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

SSL Early Lessons Learned – Status Update, May 2015



SPARC International Lighting Event

May 27-29

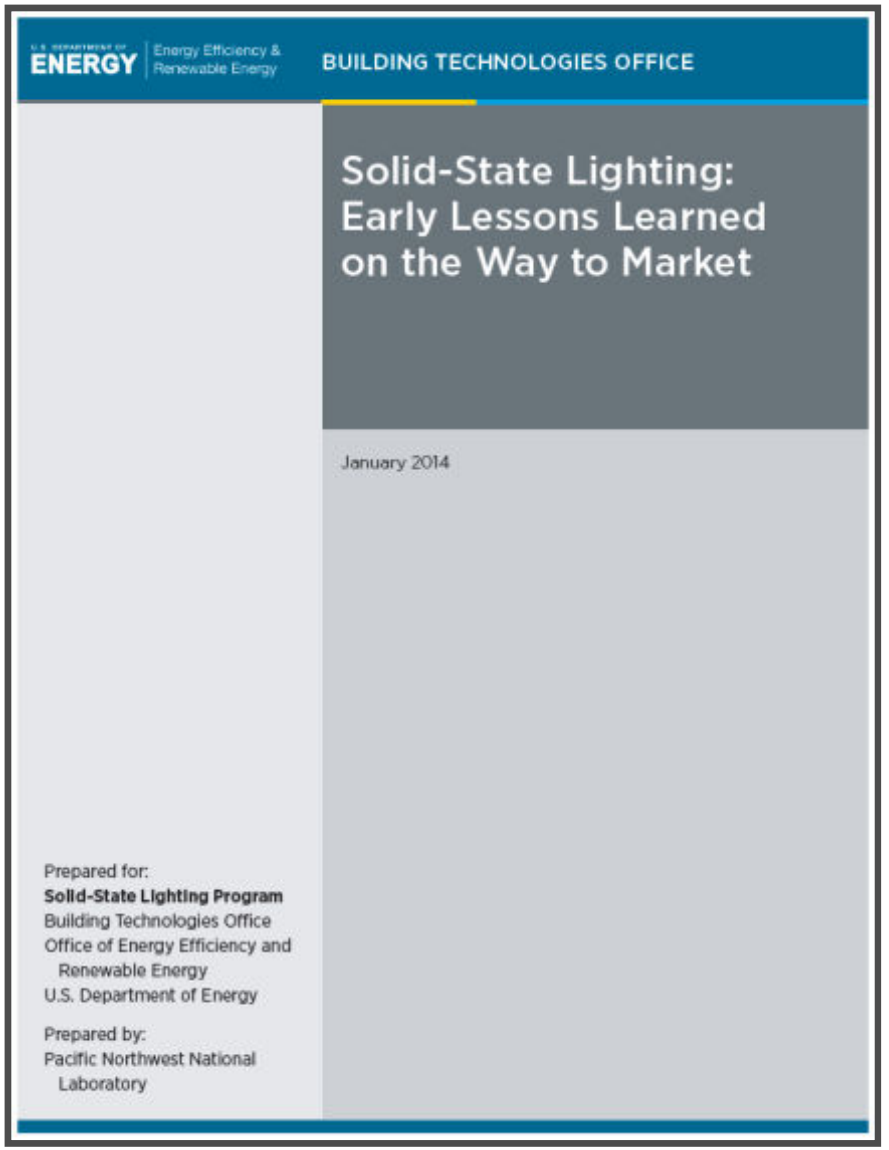
Sydney, Australia

Marc Ledbetter

Pacific Northwest National Laboratory

Key Lessons

1. Testing costs
2. Lifetime
3. Product families
4. Color quality
5. Color stability
6. Flicker
7. Glare
8. Dimming
9. Interoperability
10. Serviceability
11. Existing infrastructure
12. Qualification programs



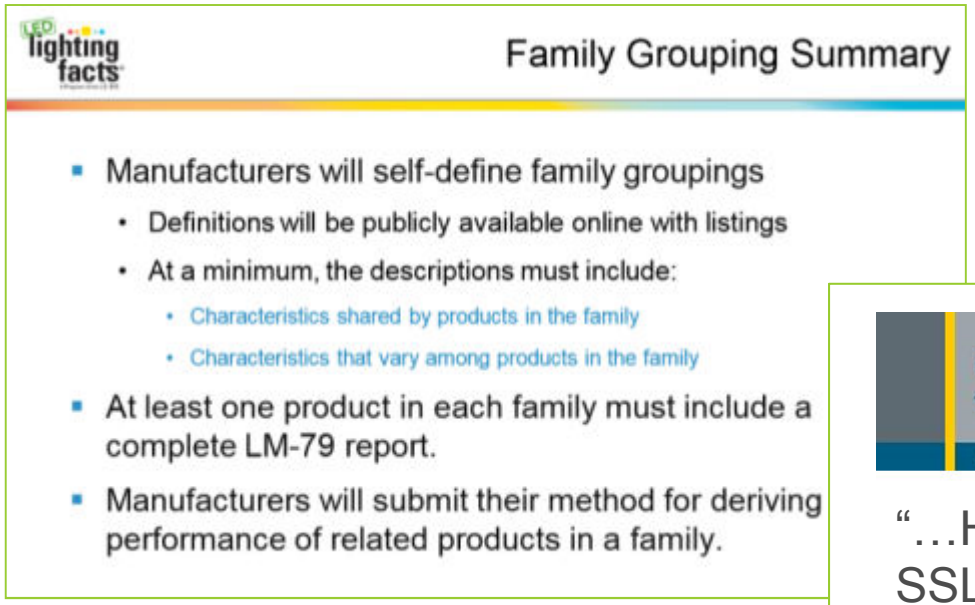
http://energy.gov/eere/ssl/market-studies

Lesson 1: Testing Costs

Rigorous testing requirements adopted in the early days of SSL industry development were necessary to counter exaggerated claims of performance by some manufacturers, but they eventually led to unreasonably high testing costs

Lesson 1: Testing Costs - UPDATE

- Key issue is absolute vs. relative photometry
- U.S. DOE addressed issue via LED Lighting Facts and communications
- About 40% of new LED Lighting Facts product entries are in families

