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

The Lowdown on TLEDs

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LIGHTFAIR® International

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U.S. Department of Energy

Order of the Day…

1. An introduction into the current state of the TLED market - Jeff McCullough
   - Size and current state of the market
   - Prior DOE Studies
   - How do TLEDs save energy?
   - The Troffer Conundrum

2. Learn about the “ABCs”… of UL 1598 - Tracy Beeson
   - What are the different types
   - Wiring diagrams
   - Installation lessons learned
   - Pitfalls, areas to be concerned about

3. Facilitated discussion on the questions/concerns you have with respect to TLEDs - Naomi Miller + All

Top 10 reasons why everyone is interested in TLEDs?

1. They last longer (forever maybe) than fluorescent lamps
2. A TLED is perceived to be the lowest cost option to get the benefits of LED
3. Efficacy has been steadily increasing
4. Prices have been steadily decreasing
5. I get to keep my existing fixture that's been in my ceiling for 20 years, yippee!
6. They don't have any of that bad 'ol mercury
7. Many continue to cling to the old paradigm that… "a-lamp-is-a-lamp" and all lamps interchange "one-for-one"
8. I can potentially do away with my ballasts and get into the "lamps only" business
9. Installation is just a "point" and "click" away
10. They truly are shiniest damn thing in my ceiling!

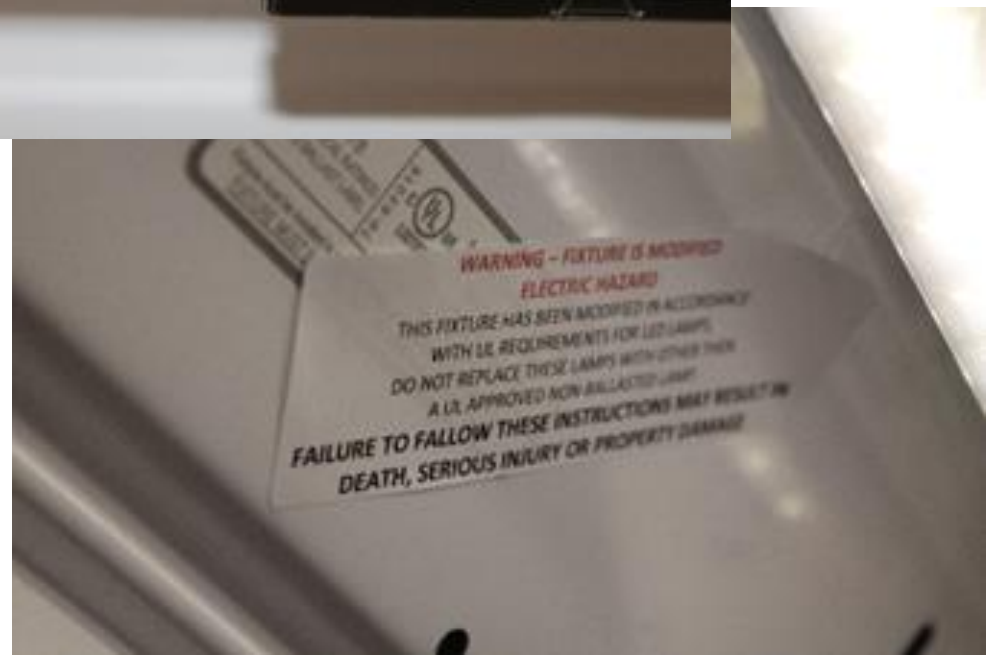
A True Case Study from a 1st Generation TLED Installation

1st Generation System

- Installed circa 2010
- 16 W, 1400 lm, 87.5 lm/W
- 4200-4600K claimed “cool white”
- Reached < L_{70} in 6 years and is currently delivering 50% of initial fluorescent levels
- Warranty: 50,000 hour/5 year “life” claimed by manufacturer. No L_{70}!

2016 system

- 18 W, 1950lm, 108 lm/W
- 4100K (3000-6500K offered)
- L_{70}: 50,000 hours
- Warranty: 5 years (with a 10-year option)
- Results in increased energy usage!



Size of Market

Configuration	Mixture	Approx. # of Installations	Hours	Input Power (W)	Estimated Energy (TWh)
2’x4’	74%	~272,000,000	10.5	74	77.1
2’x2’	16%	~59,000,000	10.5	59	13.3
1’x4’	8%	~29,000,000	10.5	44	4.9
Total	100%	~367,000,000			95.3

Notes:

- Quantities extrapolated from DOE SSL Niche Report & NEMA LE5-2001
- Power values assume a mixture of lamps, ballast factors, and ballast efficiencies
- TWh = 1,000,000,000,000 watt-hours

Interior Lighting by the Numbers - Commercial Buildings

- Commercial lighting is ≈ 2.6% of **ALL** primary energy consumption in the U.S.
- Troffers ≈ 1% of **ALL** energy use
- ≈ 20% of building energy is lighting and troffers are ≈ 50% of that energy

