U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

It’s 2015: Should All Your Sockets be Filled with LEDs?


Acuity - Peerless


Axis


Juno

NGL 2013 Indoor Competition - Recognized Products

The Grainger Show

February 16,-18, 2015

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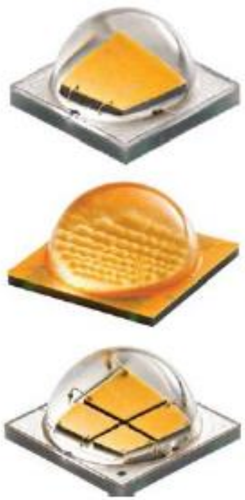
Pacific Northwest National Laboratory

Outline

- A look at the basics of LED lighting
  - Semiconductor technology
  - Continues to change and improve rapidly
  - Can be much more efficient than traditional lighting technologies
  - Excellent energy savings potential
- where it's being used today
  - Replacement lamps, especially reflector lamps, but also A lamps, and TLEDs
  - Outdoor area and roadway lights, street lights
  - Downlights
  - Troffers
- unique performance attributes and challenges
  - Controllable but compatibility issues
  - Flicker
  - Serviceability and interchangeability
- where the technology is going
  - More controls
  - New intelligence
  - New form factors

LED Packages

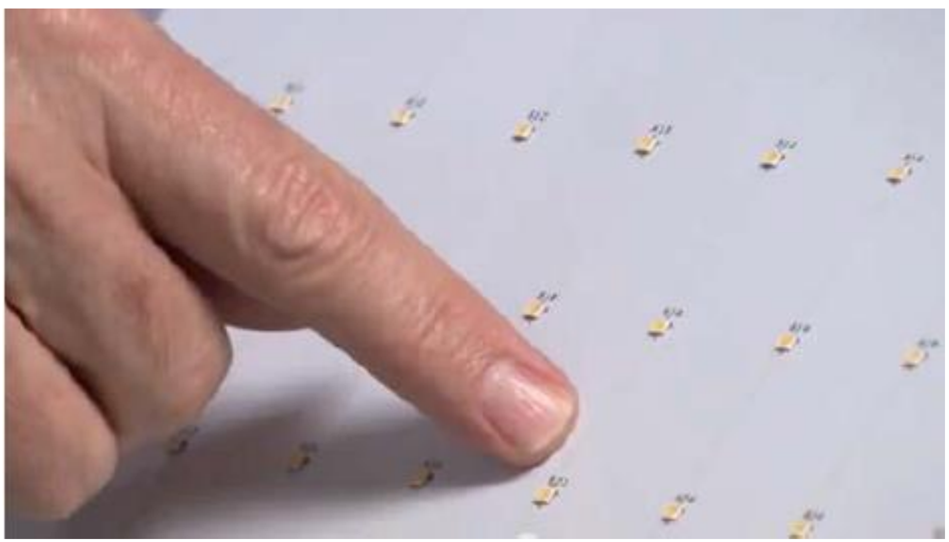


Cree Gen 2
XLamps

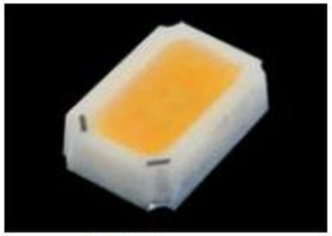
Lumileds
Luxeon S family

Osram Opto
Soleriq E Series

Bridgelux
Vero Series



Finelite – mid-power LEDs on PCb used in 2x4 troffers



Nichia
NS2L150B

Samsung
LM561B

LED Modules and Light Engines

Philips Fortimo

Osram PrevaLED

GE Infusion

LEDs: A New Light Source for Everything

- Outdoor lighting – MV, HPS, MH, induction
- Indoor commercial – FL, MH, halogen, CFL
- Residential – incandescent, halogen, CFL
- LEDs can potentially replace ALL
  - Plus automotive, indicator, display, etc.

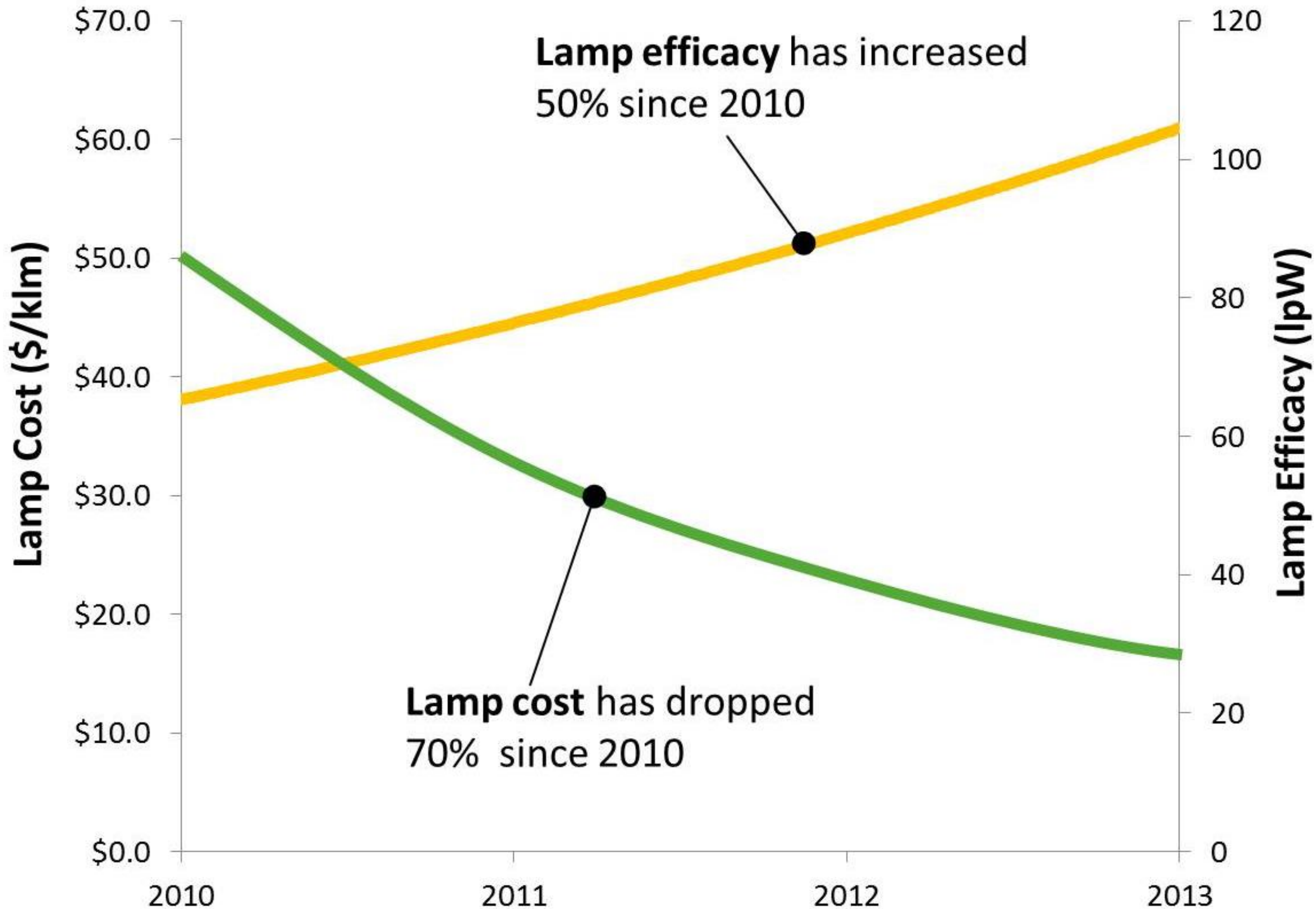
LED Efficacy Compared to Traditional Sources