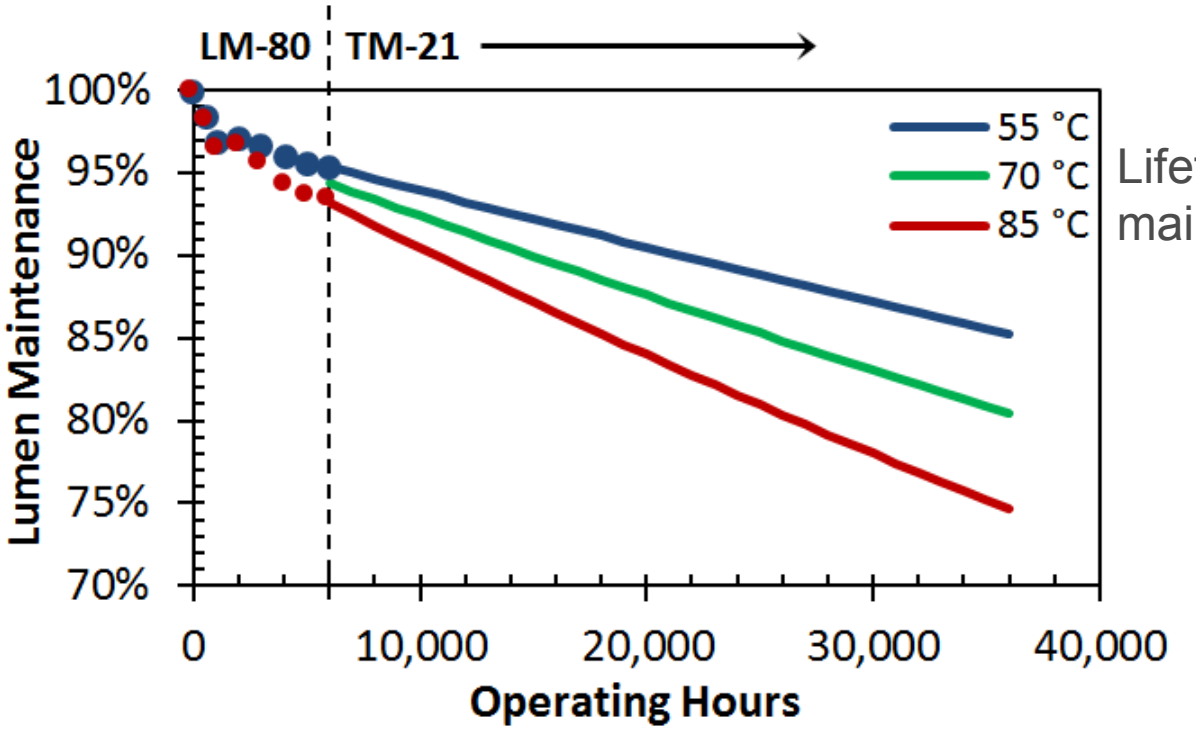


Manufacturer white paper on methodology

"…However, an increasing number of SSL manufacturers have shown that they can accurately calculate performance by extrapolating absolute testing results from one or more products to a family of similar products…"

Lesson 2: Lifetime

Despite the promise of long life, there is no standard way to rate the lifetime and reliability of LED products

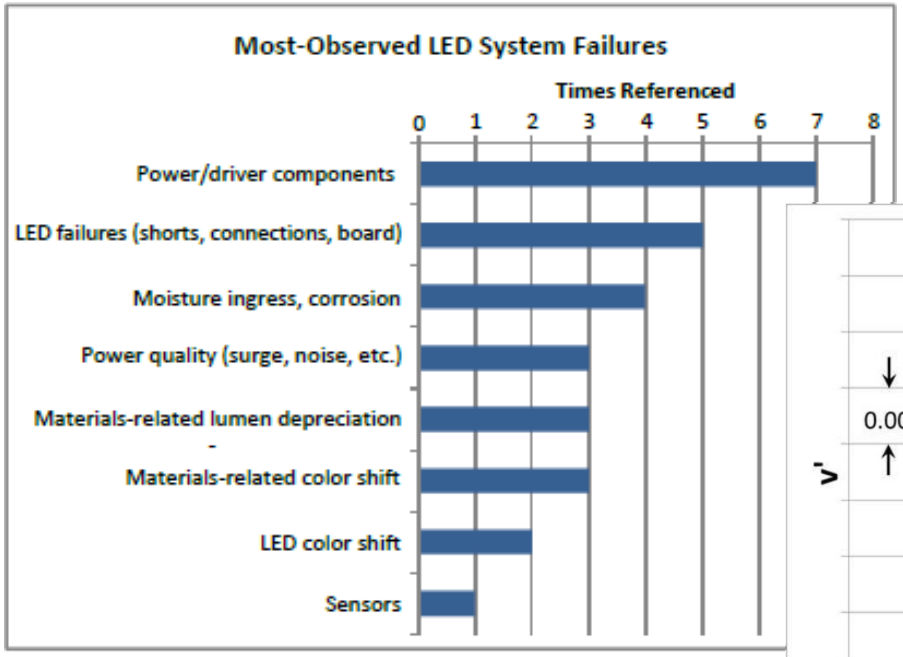


Lifetime ≠ lumen maintenance

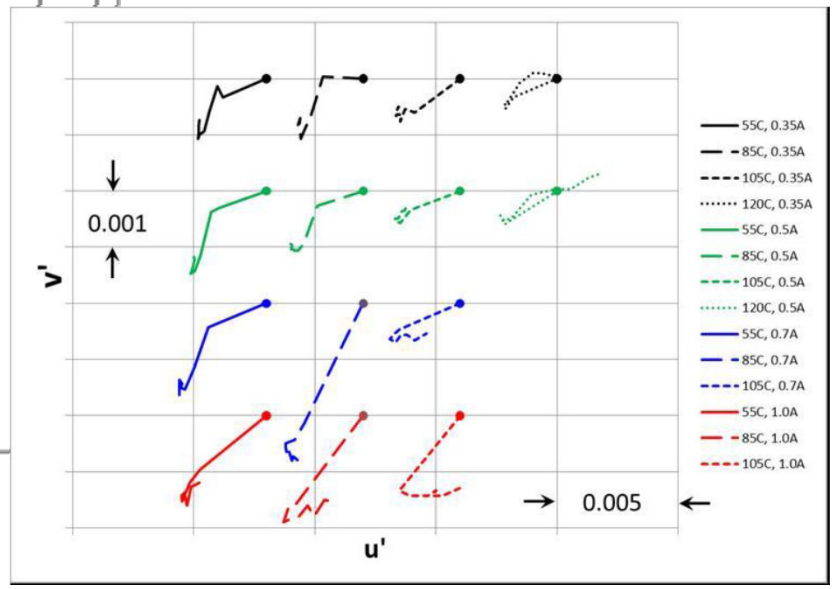
www.ssl.energy.gov

Lesson 2: Lifetime - UPDATE

- DOE/NGLIA LED Systems Reliability Consortium 3rd edition "LED Luminaire Lifetime: Recommendations for Testing and Reporting"
  - "Lumen depreciation is not a proxy for luminaire lifetime."
- Consortium doing more research to build luminaire reliability model
- ANSI C82 developing LED driver robustness test procedure
- Predicting color shift remains a big issue



http://energy.gov/node/1009291/



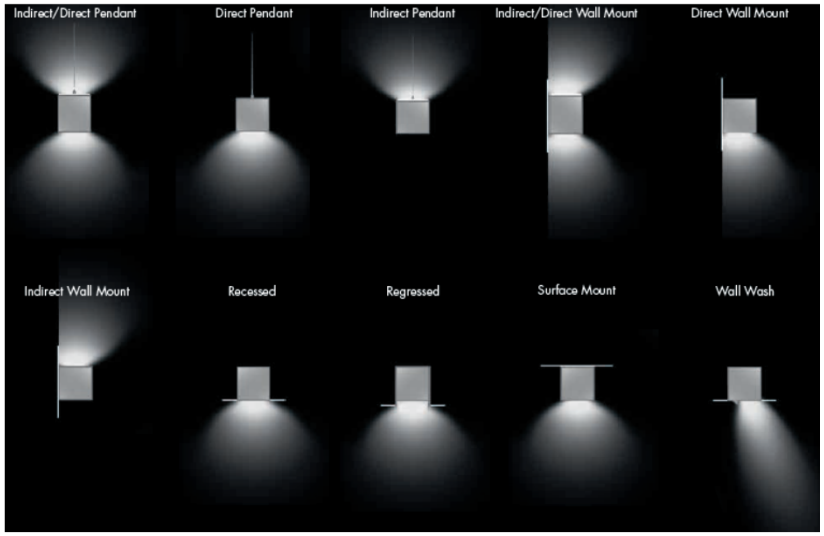
Lesson 3: Product families

Specifiers prefer complete families of products, but the rapid evolution of LED technology presents a challenge to manufacturers in creating and maintaining complete product lines

