - Benchmarking (other light sources)



5) Technical Information



Technical Information (cont.)

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 wattage (nominal W)	26	15	65	100	9 x 1W LEDs
	Lamp efficacy (lm/W)	70	50	12	17	45
LUMINAIRE	Luminaire efficiency	50%	90%	90%	50%	unknown
	Delivered light output (lumens), initial	900	675	680	850	300
	Luminaire wattage (nominal W)	27	15	65	100	15
	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

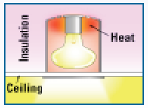
Luminaire – a complete lighting unit including lamp(s), ballast(s) (when applicable), and the parts designed to distribute the light, position and protect the lamps, and connect to the power supply.

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.



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

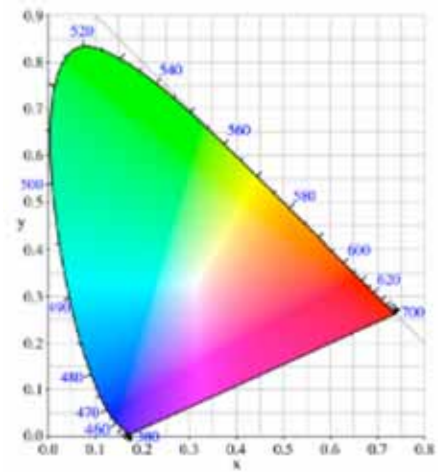
Technical Information Network

- Cooperative agreements to be awarded soon to selected partners: (CEE and NEEP)
- Outreach to efficiency orgs, utilities, and their contractors
- Leverage existing programs & contacts
- Quarterly meetings
- Disseminate information to:
  - Retailers, builders
  - Consumers, others

6) 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 maintenance)
- Definitions and nomenclature