Product category	Typical incandescent	Typical fluorescent	Typical HID	LED*
	Lamp or luminaire efficacy in lumens per watt (lm/W)			
A19 bulbs	15	40-60	NA	77
2x4 troffers	NA	70-100	NA	97
Downlights	12	45	NA	65
Streetlights	NA	NA	69-81	90

*LED values are average for all products of that category currently listed by LED Lighting Facts. LED streetlight values are average of current DLC Qualified outdoor pole/arm mounted area and roadway luminaires.

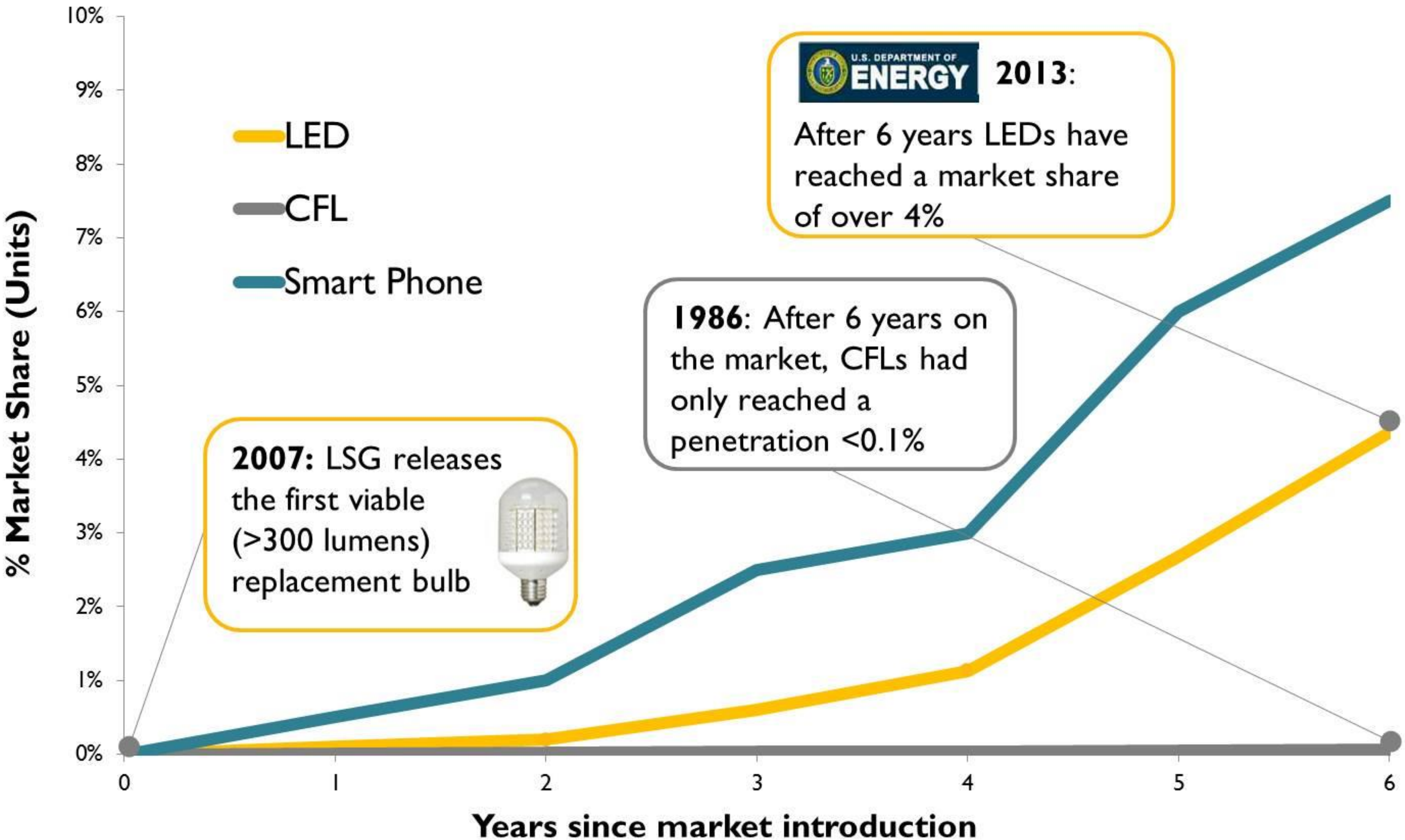
LED 60W Lamp Cost and Efficacy Trends

Similar trend lines emerging for other applications



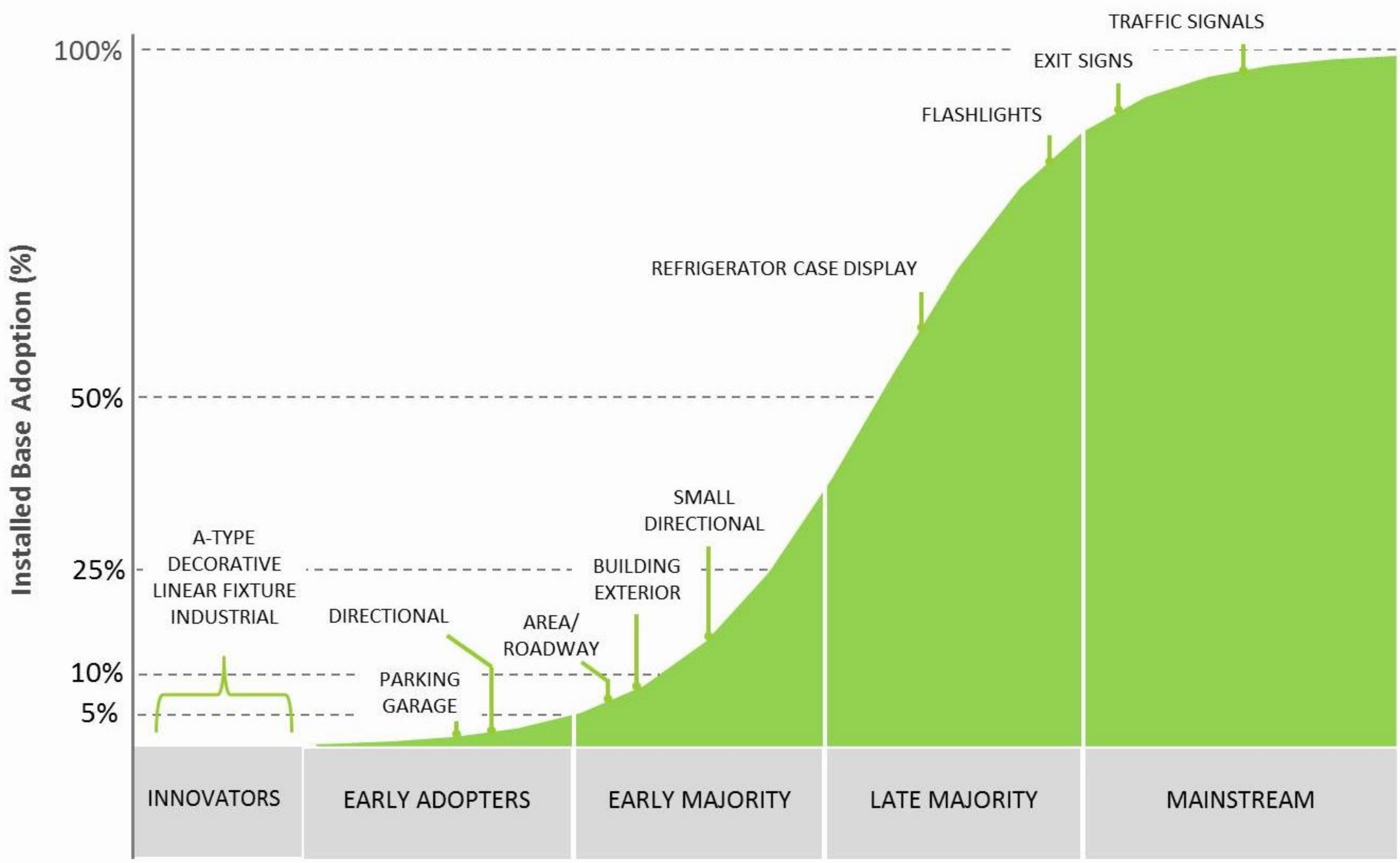
Source: Navigant Consulting