	16151	16135	16134
Image:			
Product Number:	16151	16135	16134
Name:	50PAR30HALIRSSP10TL 120 10/CS 1/SKU	39PAR30HALWFL50DL 120V 10/CS I/SKU	39PAR30HALNFL25DL 120V 10/CS 1/SKU
Select For New Comparison:	☑	☑	☑
Details			
Abbrev. With Packaging Info.	50PAR30HALIRSSP10TL 120 10/CS 1/SKU	39PAR30HALWFL50DL 120V 10/CS I/SKU	39PAR30HALNFL25DL 120V 10/CS 1/SKU
Approx. Lumens	950	520	520
Average Rated Life (hr)	4500	3000	3000
Base	E26 Medium	E26 Medium	E26 Medium
Beam Angle (deg)	10	50	25
Beam Type	SP	WFL	FL
Bulb	PAR30	PAR30	PAR30
Centerbeam Candlepower (cp)	10600	600	1600

Lesson 3: Product families - UPDATE

- Families of specification-grade fixtures and lamps are becoming more available
- Still need better availability of families with different output levels
  - e.g., 500, 1000, 2000 lumens



Finelite HP 4 Product Family

Specifications | Variations | Documentation

LM16-35-30K-17D - 35W eq, 17° Spot

LM16-35-30K-25D - 35W eq, 25° Flood

LM16-35-30K-40D - 35W eq, 40° Wide Flood

LM16-50-30K-17D - 50W eq, 17° Spot

LM16-50-30K-25D - 50W eq, 25° Flood

LM16-50-30K-40D - 50W eq, 40° Wide Flood

Cree LM Series MR-16 Replacements

PERFORMANCE

Direct, Recessed, Surface Mount, Indirect, and Wall Wash

	Lumen Distribution Per 4-Foot Section (4000K)								Typical Fluorescent		
	HP - 4 D, HP - 4 R, and HP - 4 SM		**HP - 4 I**		**HP - 4 WW** (Kicker)		**HP - 4 WW** (Open)				
	SO	HO	SO*	HO*	SO*	HO*	SO*	HO*	1 T8	1 T5	2 T5
Lumens	1447	2754	1655	3011	827	1505	899	1636	1495	1399	2750
Wattage	18.1	36.9	18	35.6	9.9	19.1	9.9	19.1	28.2	28	56
LPW	79.9	74.6	92	85	83.5	78.8	90.8	85.7	53	50	49

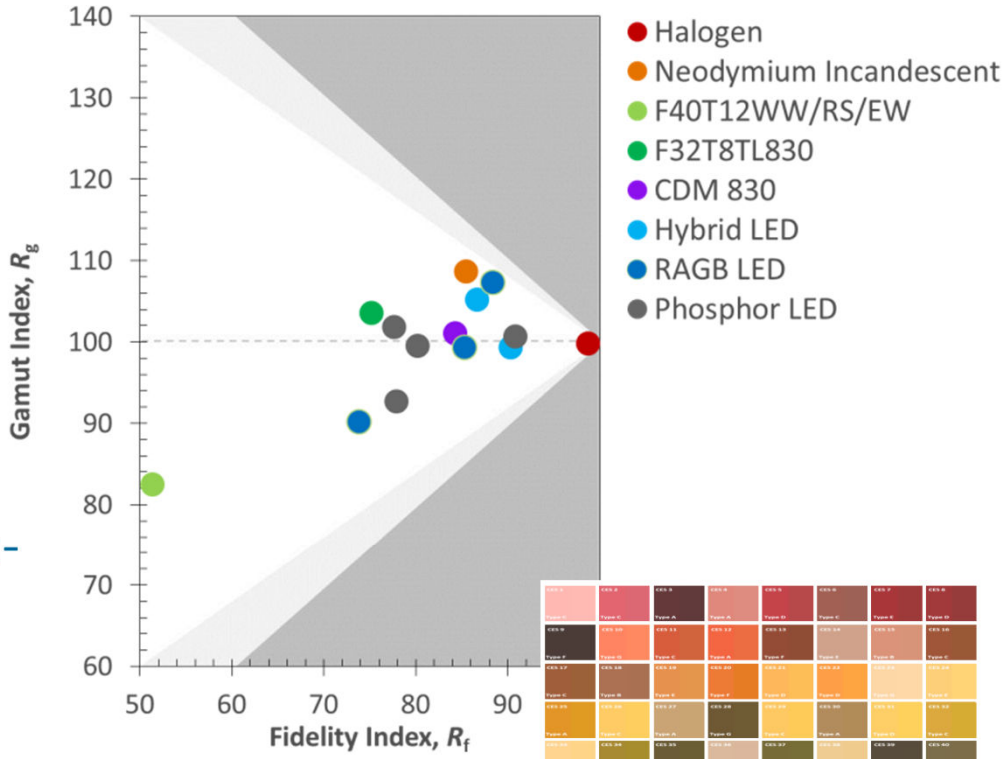
* Family Correlated based on 3500K HO test. *HP-4 I:* ITL LM79 Report ITL76759; *HP-4 WW (Kicker):* ITL LM79 Report 79770; *HP-4 WW (Open):* ITL LM79 Report 79771

Lesson 4: Color quality

The range of color quality available with LED-based products and the limitations of existing color metrics may confuse users