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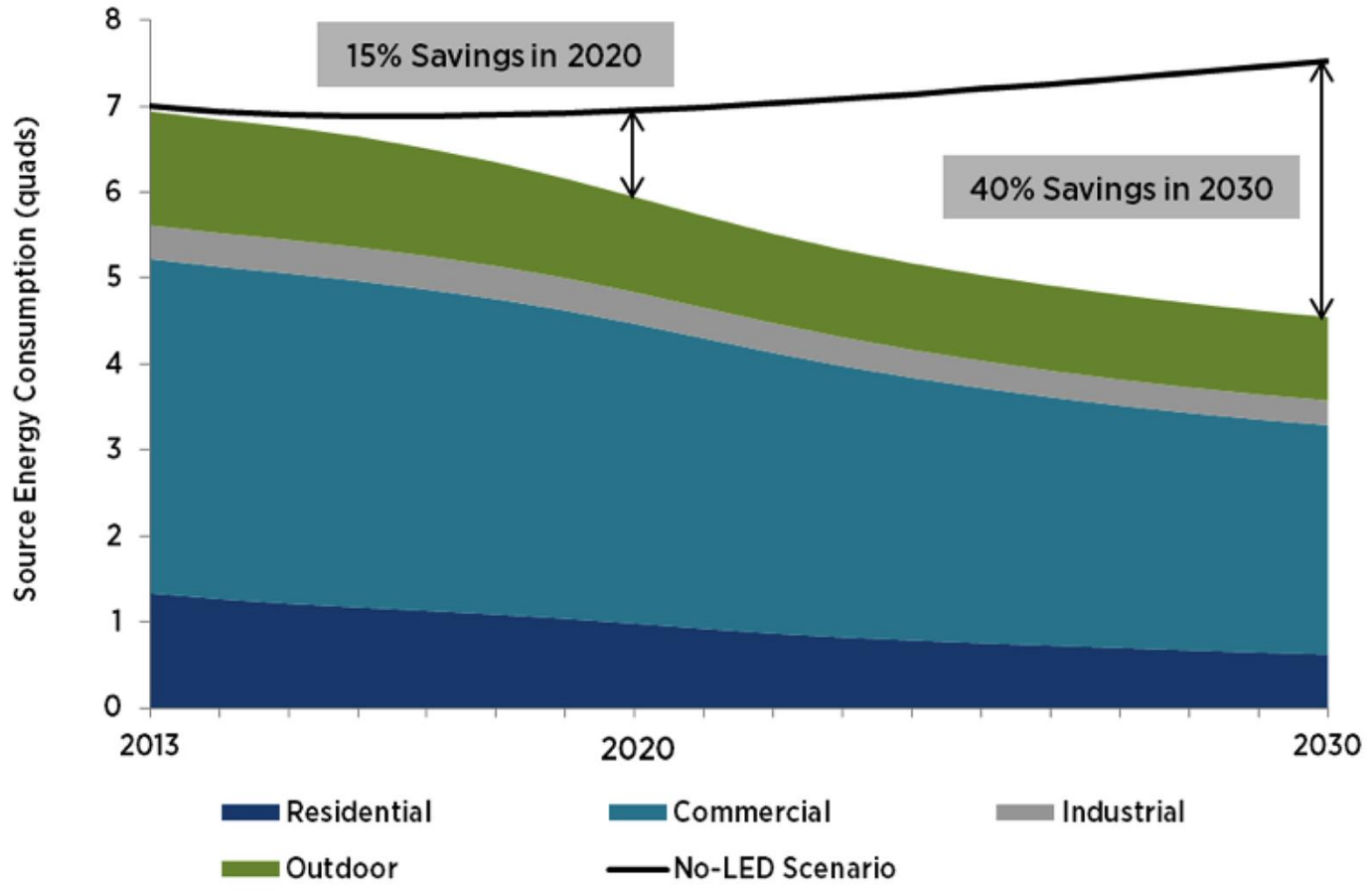
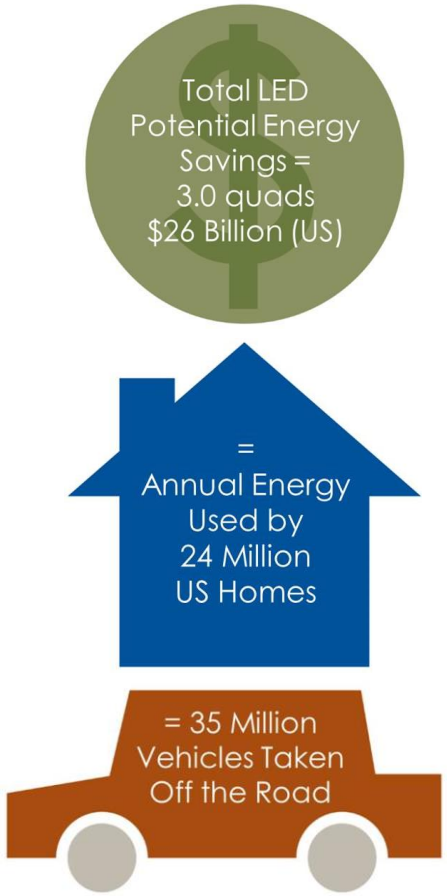
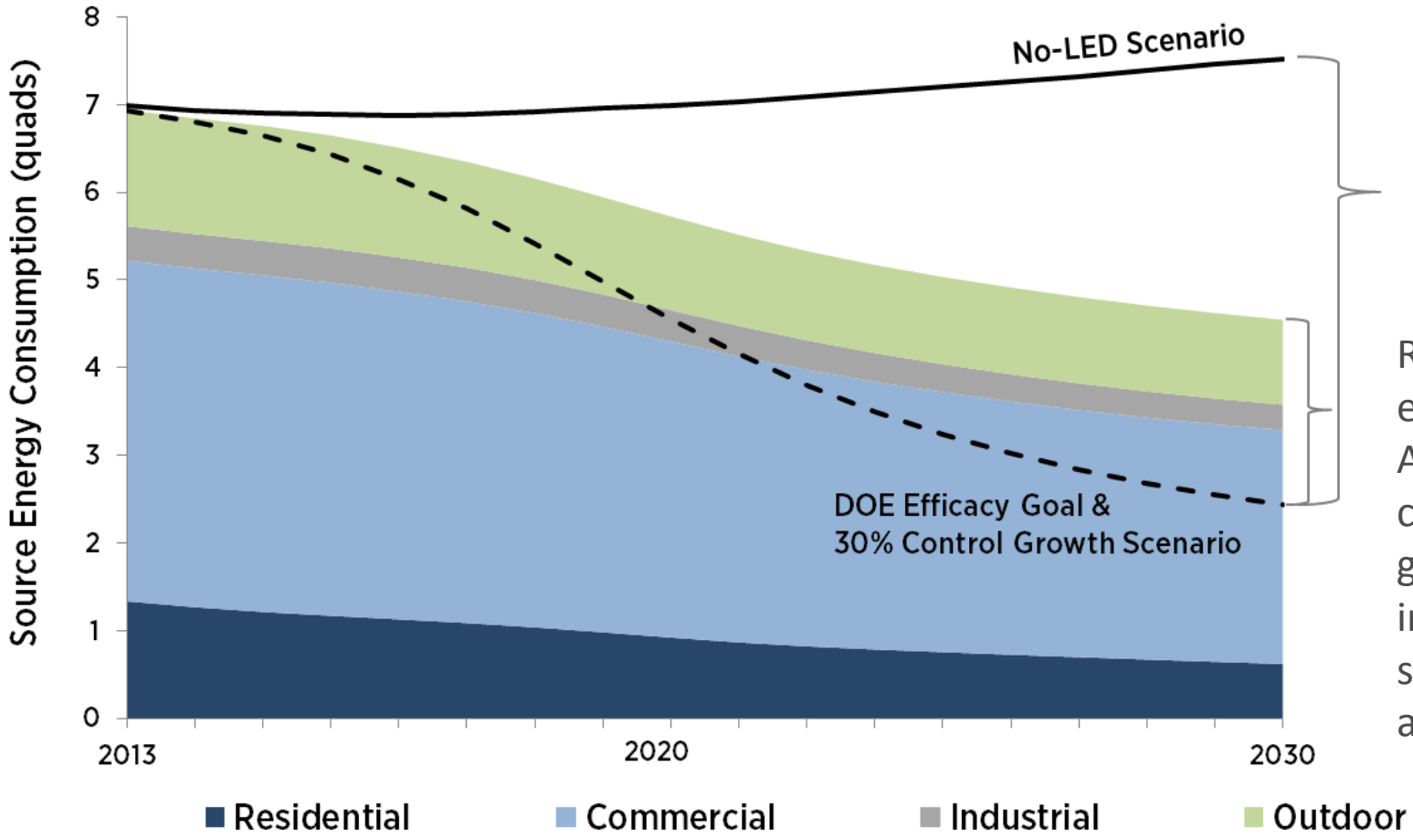
Energy Savings Forecast