Market Share So Far



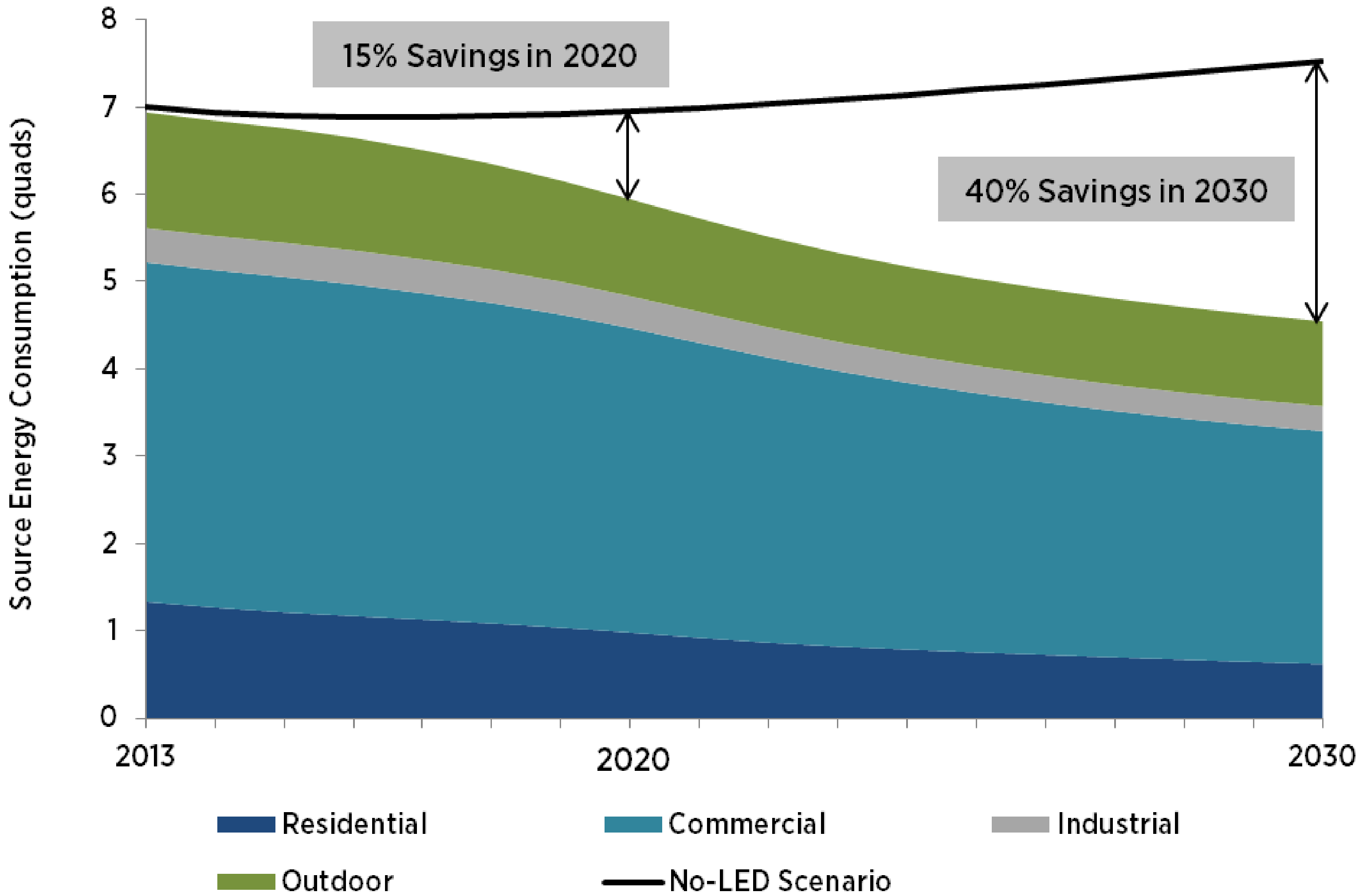
Source: DOE 2013

The Evolution of Adoption: It Takes Time



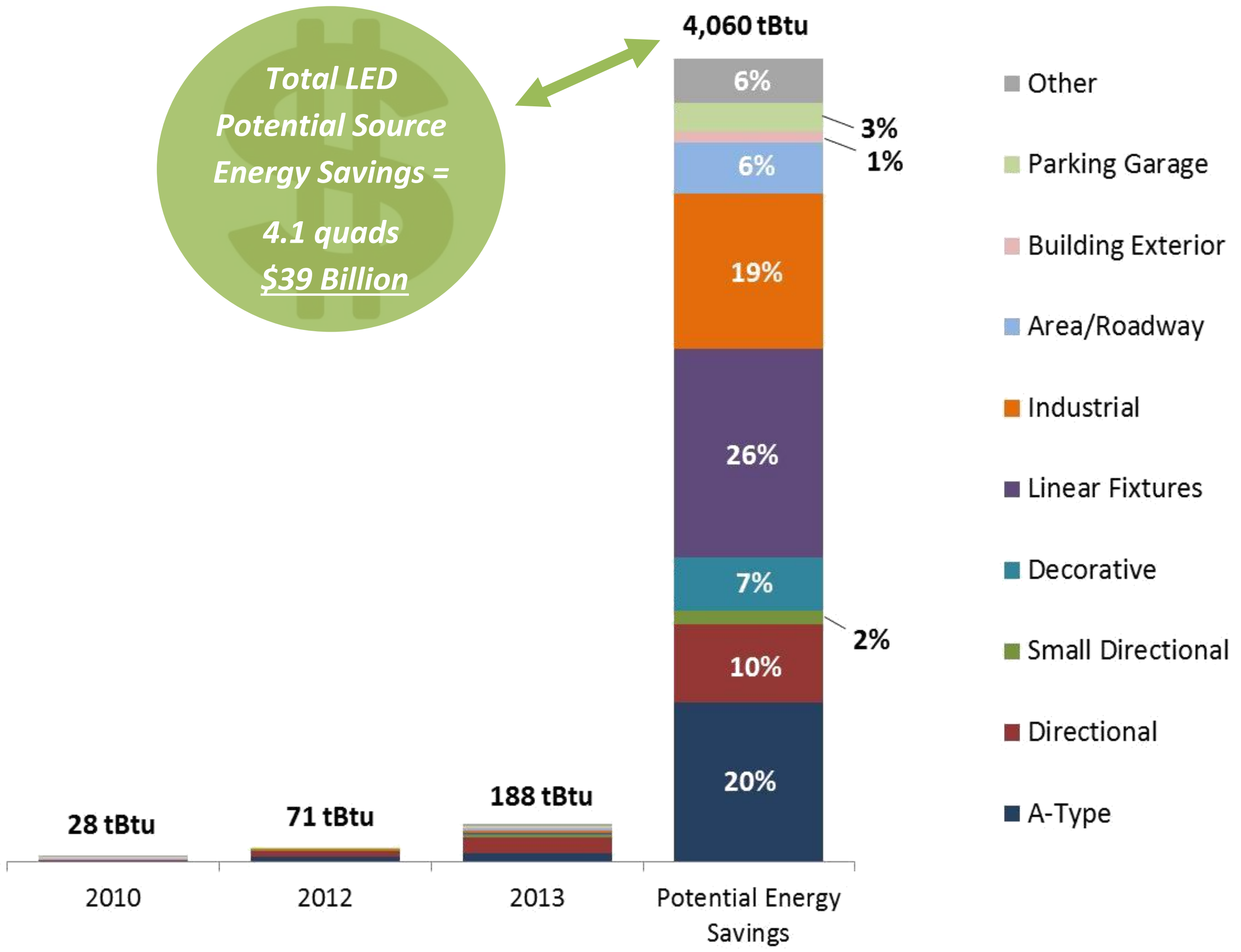
Source: Navigant Consulting

DOE Focus



Source: Energy Savings Forecast of Solid-State Lighting in General Illumination Applications
(August 2014)
www.ssl.energy.gov

