Residential Lighting: Lamps

Jeff Quinlan
Acuity Brands, Next Generation Lighting Industry Alliance

Taylor Jantz-Sell
US EPA ENERGY STAR

Nicole Graeber
California Lighting Technology Center
GoToWebinar Logistics

• Please use question pane to ask questions at any time, or if you have any technical issues

• TAG members – Audio will be unmuted after 1:00 PM for our discussion.

NOTE: Today’s presentation is being recorded and will be available at http://e3tnw.org/Webinars
Residential Lighting: Lamps

Jeff Quinlan – *Lamp Efficacy*
Acuity Brands, Next Generation Lighting Industry Alliance

Taylor Jantz-Sell – *Specialty Lamps*
US EPA ENERGY STAR

Nicole Graeber – *Linear LEDs*
California Lighting Technology Center

Emerging Technologies Showcase  November 29, 2017
Jeff Quinlan
Acuity Brands
VP Engineering & Illumination
Chairman Next Generation Lighting Industry Alliance
Agenda

• What are the big trends
  – High Efficacy
  – Lower Cost
  – Smaller Aperture
  – Lamp Type / Performance
  – Retrofit

• Things you need to know
  – Spectrum or at Least CCT
  – Distribution
  – Glare
  – Dimming
    • Output & Color
  – Life
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Efficacy Trend

Aperture Size & Shape

1” Aperture
Mini-LED Downlights and Adjustables
Reflector Lamp

- **LED Efficacy**
  - 100 LPW
- **Warm Dimming**
- **Wide range of CCT**

- **Applications**
  - Ambient
  - Soft, directional accent

Incandescent | CFL | LED
---|---|---
**BR Floods**

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Acuity Brands Lighting © 2017
A Lamps

- LED Efficacy
  - 83-133 LPW
  - Up to 200 LPW
  - Warm Dimming
  - Wide range of CCT

- Applications
  - Torchiers
  - Table Lamps
  - Vanities
  - Downlights
  - Decorative

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Retrofit Downlights

- LED Efficacy
  - 60-90 LPW (Fixture)
- Warm Dimming
- Wide range of CCT

- Applications
  - Downlights
  - Wall Wash
  - Gimbals
  - Slope Ceiling
Things you need to know

- Look at several things
  - Is there a Lighting Facts Label?
  - What is the color temperature?
  - What kind of LEDs are used?
  - Look for actual wattage not just replacement.
Distributions

Efficacy is a function of Distribution
Glare and Performance

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Dimming – Forward Phase
Figure 8.1 Components of an LED Lamp


Thank You
Specialty Bulbs

The opportunity for savings

Taylor Jantz-Sell

ENERGY STAR Lighting Program Manager
What are we talking about?
## 2016 Estimated LED Penetration by bulb type

<table>
<thead>
<tr>
<th>Bulb Type</th>
<th>% of installed base</th>
<th>Units installed (millions)</th>
<th>Energy Savings potential (tBtu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A type</td>
<td>13.5%</td>
<td>436</td>
<td>491</td>
</tr>
<tr>
<td>Decorative</td>
<td>6.7%</td>
<td>58.9</td>
<td>283</td>
</tr>
<tr>
<td>Directional</td>
<td>15.3%</td>
<td>82.4</td>
<td>129</td>
</tr>
<tr>
<td>Small Directional</td>
<td>47.6%</td>
<td>21</td>
<td>58.9</td>
</tr>
<tr>
<td>Downlighting</td>
<td>19.8%</td>
<td>137</td>
<td>231</td>
</tr>
</tbody>
</table>

### National Savings Opportunity

- Federal standards that have taken effect address the most common A lamps, (there is still 491 tBTU in remaining savings for A lamps)
  - DOE estimates there remains 470.9 tBTU in potential savings for decorative and directional lamps (replace existing stock with LED)
- Future (TBD 2020 or later) standards could apply more broadly since DOE expanded definition of the General Service Lamp (GSL)
  - Lumen range of 310-3300
  - Reflector lamps
  - Decorative lamps

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Lamp types that would still be exempt after EISA Phase 2 (2020 or later)

- Appliance lamps
- Black light, bug lights, colored lights
- G shape with diameter $\geq$ 5 in. e.g. G40s or bigger
- Linear fluorescent lamps (covered elsewhere)
- HID lamps
- Infrared lamps
- J types that don’t have screw bases
- Wedge or prefocus based lamps
- Left-handed thread lamps
- Special use lamps, e.g. Marine lamps, Mine signal service
- MR16 or bigger lumens $\geq$ 800 + “specialty MR”
- “other fluorescent lamps”
- Plant light lamps
- R20 short lamps
- Reflector lamps with diameters less than 2 inches and non Edison bases
- S or G shapes 1.5 inches in diameter or smaller
- Sign service lamps
- Silver bowl lamps
- Showcase lamps
- T shaped lamps with a diameter less than an inch that are not CFLs
- Traffic signal lamps
Dimmability