Lesson 4: Color quality - UPDATE

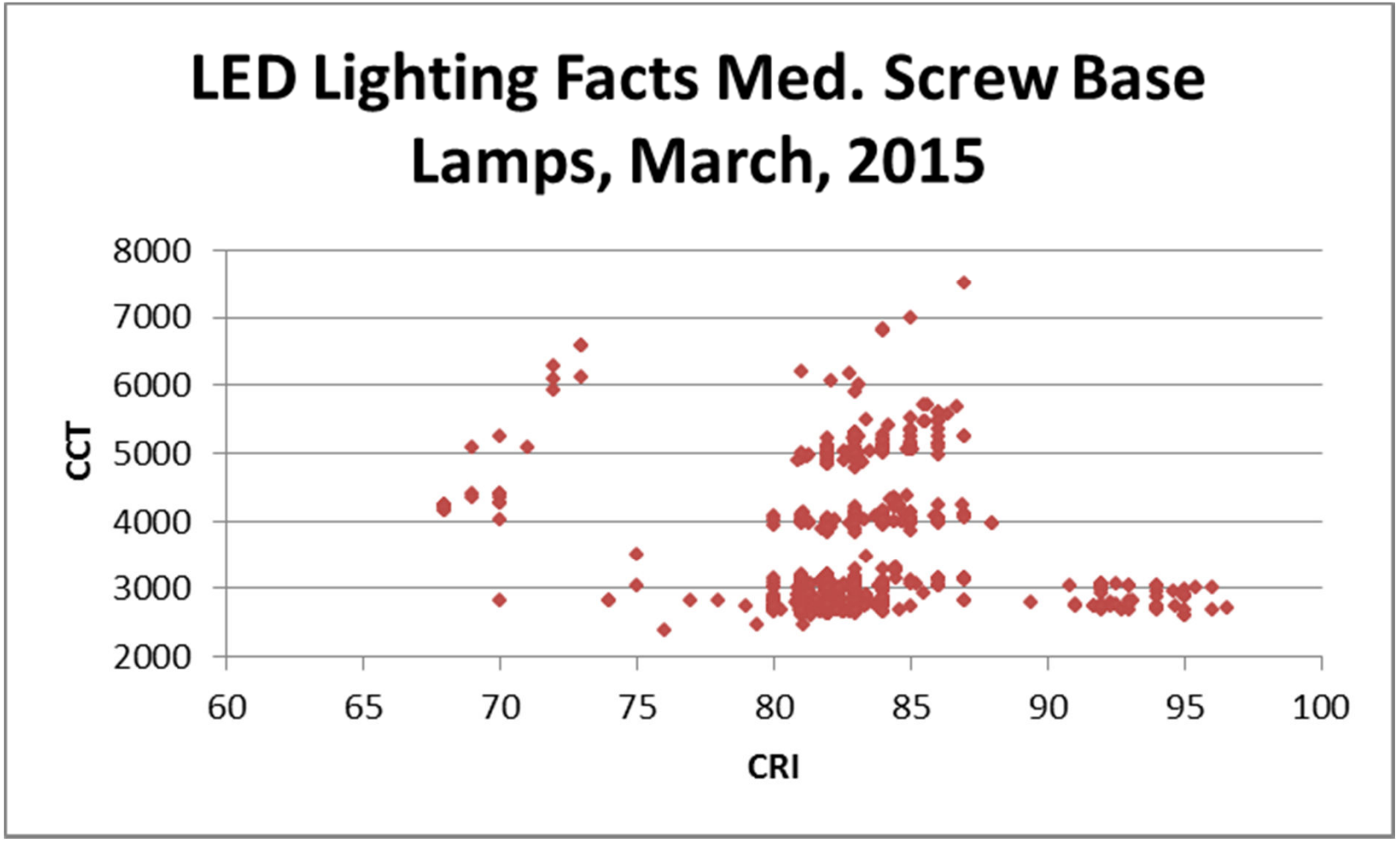
- IES Color Metric Task Group
  - TM-30 before IES Board
  - Based on mathematical approach; no preference weighting
  - Uses 99 color samples
  - Focus on fidelity and gamut
  - Two-metric system
- NGL judges say color "much improved" and "almost a non-issue"
- California now requires 90+ CRI for LED replacement lamps receiving utility rebates