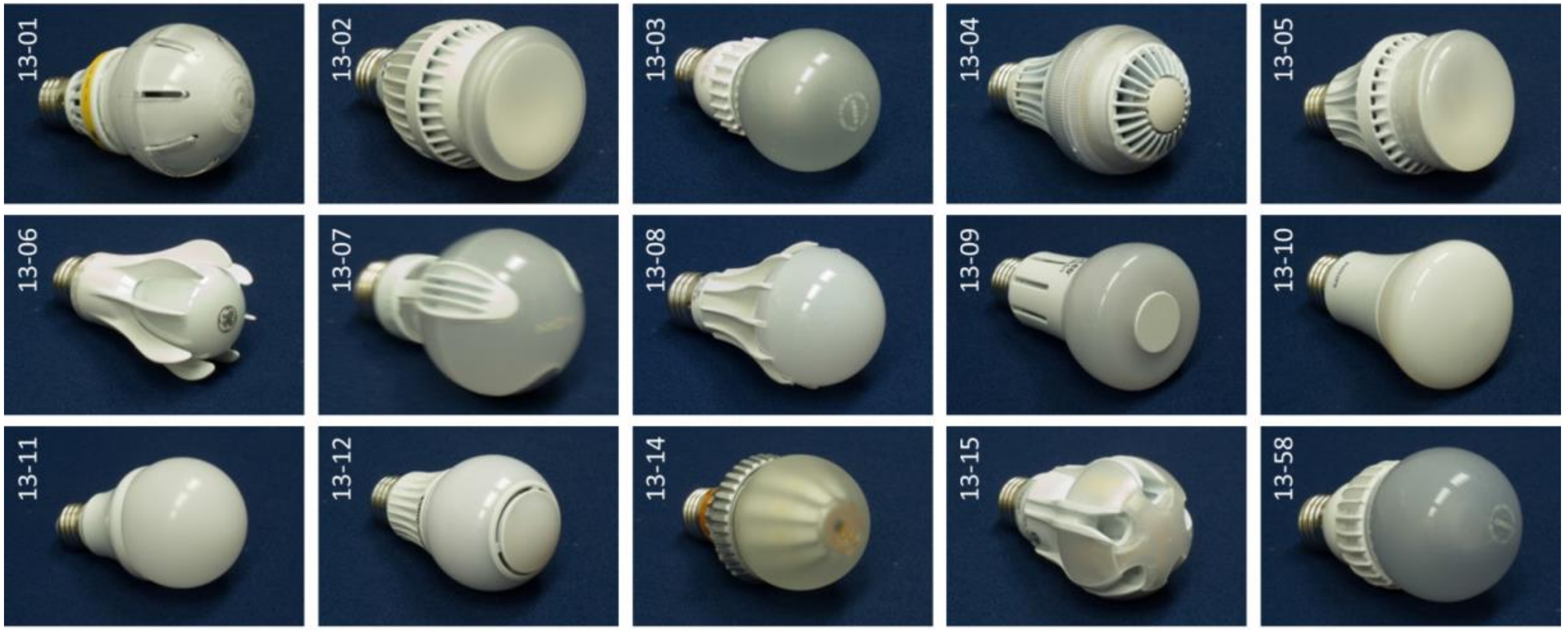
Comparison of LED Energy Savings to Available Potential



Source: LED ADOPTION ASSESSMENT – 2013 UPDATE. DOE.

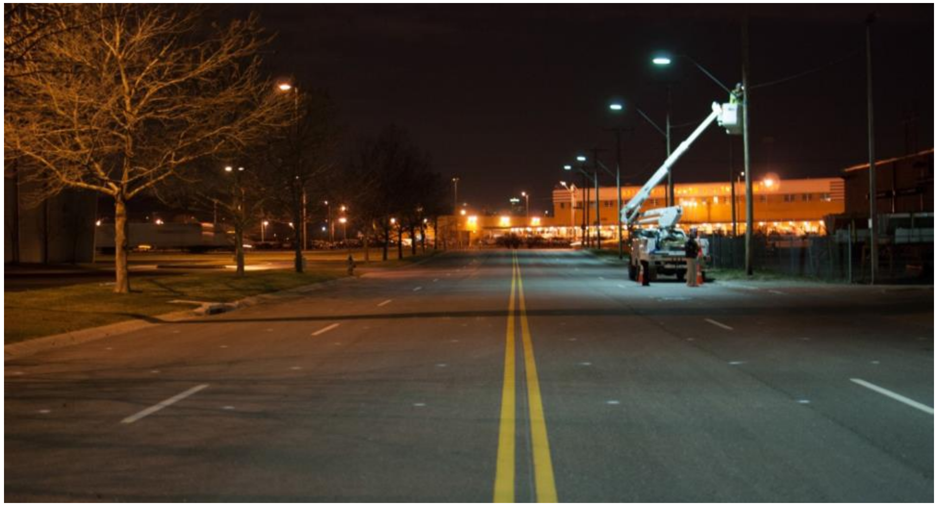
LED Lamps Now Common & Changing Fast

800 Lumen Category (60 W Equivalent)



Cree Philips GE

Streetlights Being Changed to LED in Many Cities



Kansas City, MO

Portland, OR

Philadelphia, PA

Some Results of the DOE LEEP Campaign

Organization	Parkg Facility	Orig Wattg	Type	New Wattg	Type	Total Area Square Feet (1K)	Avg Site Savings	Notes
Allentown Prkg Auth	Garage	100-400	MH	40-100	LED	434	**75%**	With controls
Walmart	Lots	400	MH	200	LED	31,018	**57%**	
Hines	Lots	100-400	MH	44-132	LED	857	**70%**	
Parmenter	Lots	100-250	MH	39-56	LED	307	**68%**	
Regency	Lots	150-1000	MH	37-557 800	LED MH	14,573	**39%**	Some controls
Thedacare	Garage	175	MH	29	LED	126	**86%**	
U Md Med Cntr	Garage	250-400	MH	51-200	LED	309	**75%**	
CLTC	Lots	70-250	MH	83-90	LED	150	**58%**	Controls
MCBQ	Lots	100-400	MH	74-169	LED	3,779	**66%**	
U of PA	Garage	250	MH	160	LED	154	**67%**	
Prince William Cnty	Lots	250-400	MH	105-188	LED	119	**82%**	Controls
Howard Hughes	Garage	400	MH	115	LED	292	**78%**	Controls