- Dimmability has improved: lower dimming levels and improvements in compatibility
- New STANDARDS + ENERGY STAR requirements
  - NEMA Lamp+Dimmer Compatibility Program
    - NEMA SSL 7A for dimmers and lamps for compatibility
    - NEMA 77 for dimmers and lamps for flicker
    - ENERGY STAR dimming requirements
    - Expected roll out of logo 2018

Look for this logo to find LED bulbs and dimmers that work together.
Decorative

- 27% of sockets
- Baseline Efficacy: 6-12 lm/w
- No federal standard...yet
- Current ENERGY STAR minimum efficacy: 65 lm/w
ENERGY STAR Directional Bulbs

Directional

- Baseline Efficacy: 6 – 32lm/w
- Some federal standards exist
- Popular exemptions e.g. BR30
- 6% of sockets
- ENERGY STAR: 61 (90+CRI), 70 (80-90CRI) lm/w
BPA 2017 Market Intelligence & Incentives

**Payment**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>RETAIL</th>
<th>BY REQUEST</th>
<th>MAILED NON-REQUEST</th>
<th>DIRECT INSTALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED Decorative and Minibase*</td>
<td>$4</td>
<td>$5</td>
<td>$4</td>
<td>$7</td>
</tr>
<tr>
<td>LED General Purpose and Dimmable, Three-Way (Omnidirectional)*</td>
<td>$4</td>
<td>$6</td>
<td>$5</td>
<td>$7</td>
</tr>
<tr>
<td>LED Globe</td>
<td>$4</td>
<td>$6</td>
<td>$5</td>
<td>$7</td>
</tr>
<tr>
<td>LED Refectors and Outdoor (Directional, includes R, PAR, BR, MR)*</td>
<td>$5</td>
<td>$7</td>
<td>$6</td>
<td>$9</td>
</tr>
<tr>
<td>Bi-Pin Multifaceted Reflector (MR)</td>
<td>$4</td>
<td>n/a</td>
<td>n/a</td>
<td>$5</td>
</tr>
<tr>
<td>Bi-Pin Non-Multifaceted Reflector (Non MR)</td>
<td>$4</td>
<td>n/a</td>
<td>n/a</td>
<td>$5</td>
</tr>
</tbody>
</table>

**FIGURE 21** Remaining Inefficient Share By Application

- **Source:** Analysis of Nielsen Sales data and NEEA Shell Data, 2015
- **Colors:**
  - Red: HALOGEN
  - Orange: INCANDESCENT

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Trends

- Filament style
- Vintage shapes
- Amber tint
- Dimmability improvements (including warm dim color shifting)
- Cost improvements but still higher than A line
- Color quality
- Connected
<table>
<thead>
<tr>
<th>Product Description</th>
<th>Price</th>
<th>Rating</th>
<th>Store Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE LED 5 Watt G25 Soft White Frosted Globe</td>
<td>$7.89</td>
<td>4.5</td>
<td>25+ stores</td>
</tr>
<tr>
<td>Feltelectric LED Light Bulb, White, 8 W</td>
<td>$6.00</td>
<td>4.5</td>
<td>10+ stores</td>
</tr>
<tr>
<td>60W Equivalent Soft White (2700K) G25 Dimmable LED Light Bulb</td>
<td>$16.52</td>
<td>4.5</td>
<td>5+ stores</td>
</tr>
<tr>
<td>Dimmable LED G25 Globe, 4.5W, 40W Equal, Medium Base, Green</td>
<td>$10.68</td>
<td>4.5</td>
<td>5+ stores</td>
</tr>
<tr>
<td>6 Pack LED G25 Vanity Globe Light Bulbs - DIMMABLE - 6W (40 Watt</td>
<td>$29.99</td>
<td>3.5</td>
<td>Amazon - Seller</td>
</tr>
</tbody>
</table>

**Emerging Technologies**

Globes $8 average for dimmable
Candle Shape $3-10

$9.43  Home Depot
$32.39  Houzz
$8.93  Home Depot
$11.35  Grainger Industrial Supply
ENERGY STAR Certified Selection
Simple Choice for Quality + Efficiency

- Amber Light (2200K-2500K) (126)
- Candelabra Screw Base (E12) (698)

Visit the product finder to look around with filter combinations e.g. CCT + dimmability

https://www.energystar.gov/productfinder/product/certified-light-bulbs/results
Tips for Utility Programs

• Focus on features
  – Quality performance is key – not all LED bulbs are the same. Only rebate bulbs that have earned the ENERGY STAR rebates are still needed to differentiate between lower life/lower cost bulbs.
  – There will be a mix of color temperatures out there – this can often lead to a negative experience – manage expectations & educate on light color.
  – Specialty lamps like candles are often used with dimmers and people want them to dim really low for ambiance – promote good dimming, manage expectations e.g. not all dim the same, use with compatible dimmers.
  – Trendy + efficient – you can have both style and efficiency – market vintage differently because the look is so important – e.g. amber tint is a real customer preference for certain applications but not universal.