Finelite

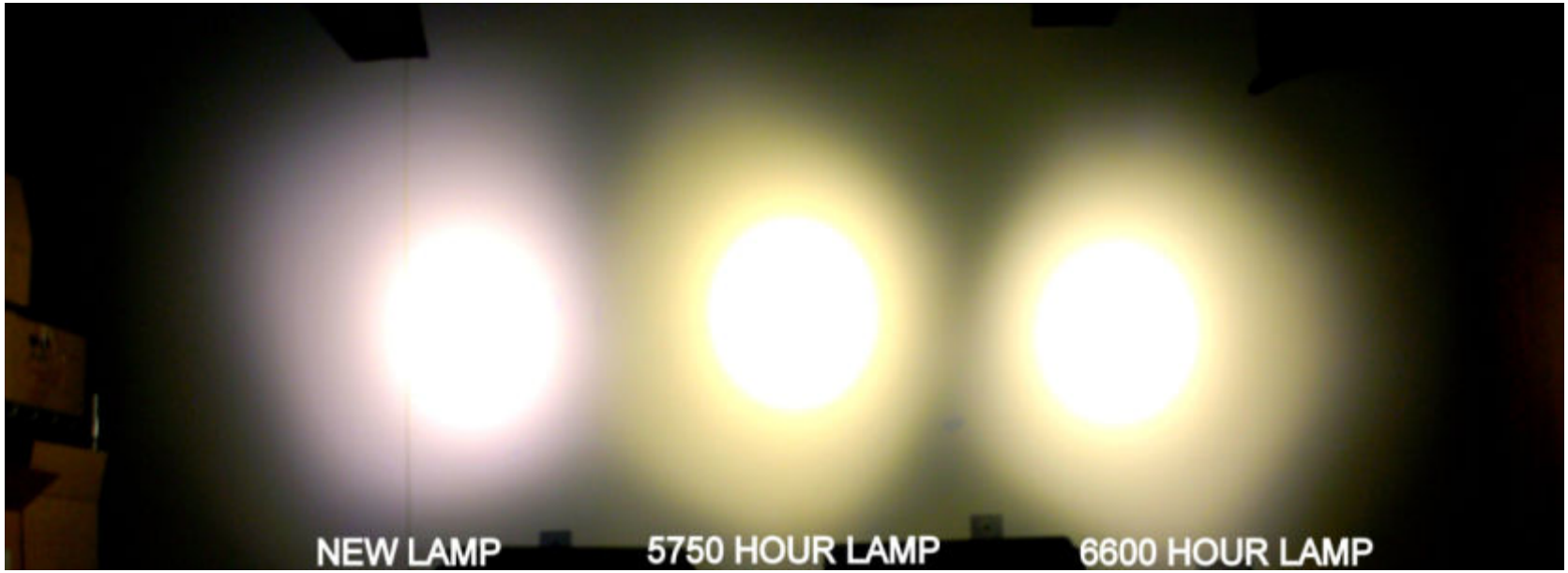
99 color samples used in TM-30

Lesson 4: Color quality - UPDATE



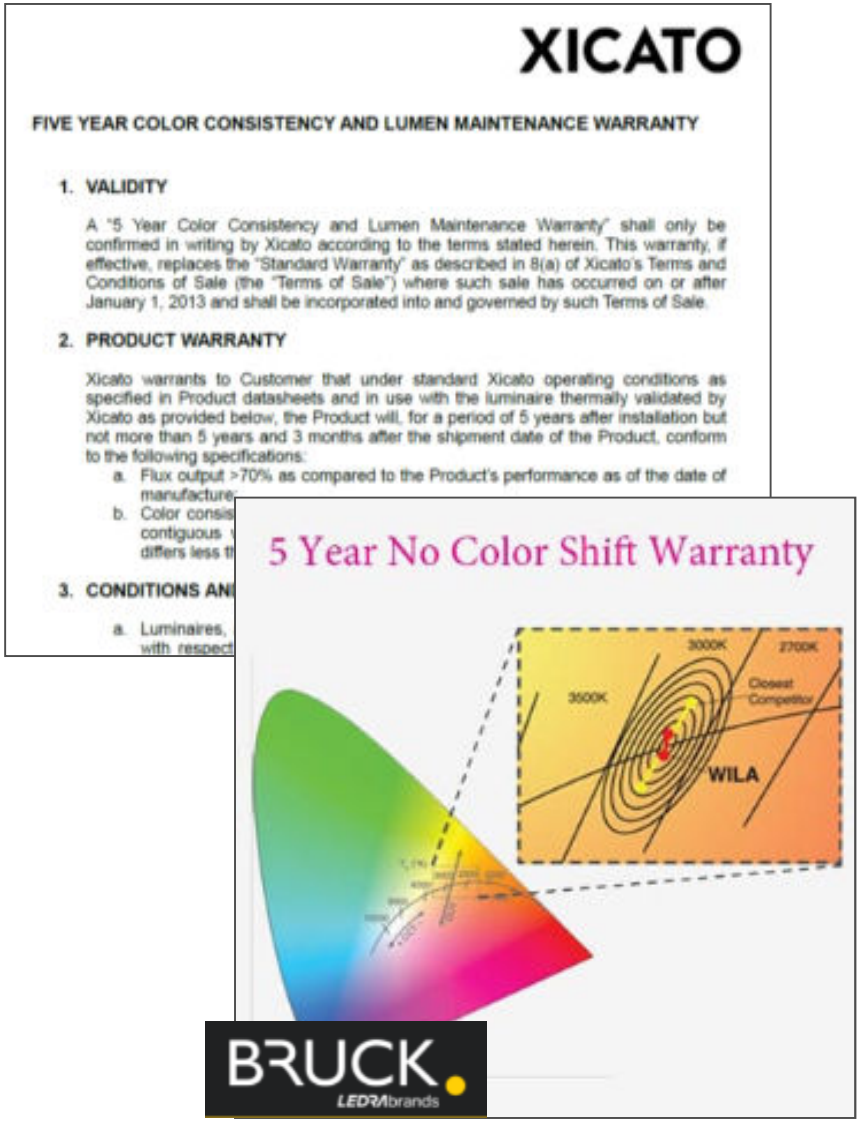
Lesson 5: Color stability

The color delivered by some LEDs shifts over time, enough to negatively impact adoption in some applications



Lesson 5: Color stability - UPDATE

- Some manufacturers now offer warranties for color shift
- IES PIF on color stability
  - Should lead to a TM for projecting color shift over time
- DOE/NGLIA LED Systems Reliability Consortium 3rd edition “LED Luminaire Lifetime: Recommendations for Testing and Reporting”
  - Color shift is recognized failure mode for some types of products

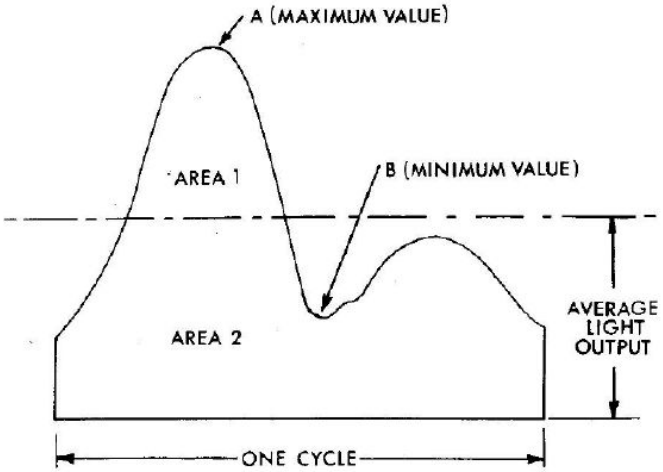


Lesson 6: Flicker

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

Lesson 6: Flicker - **UPDATE**

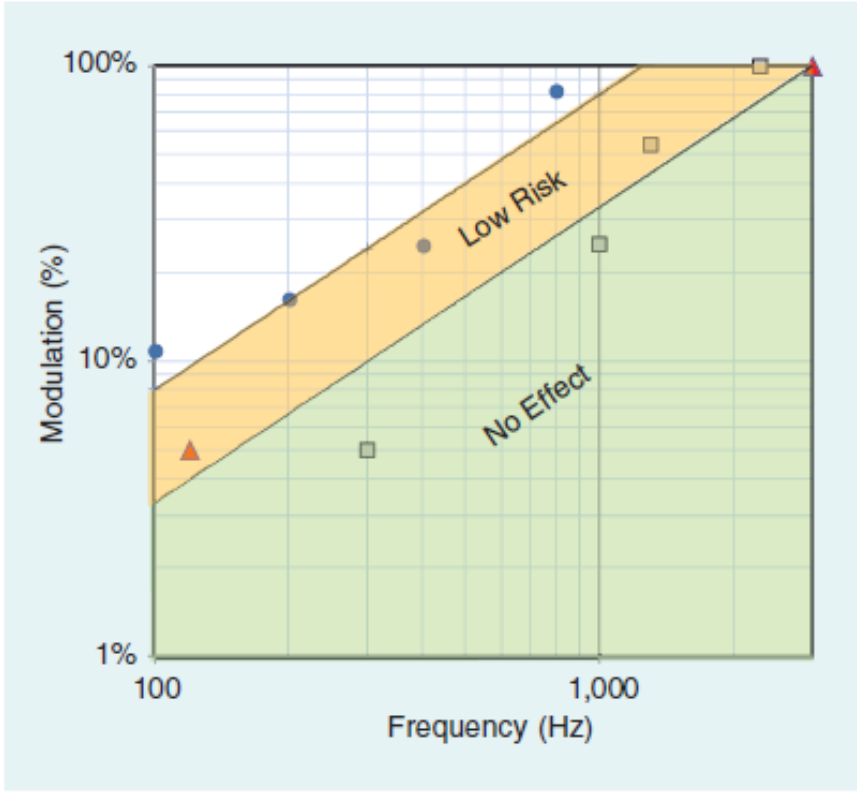
- IEEE PAR1789 committee Recommended Practice passed by IEEE Board. To be published soon.
- Article, “Designing to Mitigate the Effects of Flicker in LED Lighting”
  - IEEE Power Electronics Magazine, Sep 2014



Source: IESNA Lighting Handbook, 9th Edition (Rea 2000)

Figure 1.3. Periodic Waveform Reference for Traditional Flicker Metrics

Percent Flicker = 100% x (Max-Min) / (Max + Min) = 100% x (A-B) / (A+B)



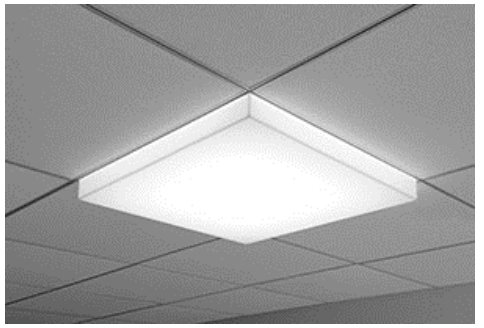
Lesson 7: Glare

LEDs can cause glare, which may negatively impact adoption in some applications

Lesson 7: Glare - UPDATE

- Recent NY Times article on new LED streetlights in NY: “To some residents, the new lights make it feel as though a construction or film crew is working outside all night. Others liken the lights to a prison yard, or joke about alien abductions.” March 23, 2015
- Next Generation Luminaires competition judges have noted improvements but glare remains their #1 complaint
- Industry is taking this seriously
  - Diffusing lenses
  - Edge lit designs
  - Other optics that reduce spot luminance and reduce contrast of LED to background
- New CIE Committee investigating glare issues (JTC 7)
  - Review UGR
  - Propose modifications to UGR to address non-uniformity of glare sources