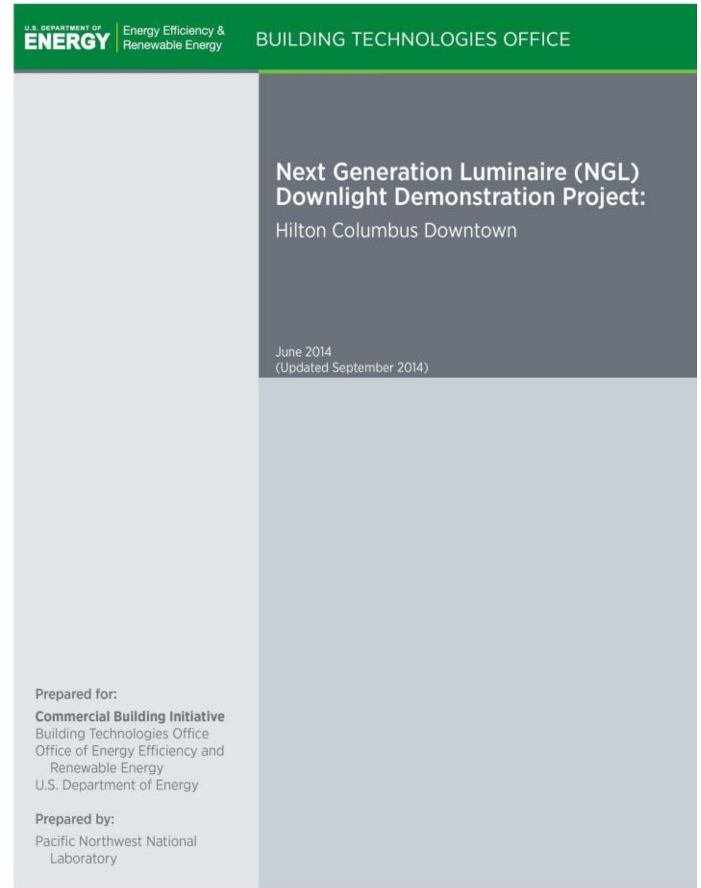
Source: Lighting Energy Efficiency in Parking, US DOE

LED Downlights in the Hilton Columbus Downtown

- LED savings:
  - 46% over CFL vertical
  - 50% over CFL horizontal
  - 79% halogen

Eaton's Cooper Lighting

Entry area rendering comparing PAR halogen (left) to LED (right). LED increased vertical illuminance by 50%.



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BUILDING TECHNOLOGIES OFFICE

Next Generation Luminaire (NGL) Downlight Demonstration Project:

Hilton Columbus Downtown

June 2014
(Updated September 2014)

Prepared for:
Commercial Building Initiative
Building Technologies Office
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

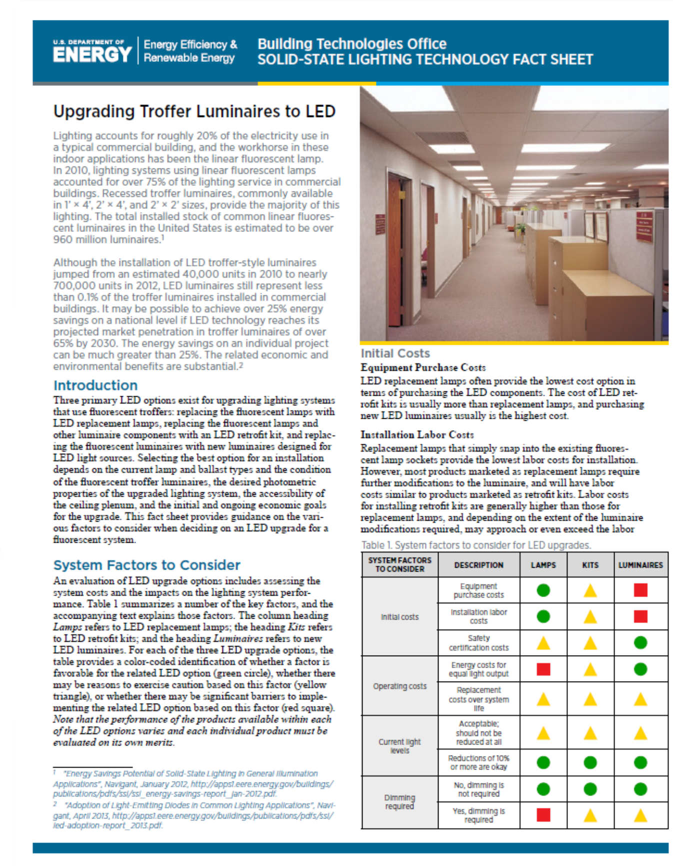
Prepared by:
Pacific Northwest National Laboratory

Various LED Options for Troffers

LED T8 lamps

Dedicated LED troffers

LED retrofit kits



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building Technologies Office
SOLID-STATE LIGHTING TECHNOLOGY FACT SHEET

Upgrading Troffer Luminaires to LED

Lighting accounts for roughly 20% of the electricity use in a typical commercial building, and the workhorse in these indoor applications has been the linear fluorescent lamp. In 2010, lighting systems using linear fluorescent lamps accounted for over 75% of the lighting service in commercial buildings. Recessed troffer luminaires, commonly available in 1' × 4', 2' × 4', and 2' × 2' sizes, provide the majority of this lighting. The total installed stock of common linear fluorescent luminaires in the United States is estimated to be over 960 million luminaires.[1]