Source: Navigant

Much Deeper Energy Savings Still Achievable

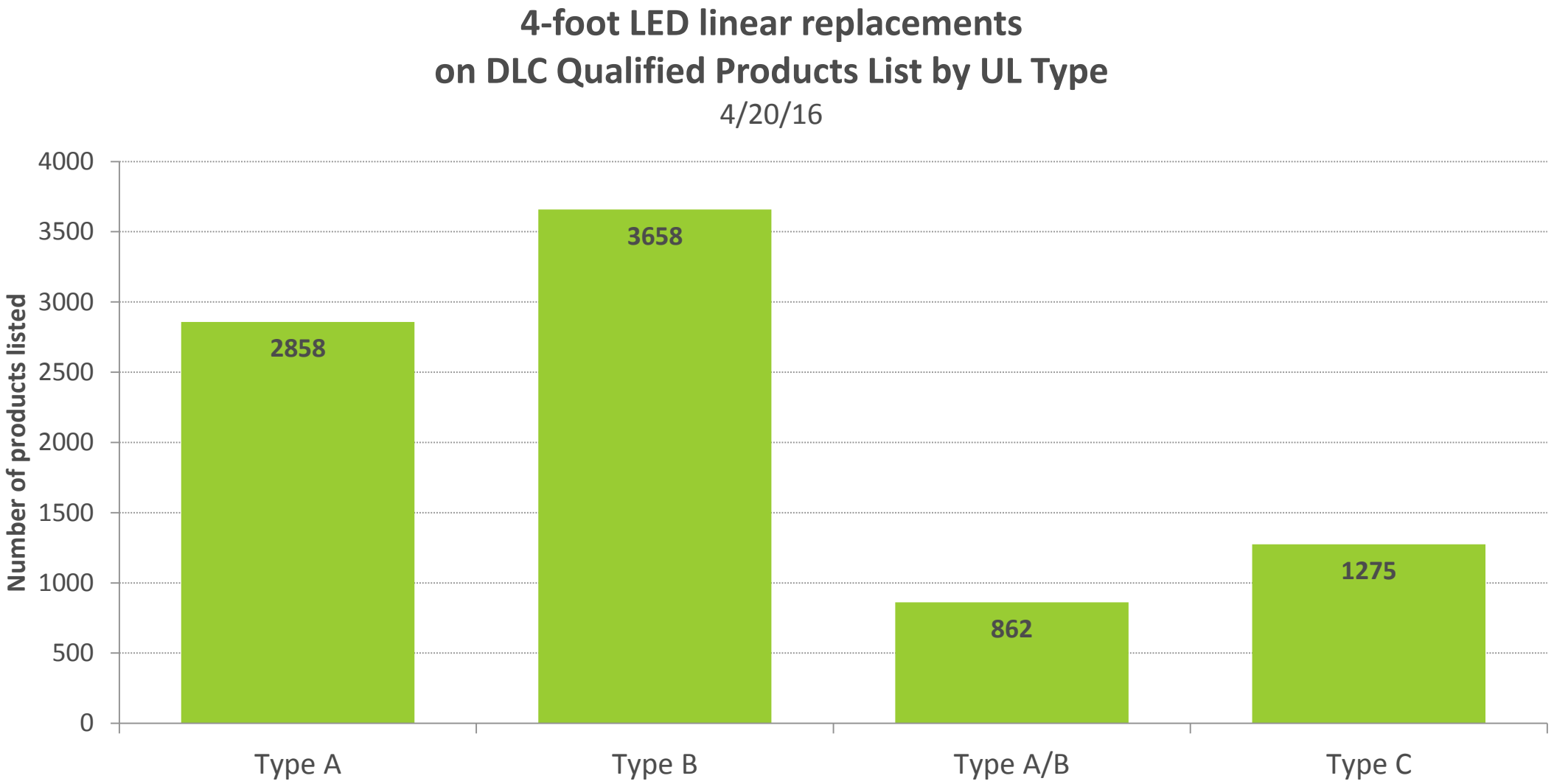


68% Energy Savings

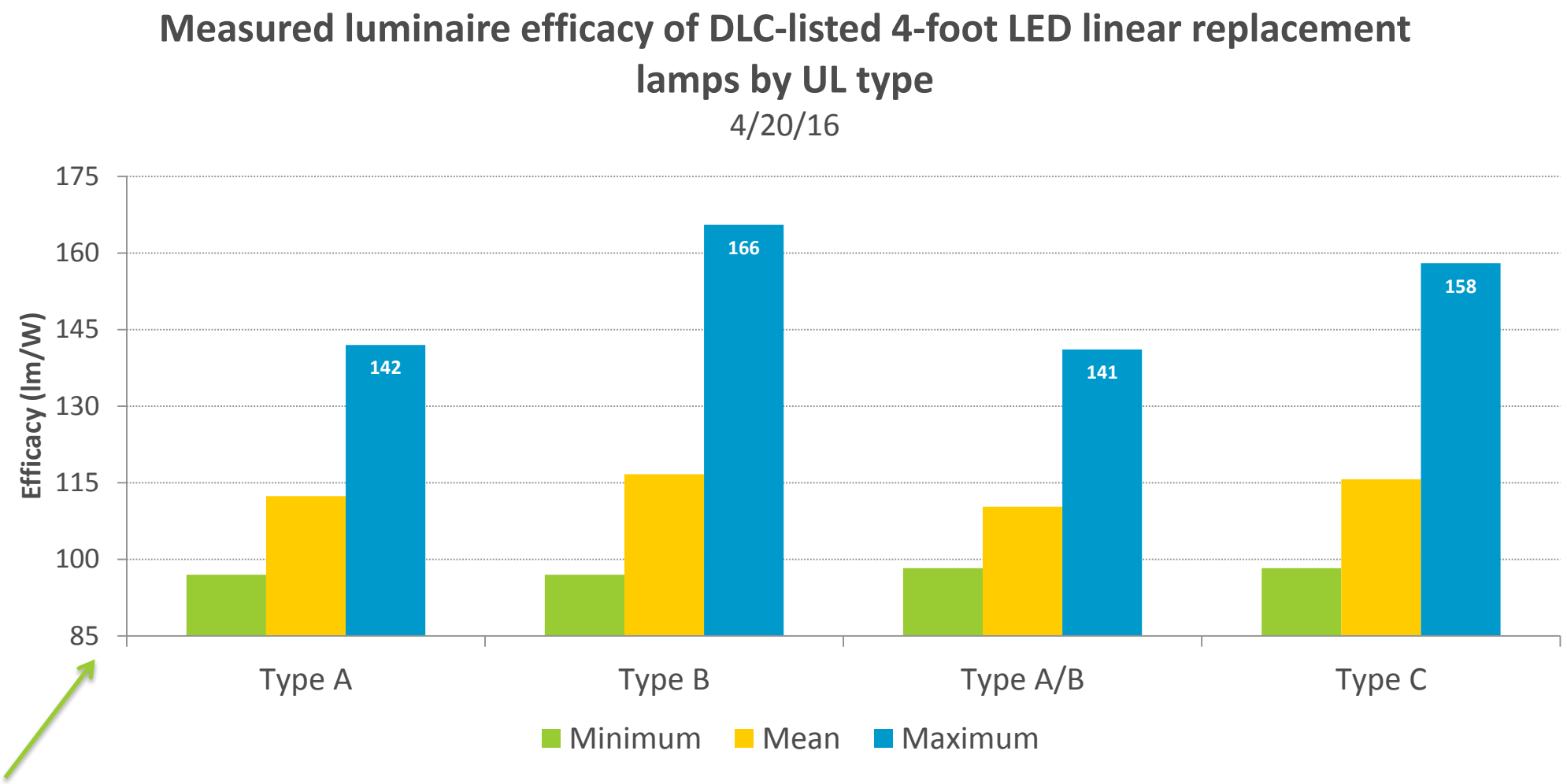
Reaching DOE efficacy goals AND high controls growth can increase savings by an additional 28%

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

TLEDs Today (2016)



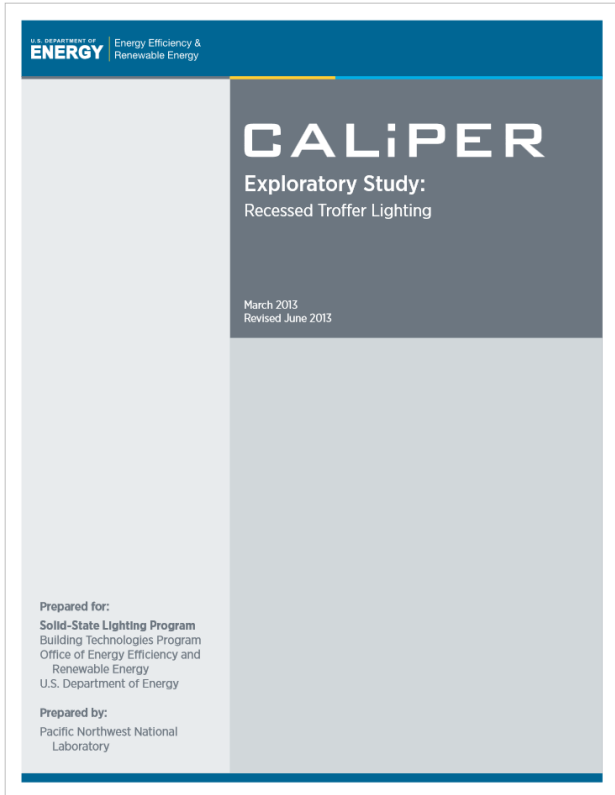
TLEDs Efficacy



Min required luminaire efficacy is 85 lm/W

Prior DOE Studies into TLEDs

Reports



Application Summary Report 21: Linear (T8) LED Lamps (March 2014)

- **Report 21.1:** Linear (T8) LED Lamps in a 2 × 4 K12-Lensed Troffer (April 2014)
- **Report 21.2:** Linear (T8) LED Lamp Performance in Five Types of Recessed Troffers (May 2104)
- **Report 21.3:** Cost-Effectiveness of Linear (T8) LED Lamps (May 2014)
- **Report 21.4:** Summary of Linear (T8) LED Lamp Testing (June 2014)

- "Only one product tested for this report could be installed without removing the existing fluorescent ballast, assuming the luminaire was equipped with an instant-start electronic ballast."

Exploratory Study: Recessed Troffer Lighting (May 2013)

Fact Sheets

www.energy.gov/eere/ssl/led-linear-lamps-and-troffer-lighting

How Do TLEDs Save Energy and $?