NGL Indoor 2014
Noted for glare control

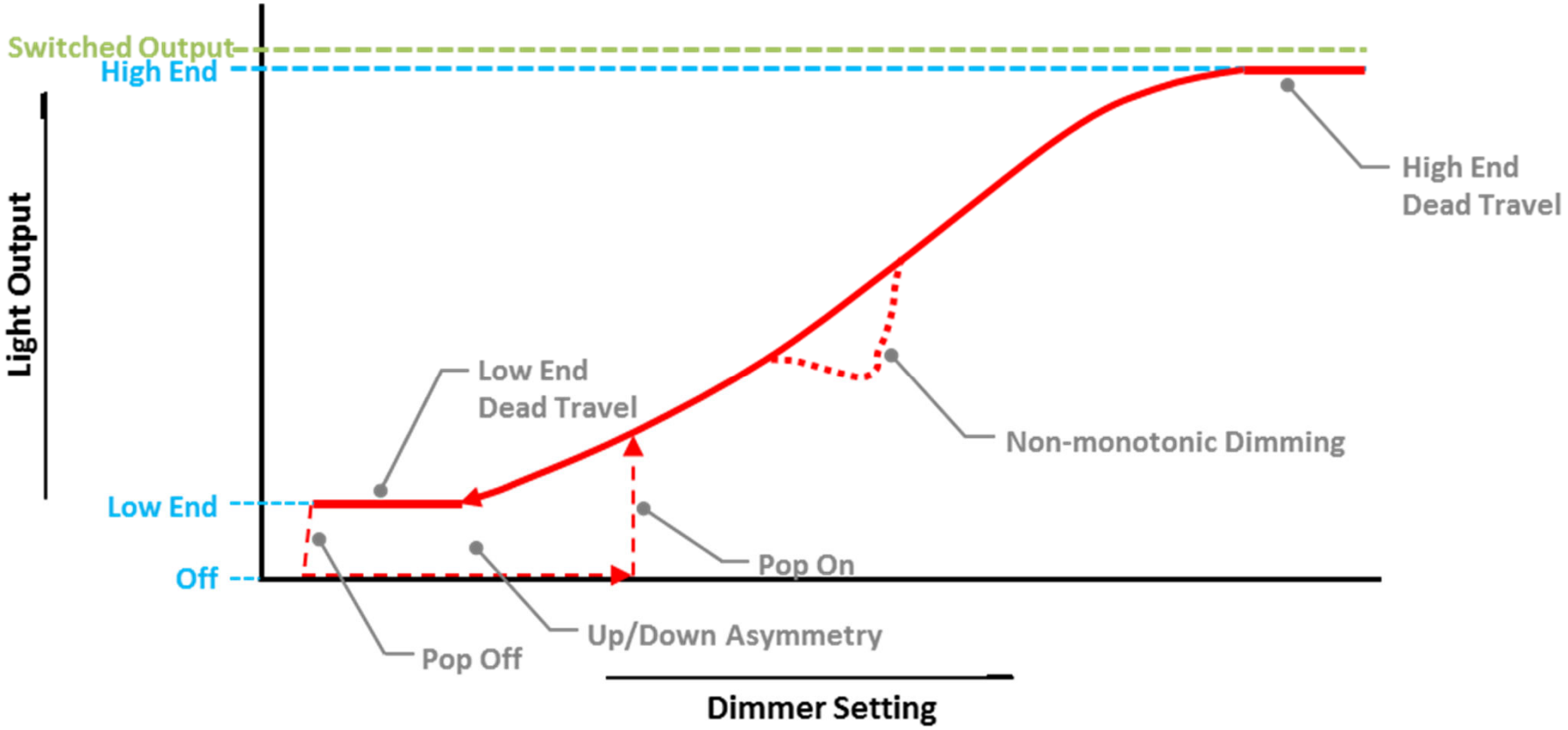


Focal Point

Acuity Brands - Peerless

Lesson 8: Dimming

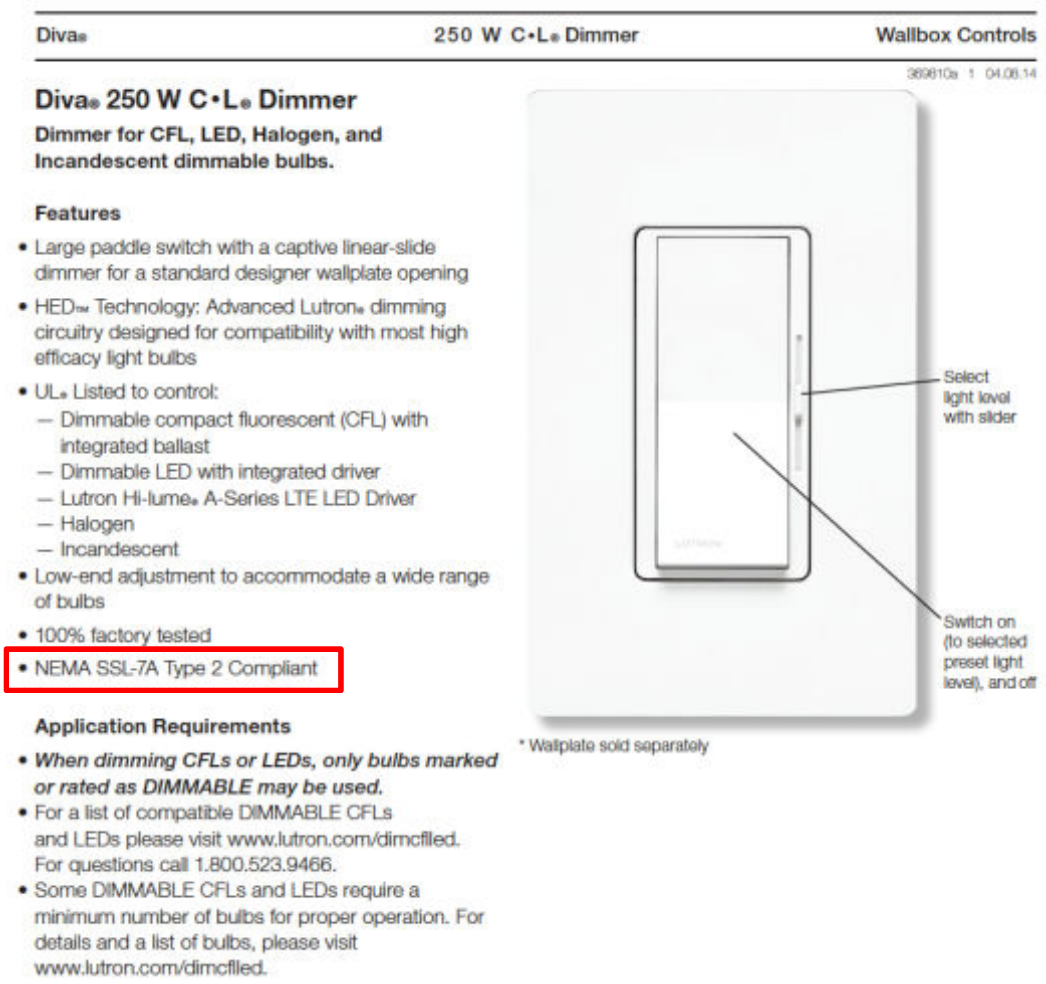
Achieving high-quality dimming performance with LED lamps is difficult, but improving



Source: Modified from NEMA SSL-6

Lesson 8: Dimming - **UPDATE**

- NEMA SSL-7A compliant products beginning to appear on market
- NEMA SSL-7B in progress
- CALiPER tested PAR38 LED lamps:
  - Some achieve high quality dimming, almost identical to incandescent



Diva® 250 W C•L® Dimmer Wallbox Controls

369810a 1 04.08.14

Diva® 250 W C•L® Dimmer

Dimmer for CFL, LED, Halogen, and Incandescent dimmable bulbs.