Although the installation of LED troffer-style luminaires jumped from an estimated 40,000 units in 2010 to nearly 700,000 units in 2012, LED luminaires still represent less than 0.1% of the troffer luminaires installed in commercial buildings. It may be possible to achieve over 25% energy savings on a national level if LED technology reaches its projected market penetration in troffer luminaires of over 65% by 2030. The energy savings on an individual project can be much greater than 25%. The related economic and environmental benefits are substantial.[2]

Introduction

Three primary LED options exist for upgrading lighting systems that use fluorescent troffers: replacing the fluorescent lamps with LED replacement lamps, replacing the fluorescent lamps and other luminaire components with an LED retrofit kit, and replacing the fluorescent luminaires with new luminaires designed for LED light sources. Selecting the best option for an installation depends on the current lamp and ballast types and the condition of the fluorescent troffer luminaires, the desired photometric properties of the upgraded lighting system, the accessibility of the ceiling plenum, and the initial and ongoing economic goals for the upgrade. This fact sheet provides guidance on the various factors to consider when deciding on an LED upgrade for a fluorescent system.

System Factors to Consider

An evaluation of LED upgrade options includes assessing the system costs and the impacts on the lighting system performance. Table 1 summarizes a number of the key factors, and the accompanying text explains those factors. The column heading *Lamps* refers to LED replacement lamps; the heading *Kits* refers to LED retrofit kits; and the heading *Luminaires* refers to new LED luminaires. For each of the three LED upgrade options, the table provides a color-coded identification of whether a factor is favorable for the related LED option (green circle), whether there may be reasons to exercise caution based on this factor (yellow triangle), or whether there may be significant barriers to implementing the related LED option based on this factor (red square). *Note that the performance of the products available within each of the LED options varies and each individual product must be evaluated on its own merits.*

[1] "Energy Savings Potential of Solid-State Lighting in General Illumination Applications", Navigant, January 2012, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_energy-savings-report_jan-2012.pdf.

[2] "Adoption of Light-Emitting Diodes in Common Lighting Applications", Navigant, April 2013, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/led-adoption-report_2013.pdf.

Initial Costs

Equipment Purchase Costs

LED replacement lamps often provide the lowest cost option in terms of purchasing the LED components. The cost of LED retrofit kits is usually more than replacement lamps, and purchasing new LED luminaires usually is the highest cost.

Installation Labor Costs

Replacement lamps that simply snap into the existing fluorescent lamp sockets provide the lowest labor costs for installation. However, most products marketed as replacement lamps require further modifications to the luminaire, and will have labor costs similar to products marketed as retrofit kits. Labor costs for installing retrofit kits are generally higher than those for replacement lamps, and depending on the extent of the luminaire modifications required, may approach or even exceed the labor

Table 1. System factors to consider for LED upgrades.

SYSTEM FACTORS TO CONSIDER	DESCRIPTION	LAMPS	KITS	LUMINAIRES
Initial costs	Equipment purchase costs	Green circle	Yellow triangle	Red square
	Installation labor costs	Green circle	Yellow triangle	Red square
	Safety certification costs	Yellow triangle	Yellow triangle	Green circle
Operating costs	Energy costs for equal light output	Red square	Yellow triangle	Green circle
	Replacement costs over system life	Yellow triangle	Yellow triangle	Yellow triangle
Current light levels	Acceptable; should not be reduced at all	Yellow triangle	Yellow triangle	Yellow triangle
	Reductions of 10% or more are okay	Green circle	Green circle	Green circle
Dimming required	No, dimming is not required	Green circle	Green circle	Green circle
	Yes, dimming is required	Red square	Yellow triangle	Yellow triangle

Fact sheet available!

Challenges: Dimming

Achieving high-quality dimming performance with LED lamps is difficult, but improving

Depending on:

1) characteristics of the LED sources (drivers)
2) characteristics of the dimmer
3) number and type of light sources on the circuit

You might encounter:

- Limited dimming range
- Unpredictable dimming curve
- Dead travel
- Pop-on
- Drop-out
- Flashing, ghosting
- Premature failure
- Audible noise
- Inoperability