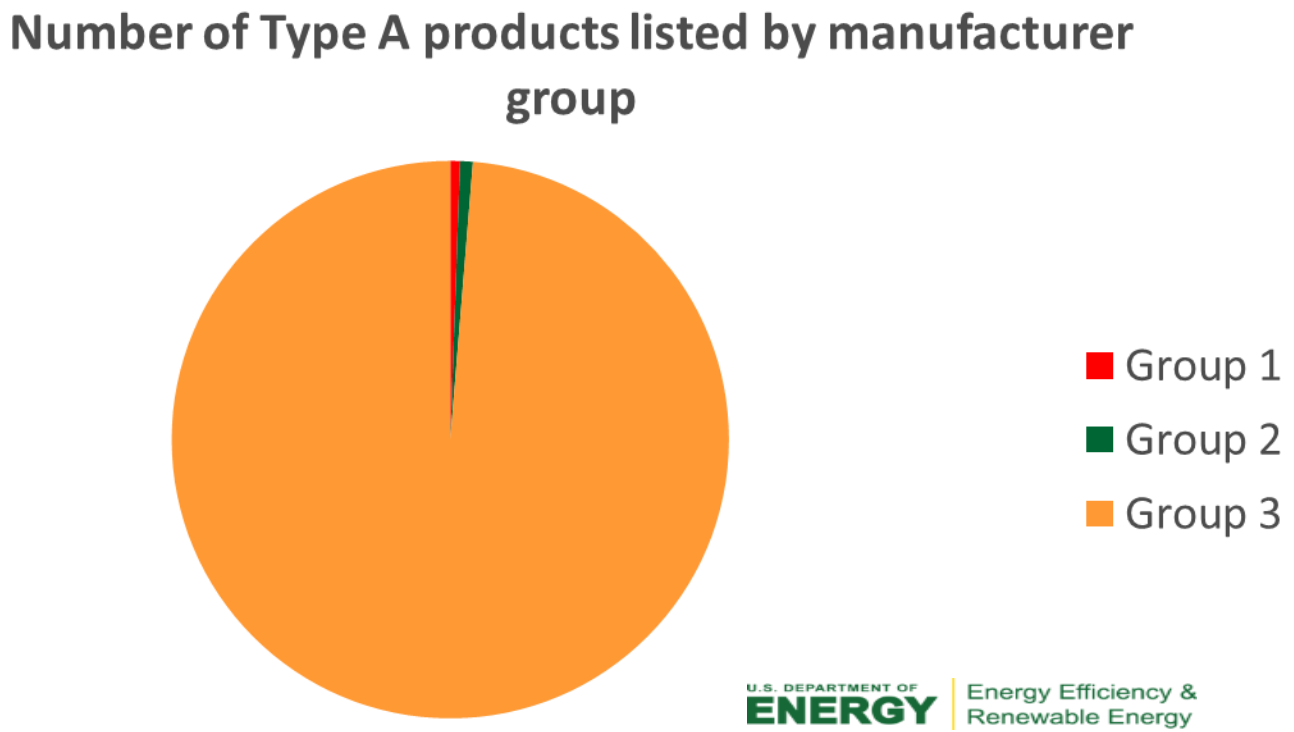
- Higher source (system) efficacy (lamp + driver) compared to fluorescent system efficacy (lamp + ballast) = reduced connected wattage.
- Greater fixture efficiency. Directionality of TLED allows for more light (useful lumens) out of the fixture.
- Energy savings of 20-30% are possible with similar light levels but ultimately is a function of the space and the existing fixture type.
- Potential for longer “lamp” life = reduced maintenance costs
- Potential to optimize existing lighting systems (reduce light levels) that are overlighted by current ASHRAE/IES standards

Key Challenges with TLEDs

- There are NO standards for:
  - Wiring configurations. No guarantee that a replacement lamp 5 years from now will be wired the same way.
  - Distribution from the lamps. Is beam angle a good surrogate? What about “batwing” distributions?
  - Light output. Fluorescent lamps are interchangeable and have standard lumen ranges
- How many manufacturers are in the market?

3 manufacturer groups for UL Type A products:

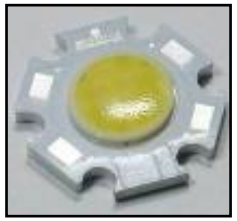
Group 1: Cree, GE, OSRAM SYLVANIA, Philips
Group 2: Lighting Science Group, Litetronics, Maxlite, Ushio, Universal Lighting Technologies, Venture, Westinghouse
Group 3: All others (about 190 companies)



How Do We Design Indoor Lighting Systems?

- Lighting designers “target” a sustained light level based on many factors:
  - The room geometry (e.g. ceiling height, location to work plane, etc.)
  - The reflectances of the room surfaces. You often see “80/50/20” used.
    - 80% for acoustic ceiling
    - 50% for light colored walls
    - 20% for dark carpet
  - Various light loss factors (LLFs)
    - Lamp lumen, dirt, temperature, fixture, ballast, voltage, etc.
    - Lamp lumen depreciation is specified at a point in time (typically 40% of rated life for fluorescents). Fluorescent lamp lumen depreciation
    - The lamp lumen depreciation for a “good” quality F32T8 85 CRI fluorescent lamp is ~0.91 or 91%. Some “premium” lamps are capable of even lumen maintenance all the way out to rated lamp life.
- The initial light levels are generally higher than the space needs so as to deliver ≥ the target light levels at a point in time
- As a practical matter light levels are generally allowed to fall about 10% below the target as the human eye will not notice the difference.
- Some building lease specifications may require a minimum light level at all times.

LEDs are not “Everlasting Gobstoppers”