Features

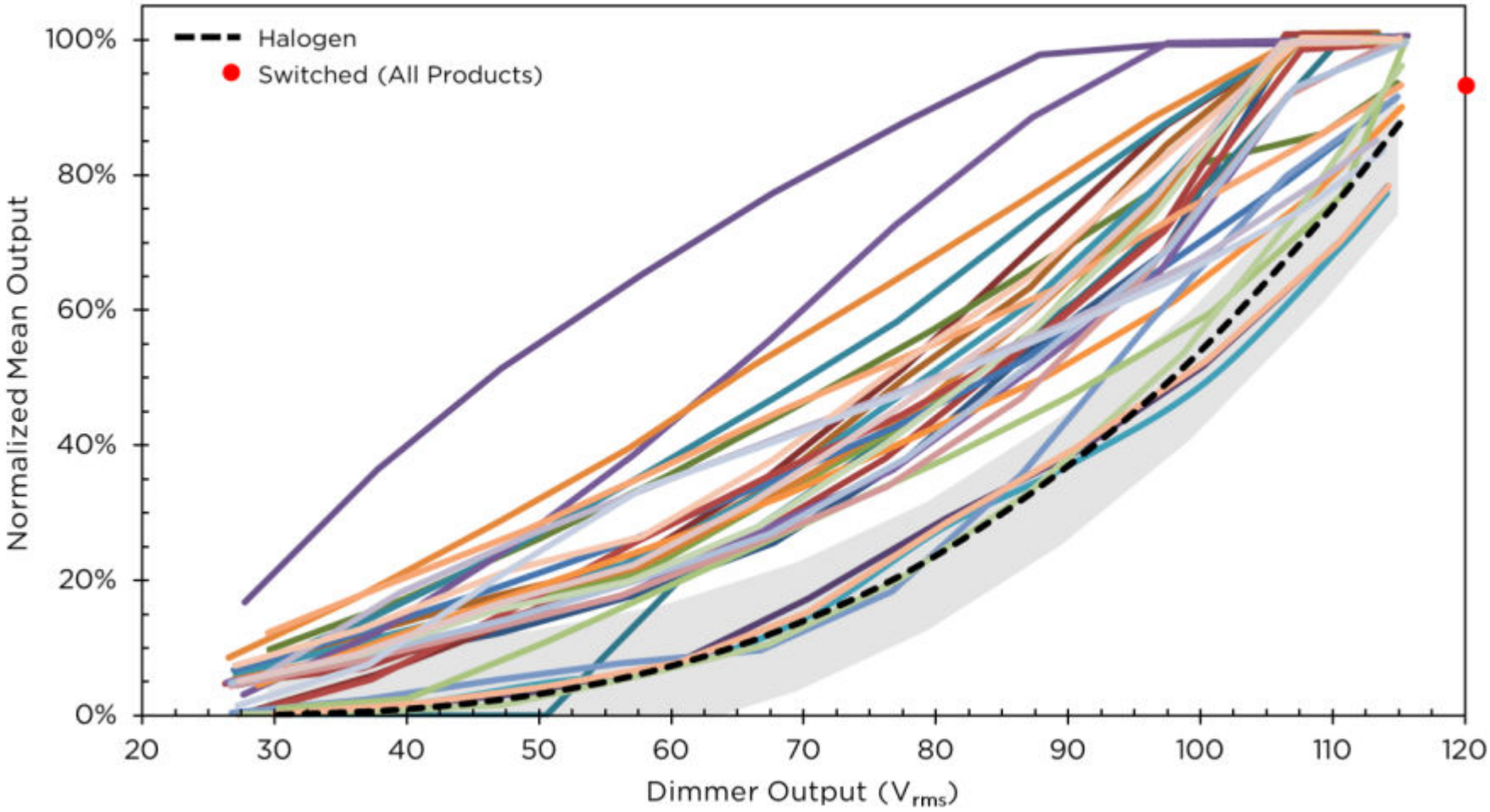
- Large paddle switch with a captive linear-slide dimmer for a standard designer wallplate opening
- HED™ Technology: Advanced Lutron® dimming circuitry designed for compatibility with most high efficacy light bulbs
- UL® Listed to control:
  - Dimmable compact fluorescent (CFL) with integrated ballast
  - Dimmable LED with integrated driver
  - Lutron Hi-lume® A-Series LTE LED Driver
  - Halogen
  - Incandescent
- Low-end adjustment to accommodate a wide range of bulbs
- 100% factory tested
- NEMA SSL-7A Type 2 Compliant

Application Requirements

- ***When dimming CFLs or LEDs, only bulbs marked or rated as DIMMABLE may be used.***
- For a list of compatible DIMMABLE CFLs and LEDs please visit www.lutron.com/dimcfiled. For questions call 1.800.523.9466.
- Some DIMMABLE CFLs and LEDs require a minimum number of bulbs for proper operation. For details and a list of bulbs, please visit www.lutron.com/dimcfiled.

* Wallplate sold separately

Lesson 8: Dimming - UPDATE



CALiPER Report 20.2 Dimming, Flicker, and Power Quality Characteristics of LED PAR38 Lamps, March 2014

Lesson 9: Interoperability

Greater interoperability of lighting control components and more sensible specifications of lighting control systems are required to maximize the energy savings delivered by LED-based sources

Lighting Control on Wi-Fi network

Example: ZigBee Light Link to Ethernet Gateway

Lesson 9: Interoperability - UPDATE

- Industry consortia actively working on interoperability
  - TALQ - outdoor
  - TCLA – indoor
  - Many others
- ANSI C137 Lighting Systems committee recently launched by NEMA; investigating systems standards, including interoperability
- U.S. DOE recently launched effort to work with industry to improve lighting application layer interoperability among lighting system components