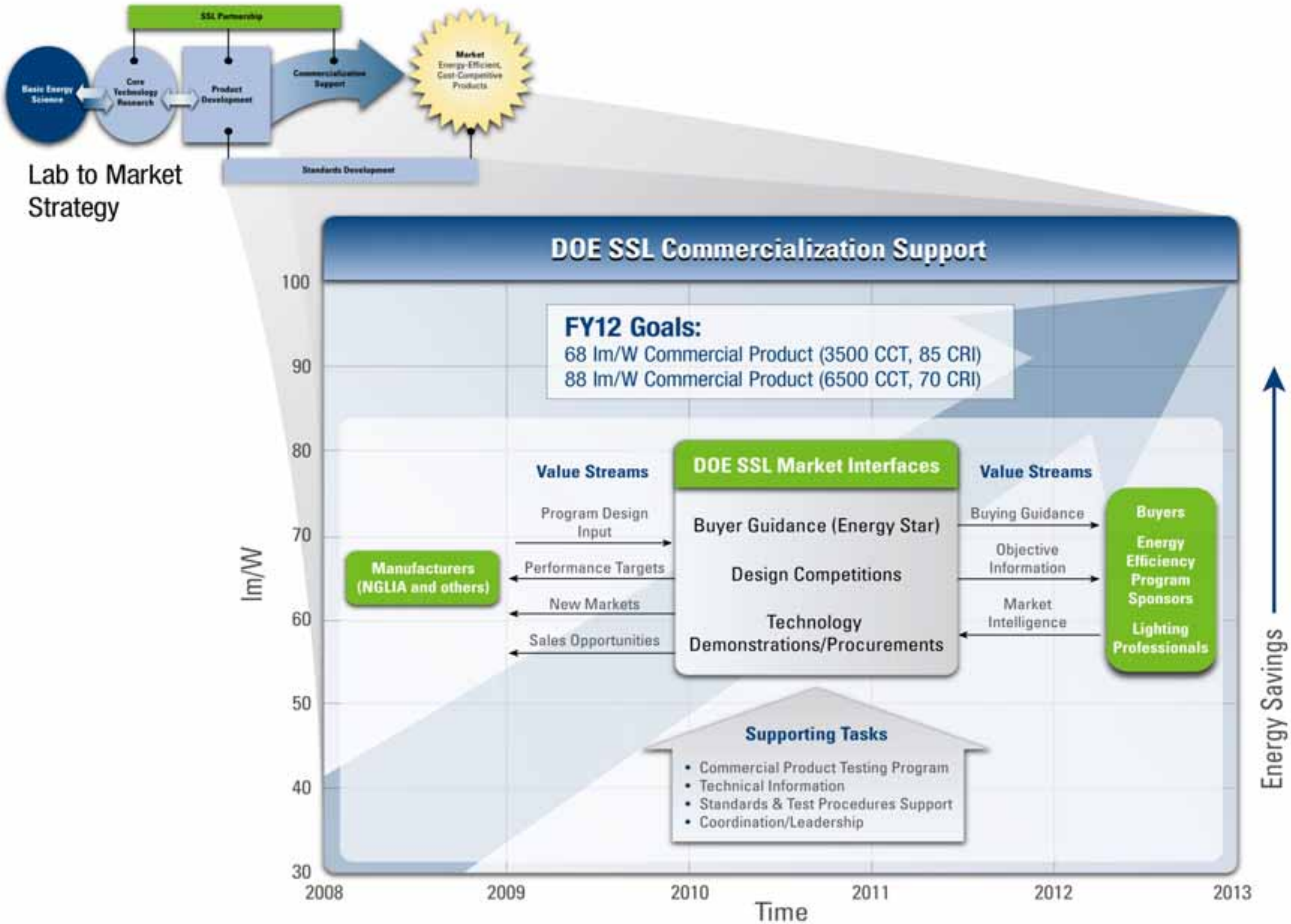


Standards and Test Procedures Support

- 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 before end of 2007

7) 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


SSL Partnership
Basic Energy Science
Core Technology Research
Product Development
Commercialization Support
Market
Energy-Efficient, Cost-Competitive Products
Standards Development
Lab to Market Strategy
DOE SSL Commercialization Support
FY12 Goals:
68 lm/W Commercial Product (3500 CCT, 85 CRI)
88 lm/W Commercial Product (6500 CCT, 70 CRI)
Value Streams
DOE SSL Market Interfaces
Value Streams
Program Design Input
Performance Targets
New Markets
Sales Opportunities
Manufacturers (NGLIA and others)
Buyer Guidance (Energy Star)
Design Competitions
Technology Demonstrations/Procurements
Buying Guidance
Objective Information
Market Intelligence
Buyers
Energy Efficiency Program Sponsors
Lighting Professionals
Supporting Tasks
• Commercial Product Testing Program
• Technical Information
• Standards & Test Procedures Support
• Coordination/Leadership
100
90
80
70
60
50
40
30
lm/W
2008
2009
2010
2011
2012
2013
Time
Energy Savings

Key Issues to be Considered in Project Development

1. Early, low-performing products can cause long-term market damage
2. High costs
3. Low color quality, high CCT
4. Incomplete standards & test procedures
5. Lead to profligate use of lighting
6. Quick obsolescence
7. Retrofit products
8. Commercial vs. residential emphasis
9. Appropriate near-term lighting applications

DOE SSL Communications Plan

- Objective: Build awareness of SSL technology, advantages, limitations, and appropriate applications
  - Continue core communications activities and tools (website, SSL UPDATES, workshops, reports, fact sheets)
  - Broaden to engage market transformation partner audiences, support commercialization plan elements
  - Input from this meeting will shape future communications planning

DOE Solid-State Lighting Website

- Current information on SSL program, progress, and events
- SSL publications: roadmaps, reports, technical fact sheets
- Solicitations
- Register for ongoing SSL UPDATES at: www.netl.doe.gov/ssl

Support for Commercialization Plan Elements

- Support and leverage partner channels to disseminate information
  - ENERGY STAR criteria, testing program results, demonstrations, design competitions, fact sheets
- Expand media relations
  - Press releases, press events, conferences, articles