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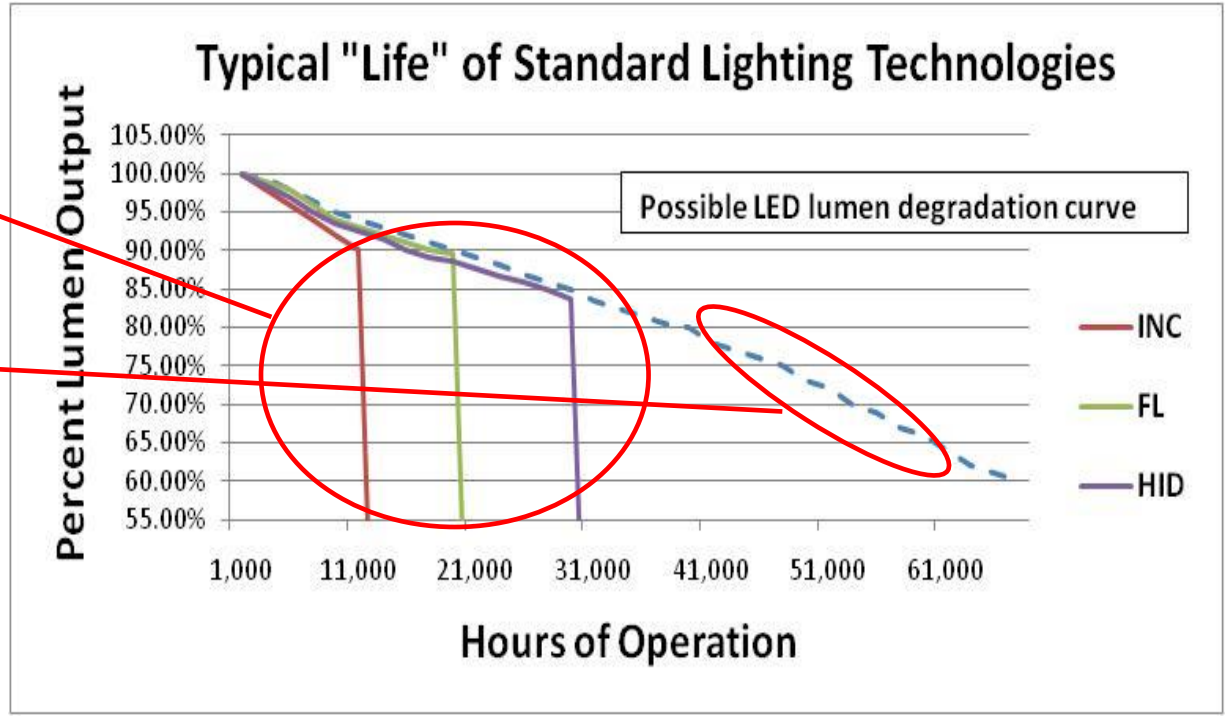
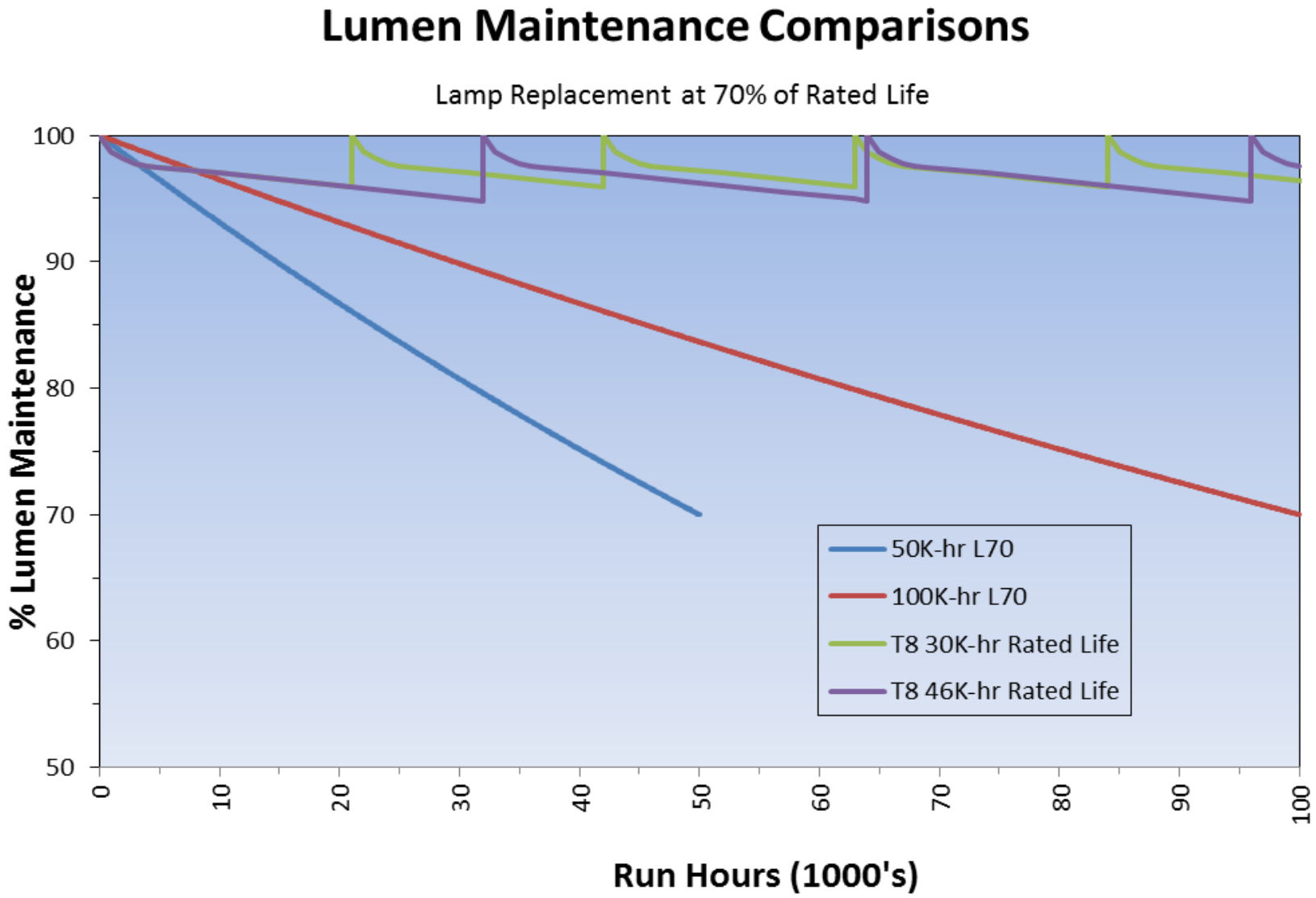
- **ALL** light sources degrade - most fail before critical light output level is reached
- LED diodes can survive but also degrade well beyond useful light level
- Industry considers lumen output as one measure of the **useful life** of an LED diode. Commonly, 70% of initial output is used.

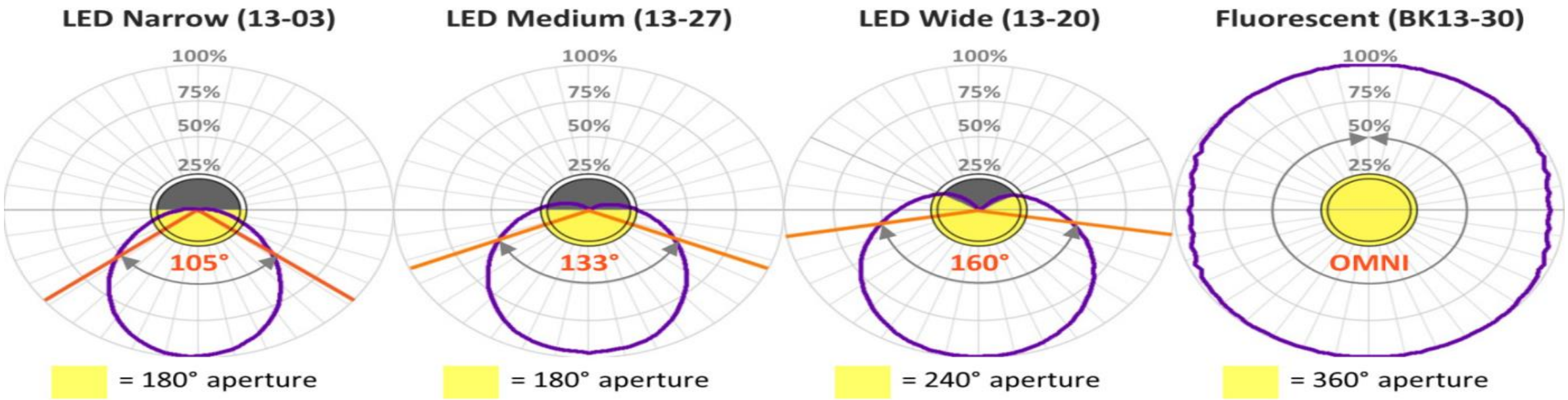


Lumen Maintenance



LED Replacement Tube Varieties

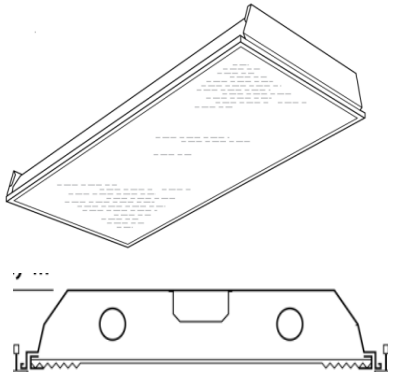
- LED replacement tubes come in a variety of distributions
- Directionality is efficacious – but can effect performance in fixtures designed for omnidirectional fluorescent tubes.



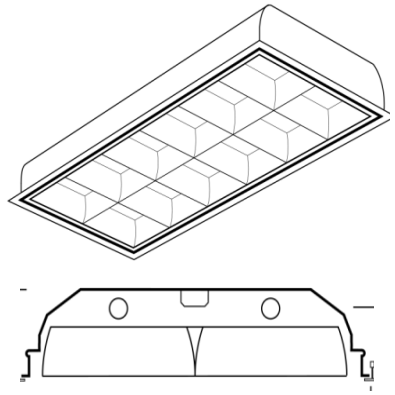
Troffer Geometry

What happens when typical LED replacement tubes are retrofitted in various fluorescent fixture types?