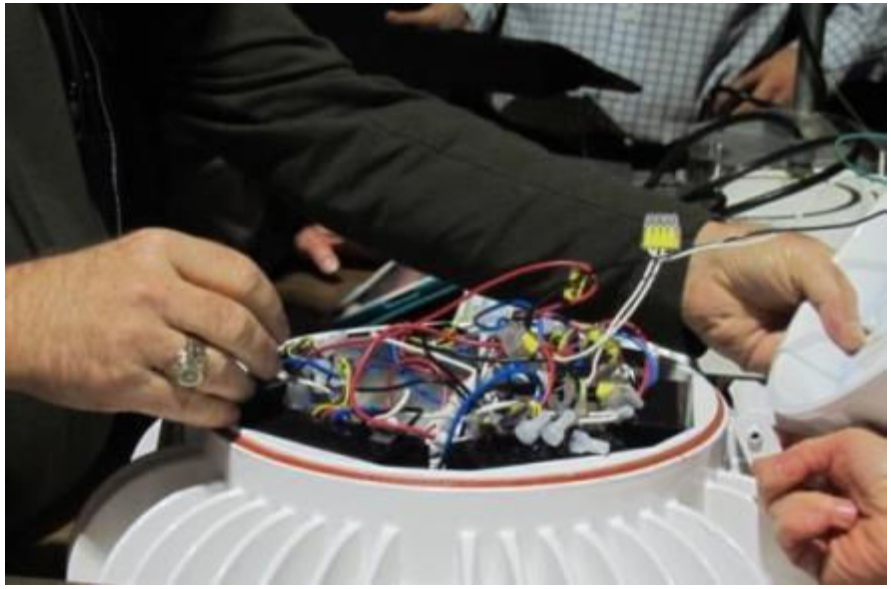
TALQ Consortium

THE CONNECTED LIGHTING ALLIANCE
SHAPING THE FUTURE OF LIGHTING

ANSI
American National Standards Institute

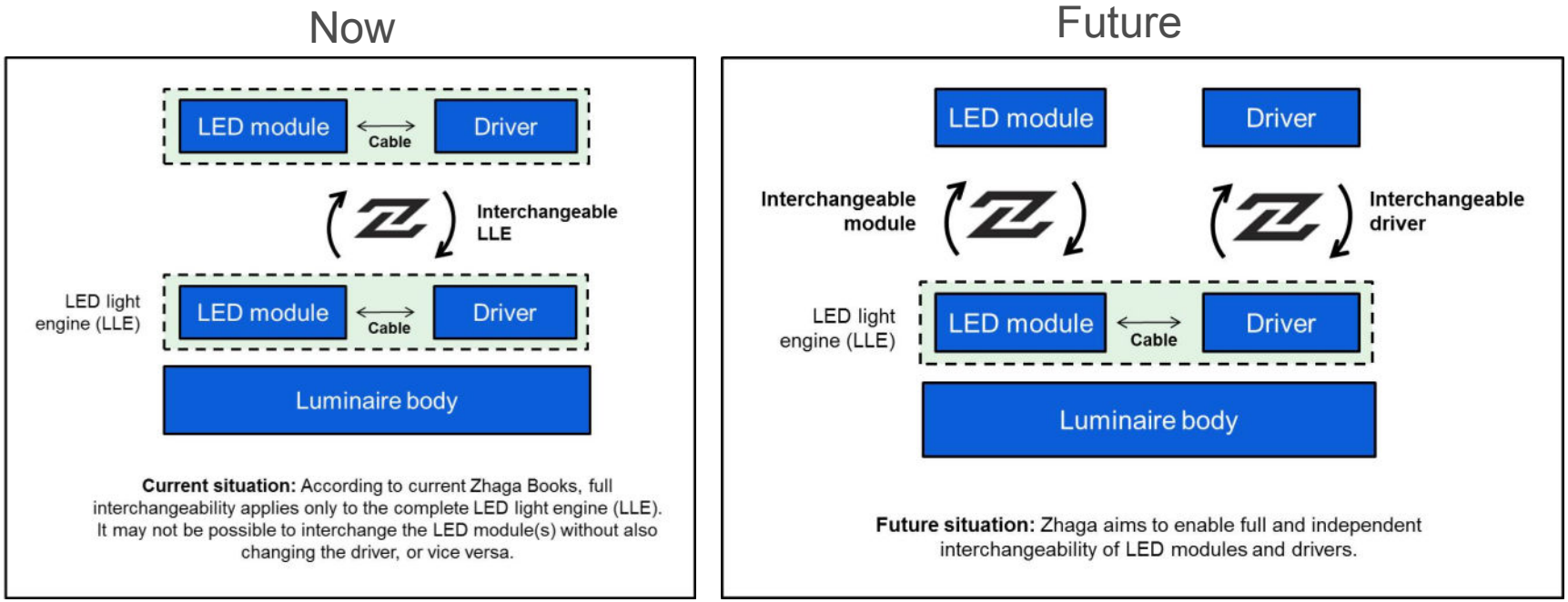
Lesson 10: Serviceability

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



Lesson 10: Serviceability - **UPDATE**

- NGL recognized several products for serviceability in 2014 & 2015
- Zhaga standards for 7 different LED light engine form factors so far; 3 more in development
  - 204 products certified so far (Apr 27, 2015)
- Zhaga recently announced initiative to enable independent interchangeability of LED modules and drivers



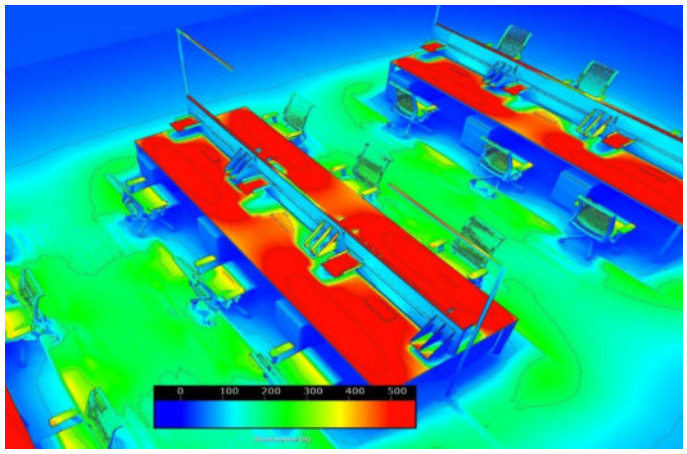
Lesson 11: Existing infrastructure

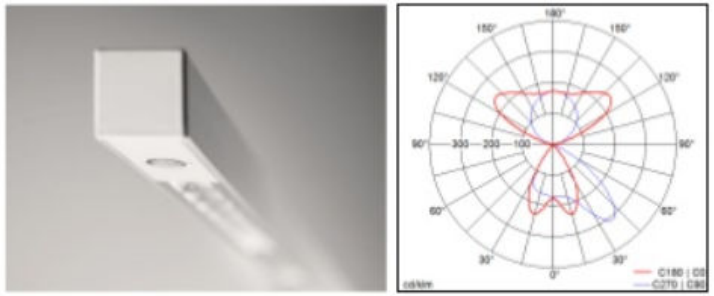
Existing lighting infrastructure limits the full potential of SSL; more effort is needed to open the doors to new lighting systems and form factors

Lesson 11: Existing infrastructure - UPDATE

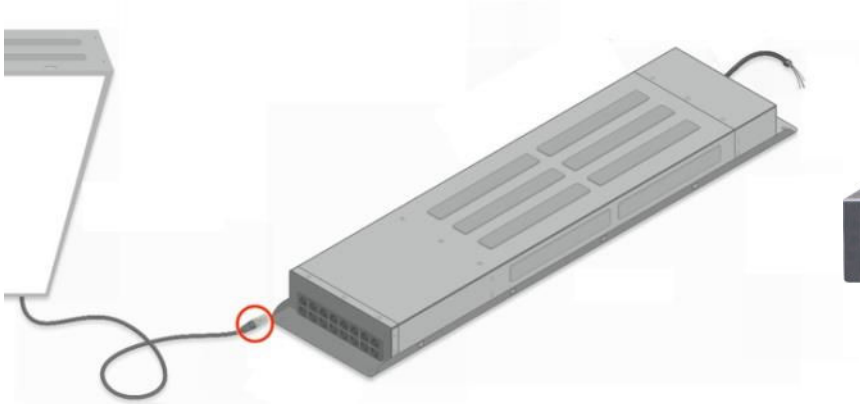
- New innovative form factors
- New controls approaches
  - Wireless, networked, integrated sensors
- New power distribution approaches
  - Low-voltage, DC power
  - Can be combined with control/communication
  - Power over Ethernet (PoE), other approaches

Zumtobel Lighting Linetik





Lesson 11: Existing infrastructure - UPDATE



Example of low-voltage LED commercial lighting combined with control/communication

Example of IEEE 802.3at compliant PoE switch

Example of DC powered ceiling system

Example of outdoor wireless controller

Lesson 12: Qualification programs

Programs that provide ways to identify quality LED products have helped support market adoption

Lesson 12: Qualification programs - UPDATE

- NGL: key resource for designers & specifiers
  - Over 400 luminaires evaluated to date
- DLC
  - more than 95,000 commercial lighting products listed
- LED Lighting Facts
  - more than 25,000 products listed
- Energy Star
  - nearly 2,000 LED lamps and more than 5,000 LED fixtures