Dimming with LED A-type Lamps

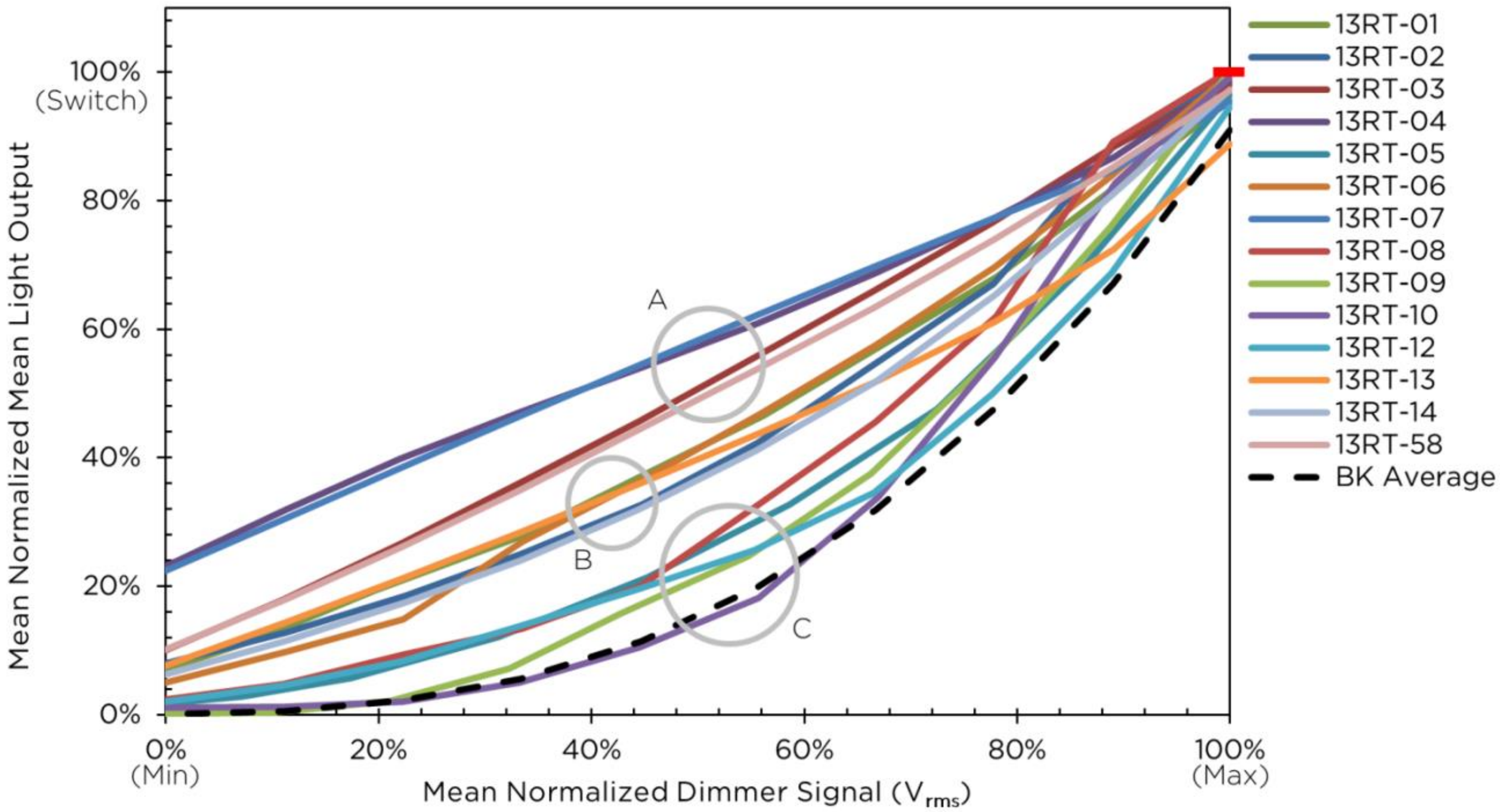


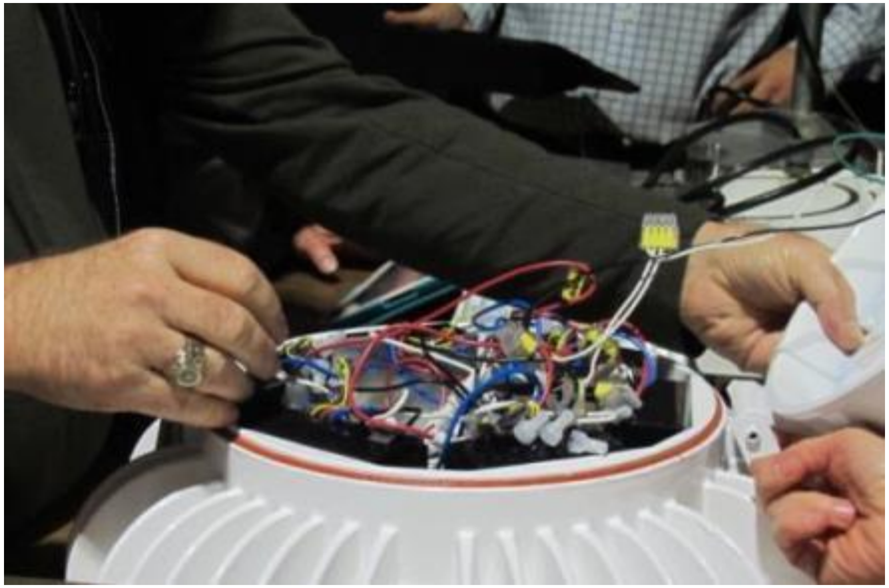
Figure 5. Dimming curves for the 14 dimmable LED lamps and the average of the two halogen benchmarks (BK). Some of the LED products exhibited a linear dimming response (A), some exhibited a partially adjusted curve (B), and some exhibited a response closer to the benchmark (C).

Challenges: Flicker

Some LEDs flicker noticeably, which may negatively impact adoption in some applications

Challenges: Serviceability

Lack of LED product serviceability and interchangeability has created market adoption barriers in certain sectors



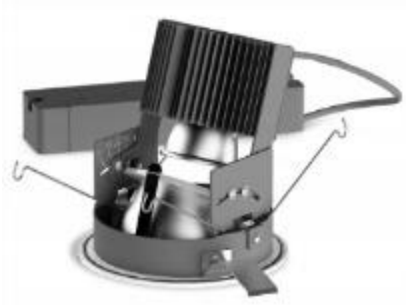
Serviceability

- NGL recognized several products for serviceability
- Zhaga standards for 7 different LED light engine form factors so far; 3 more in development
  - 174 products certified so far

GE Lighting

Examples of NGL Indoor 2014 Products noted for serviceability

Book 2 holder



Book 3 luminaire

H.E. Williams

Book 3 module

Book 4 module

What's Coming? Integrated Controls

CREE

SmartCast ™

What’s Coming? Integrated Intelligence

Uses LED lights to communicate location-based information to shoppers via smartphones

Source: Philips

What’s Coming: More Controls

GE Link

Cree Connected

TCP Connected

Lighting Control on
Wi-Fi network

Philips Hue

What's Coming? New Form Factors

Project: Holt Renfrew, Bloor Street, Toronto, Women's Designer on 2
Lighting Design: Lightbrigade Architectural Lighting Design
Interior Designer: Burdifilek
Photograph: A-Frame Studio / Ben Rahn Photographer

Source: Acuity Brands

What's Coming? New Form Factors

Source: Fred Maxik, Lighting Science

Source: GE Lighting

Thank You

Jeff McCullough
PNNL

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