K12 Lens

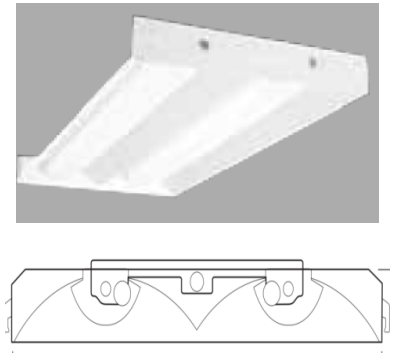


Parabolic

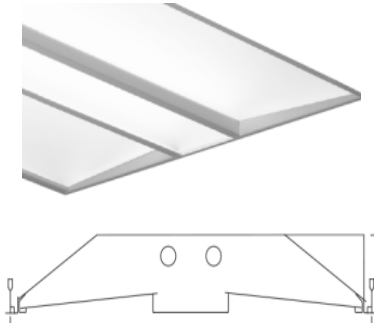


Recessed Indirect

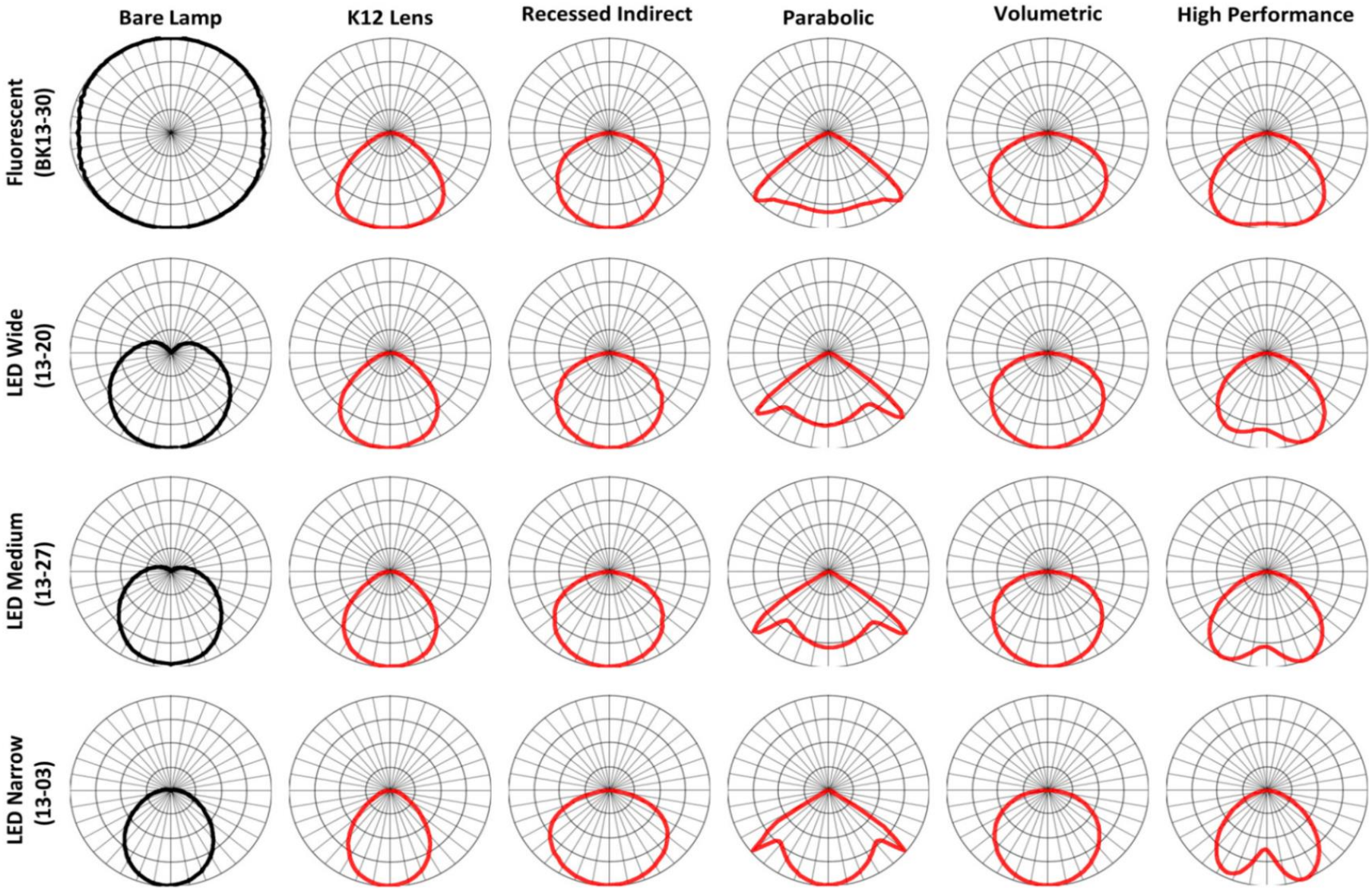
Volumetric



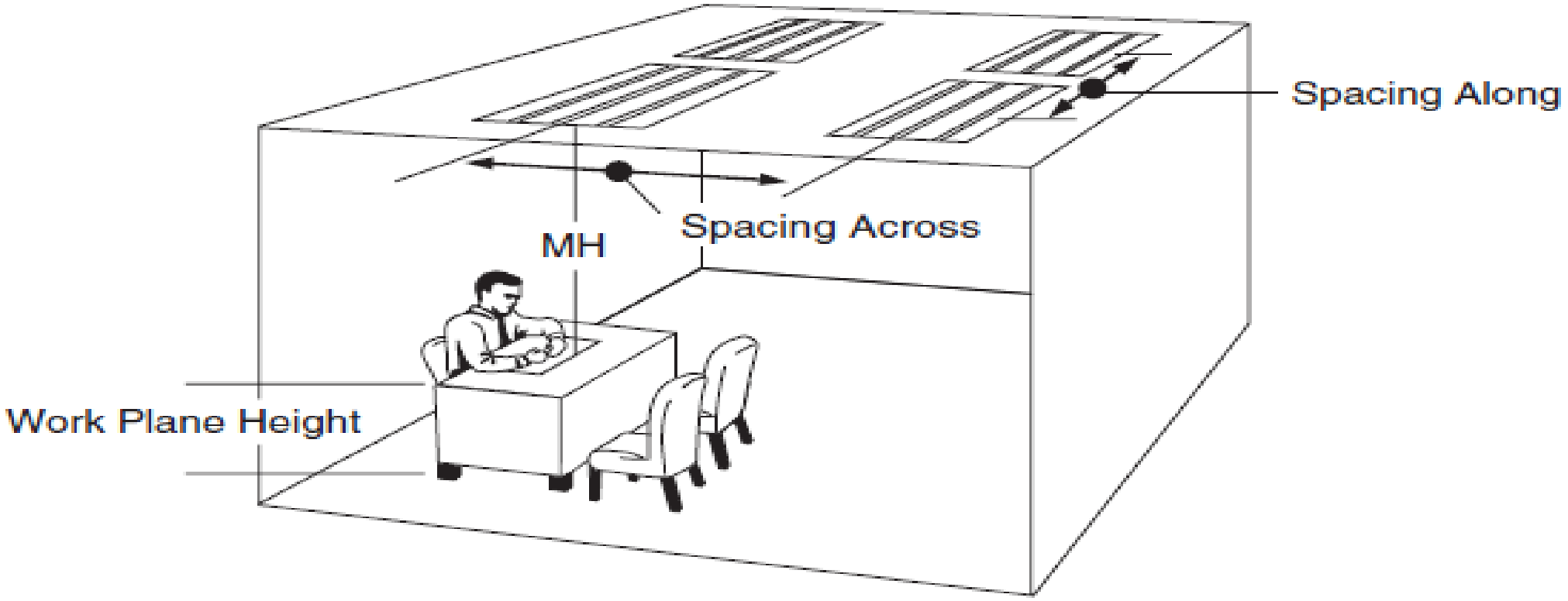
High Performance



Fluorescent Tube vs. LED Tube Distribution Patterns



Design Considerations



Luminaire Spacing = Spacing Criterion x mounting height above work plane (MH)

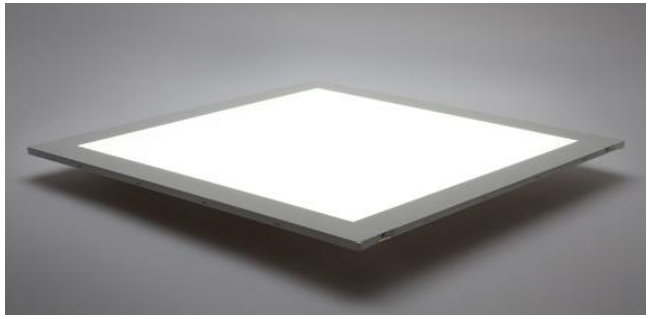
Courtesy: Acuity Lighting Technical Considerations

The Troffer Conundrum – What do I do?

Super T8 Fluorescent Lamp/Ballast

Tubular LED (TLED)

LED Retrofit Kit



New LED Fixture

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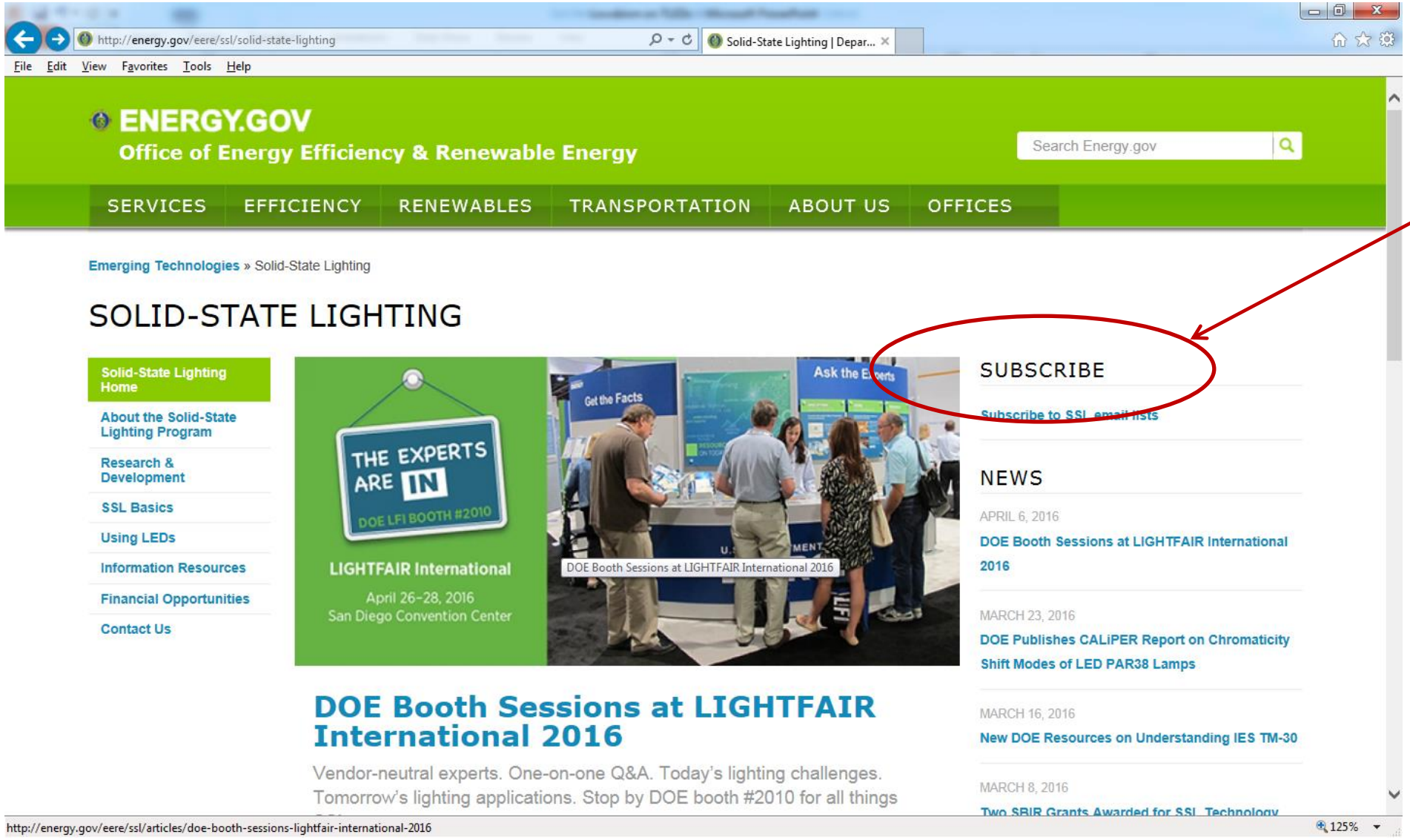
As with most things… Life is about Choices… and Lighting is no different!

Category	Power Supply	Light Source Mounting	Dimming	Controls	Risk	Total Cost	Attributes
1. LED Replacement Lamp (Ballast)	Existing fluorescent ballast	Existing fluorescent socket	Unlikely	Shut-off only (switch or occupancy sensor)	?	$	LED or LFL option, No electrician, matches lens configuration, need for future ballast replacement
2. LED Replacement Lamp (Mains)	"Mains" voltage	Existing fluorescent socket	Yes, with matching 0-10V system	Shut-off only (switch or occupancy sensor)	? ?	$$	Matches existing lens configuration
3. LED Replacement Lamp (Hybrid)	"Mains" voltage or existing fluorescent ballast	Existing fluorescent socket	Only likely if FL ballast removed	Shut-off only (switch or occupancy sensor)	? /? ?	$$	Matches existing lens configuration
4. LED Retrofit Kit (Lamp Socket)	Proprietary power supply	Existing fluorescent socket	Yes, with matching 0-10V system	Yes, with matching driver/control	? ?	$$$	Matches existing lens configuration
5. LED Retrofit Kit (Free-form)	Proprietary power supply	Free-form	Yes, with matching 0-10V system	Yes, with matching driver/control	? ? ?	$$$	Allows for light source relocation/re-alignment

Key Considerations for a Successful TLED Installation

- Give thought to your long term goals for the space. Some choices commit you to certain technology… for a long time!
- A “role” for “control.” As luminaire efficacy increases the ability to add controls later becomes less cost-effective and a potential lost opportunity.
- Use the DesignLights® Consortium Qualified Products List and DOE LED Lighting Facts® to help find products that have been tested and meet your performance goals.
- Consider developing performance-based criteria for the intended application. Why not ask your vendor to deliver a system that meets your requirements? E.g. light levels in your fixtures, maintained light levels at a period in time, etc.
- Target Facilities based on existing technology, light levels and energy costs.
- Do an honest life-cycle cost calculation or total cost of ownership.
- A mock-up is ALWAYS a good idea!

Tons of Resources @ www.ssl.energy.gov



OR…
Get your badge scanned to be automatically registered

The “A,” “B,” “A/B,” and “C”s of TLEDs – Tracy Beeson

At the time of our LED linear replacement lamp study, the lines for troffer “kits” were blurry.

- Many lamps required bypass of the ballast
- Some were wired to line voltage
- Others required an external ballast
- Some came with new sockets
- Some had new luminaire optics
- Others didn’t use the sockets at all
- Some you could install as simply as replacing the lamp

Since then, UL has helped bring clarity to some of the many options (UL 1598 certification)…

UL 1598 Classifiactions

Replacement Lamps (UL Type A):

- can operate off an existing fluorescent ballast
- do not require mechanical or electrical changes to the fixture

Internal Driver/Line Voltage Lamp-Style Retrofit Kits (UL Type B):

- do not operate off the existing fluorescent ballast.
- require rewiring of the existing fixture to bypass the ballast and send line voltage directly to the lamp holders

Dual Mode Internal Driver (UL Type A and Type B):

- operate off the existing fluorescent ballast
- also have the ability to operate off of line voltage if the troffer is rewired to bypass the ballast

External Driver Lamp-Style Retrofit Kits (UL Type C):

- employ lamp holders to connect to the fixture being retrofitted
- do not operate off the existing fluorescent ballast
- require rewiring of the existing fixture to replace the ballast with an external driver
- wired to receive only the low-voltage electricity supplied by the external driver

UL 1598- No category is perfect

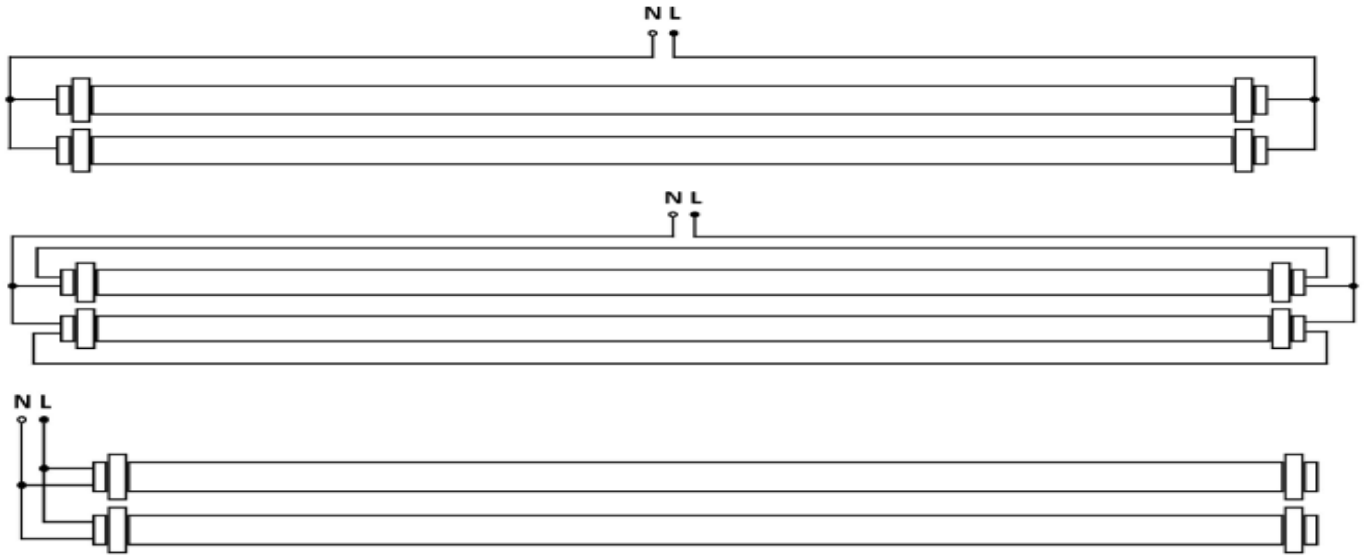
TYPE A

- More and more products available
- Plug‘n Play!
- Ballast compatibility varies
- Efficiency losses due to ballast
- Existing ballast life
- LED life/ballast life

UL 1598- No category is perfect

TYPE B

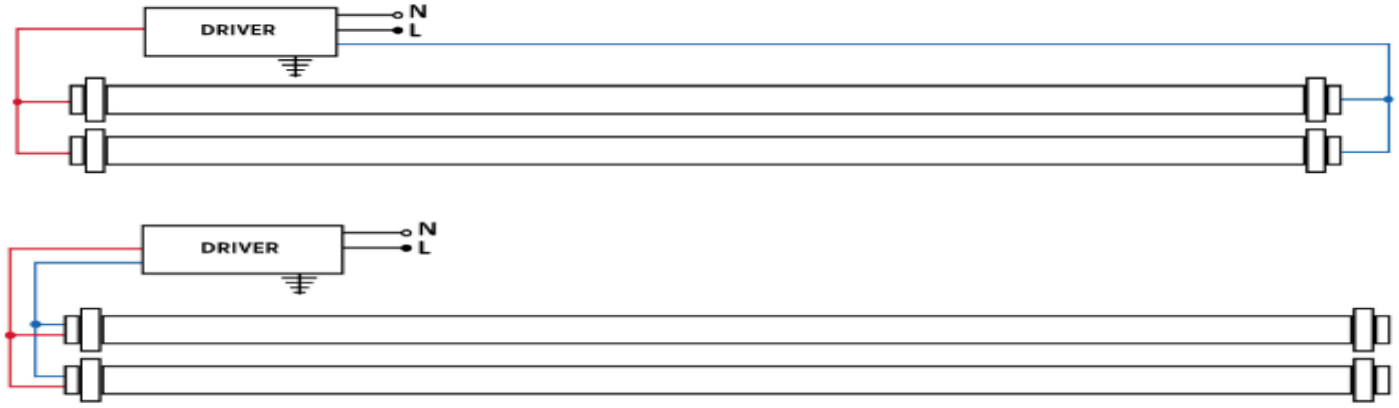
- Sockets are powered by line voltage
- Line-voltage sockets could prove dangerous for installer
- Still various wiring types



UL 1598- No category is perfect

TYPE C

- Sockets are powered by low-voltage drive current
- Still variables within this category



Considerations- Are Retrofits a Good Idea?

EXISTING CONDITIONS TO CONSIDER	DESCRIPTION	LAMPS	KITS	LUMINAIRES
Condition of sockets	Look like new	●	●	●
	Some wear but no major cracks	▲	●	●
	Look old, blackened, cracks apparent	■	●	●
Condition of interior surfaces	Nice and white	●	●	●
	Slightly worn but no major scratches or peeling paint	▲	▲	●
	Very worn, scratches in paint, some peeling paint	■	▲	●
Condition of lens or louvers	Looks new; very little wear apparent	●	●	●
	Some minor color variations or scratches in surface	▲	▲	●
	Looks old, obvious cracks or yellowing	■	■	●
Ceiling access	No concerns with working above the ceiling; easy access	●	●	●
	Some concerns about working above the ceiling; limited access	●	●	▲
	Working above the ceiling should be avoided	●	▲	■

- There is no across-the-board “best” option
- These are retrofit products. You need to know which system components are staying and compliment them.

Considerations- Selecting a Product

- Are your ballasts nearing the end of life?
  - Consider before choosing “Type A”
- What ballast is existing? Does it matter?
  - Yes!
- But I’m not going to use a “Type A” product. Does it still matter?
  - Yes!

Navigating the Wiring Variables

Existing: Instant Start Ballast

- Lampholders are shunted
  - Internally
  - Externally
- Products can be selected to reduce installation time
  - Type A- ballast compatibility
  - Type B- double ended power
  - Type C- double ended power

Existing: Programmed Start/Rapid Start/Magnetic Ballasts

- Lampholders are unshunted
- Unshunted lampholders can be easily shunted
- Products can be selected to reduce installation time
  - Type A- ballast compatibility
  - Type B- single/double ended power
  - Type C- single/double ended power

Above recommendations will reduce installation time, but new ballasts/lampholders can be installed to accommodate any TLED

Maintenance

- Re-lamping
  - Double-check manufacturer's wiring configuration (we have seen these change, even with the same model number!)
  - Clear documentation must be provided so the correct type and wiring can be purchased at time of re-lamping
  - Will the re-lamp work in the existing wiring configuration?

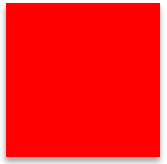
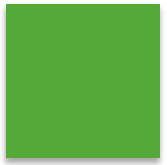
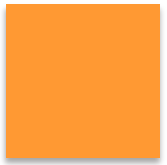
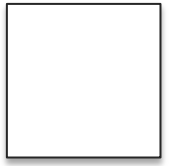
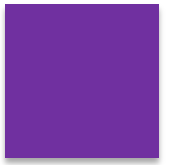
- Risks of Mis-lamping
  - Short Circuit at lamp holder
  - Re-installing fluorescent lamps- tube failure, socket damage

Facilitated Discussion – Naomi Miller

- First… there are no silly questions!
- We want to hear from YOU on what YOUR questions and YOUR concerns are to help inform further DOE investigation.
- Some “seed” questions for you:
  - How can DOE add value in this space?
  - What type of information would you like to see?
  - What concerns you the most?
  - What has been your experience with using TLEDs?

Rules of the Game

When Responding …Please tell us: Your "**Name**" and Your "**Color**"

- Utility 
- Government/DoD 
- Building Owner/ Facility Manager 
- Lighting Designer/ Specifier 
- Manufacturer 
- Contractor/ESCO
- Testing Lab 
- Market Transformation 

Ask the Experts!

Stick around,
check the schedule,
ask questions!