• Consider bulk packs
  – Most decorative fixtures (chandeliers, vanity) have multiple sockets. Incentivizing bulk packs will help transform spaces quickly, consistently and cost effectively.
Assessing the Merits of Specialty Lamps

- **Description:** How does it save energy?
  - Simply replace existing inefficient screw in bulbs and save 90% energy e.g. 6W deco bulb replacing a 60W.

- **Product Performance:**
  - Major progress in performance and aesthetics. ENERGY STAR requirements have helped guide performance levels to match incumbent technology.

- **Energy Savings:**
  - All ENERGY STAR certified bulbs are tested in accredited labs to industry standards and certified by accredited third parties. Typical savings would be 54 watts per bulb (replacing a 60W decorative bulb with a 6W ENERGY STAR decorative bulb) usage assumptions vary. Typical rated lifetime is 15,000 hours.

- **Non-Energy Benefits:**
  - One great non energy benefit for these lamps would be maintenance – many decorative bulbs are hard to reach in chandeliers, so not needing to change them for decades after they are converted to ENERGY STAR LED (minimum rated life of 15,000 hours) at least 20 years if operated 2hrs/day.
Assessing the Merits of Specialty Lamps

• **Technology, Market, and Program Readiness:**
  – Products are ready now, stocking is decent now and will continue to improve with more filament style and dimming compatibility marking in 2018.

• **Ease of Adoption:**
  – Really easy, but somewhat cost prohibitive. Pricing ranges from $3-$16 for a single dimmable decorative bulb and often there are many in a single fixture to replace at once for a consistent look. See tips.

• **Value:**
  – It’s a great value even when not rebated but a no-brainer when discounted. Depending on electric rates and usage the bulbs pay for themselves in energy bill savings in a matter of months. Bulbs that aren’t used as much will have longer payback periods.
Thank You
Linear LED Replacement Lamps

Technology Benchmarking

Nicole Graeber, Senior Development Engineer
negraeber@ucdavis.edu
California Lighting Technology Center
University of California, Davis
The Residential Market and the Linear LED Lamp (aka, the TLED)

• Average Power Reduction: **44 PERCENT**
  – Linear Fluorescent Lamp: 31.5 W
  – Linear LED Lamp: 17.8 W
  – **However!** When you look at the light output of the products, they are not equivalent. Appropriate for applications where you can reduce light level!

• On average, there are 5.1 linear lamps per US household
  – ~70 W reduction if linear fluorescent is retrofitted to LED per home

• Residential applications appropriate for linear LED replacement lamps
  – Garages
  – Laundry/utility rooms
  – Multi-family parking areas/garages
• Linear fluorescent incumbent technology (T5, T8, T12)

• Linear LED replacement lamp architectures

  – **Type A**: Internal driver that is designed to operate on a linear fluorescent lamp ballast.

  – **Type B**: Internal driver that must be connected directly to line voltage for power.

  – **Type C**: External driver that is designed to replace both the linear fluorescent lamp and fluorescent lamp ballast.

  – **Hybrids**: Linear LED lamps with two Type A, B or C options in one product. Also referred to as ‘dual-mode’ by select manufacturers
Type A Architecture

- Contain an internal driver and are designed to operate on a linear fluorescent lamp ballast, “Plug and Play”
- Utilize existing fluorescent lamp sockets for power and support
- Require shunted sockets/lamp holders (internally connected electrical contacts)
- Available to replace T5, T8 and T12 fluorescent lamps
Type B Architecture

- Utilize an internal driver and must be connected directly to line voltage for power

- Rely on the fluorescent sockets for support and may receive power through the component

- Clear markings on the lamp and/or fixture is necessary to communicate that line power is being supplied directly to the socket/lamp and avoid shock hazards

- Often more efficient than Type A products because ballast losses are eliminated
Type C Architecture

- Utilize an external driver and systems are designed to replace both the linear fluorescent lamp and fluorescent lamp ballast
- Interchangeability of any two Type C products is not guaranteed, as each may require a different type of driver to operate
- May be powered from one or both ends of the lamp
- May use fluorescent lamp sockets for support or they may rely on their own mounting hardware
Hybrid Architectures

• Type AB
  – Lamps can be installed as a simple plug-and-play replacement of linear fluorescents (Type A)
  – Then, when the ballast fails, instead of replacing it, the Type AB hybrid can be wired directly to line voltage (Type B)

• Type AC
  – Lamps are designed to work either with a fluorescent ballast or with an electronic driver.
  – When used as a Type A product, retrofits can be quick and simple.
  – When used as a Type C product, energy efficiency and performance are optimized.
LINEAR LED LAMPS
APPLICATION AND INTEROPERABILITY EVALUATION
cltc.ucdavis.edu/publication/linear-led-lamps-application-and-interoperability-evaluation
Study Objectives

1. Performance in Atypical Applications Evaluation
   - Bare lamp strip
   - Wrap
   - Pendant

2. Interoperability Testing
   - LED products installed in fixtures with incompatible fluorescent ballasts
   - Products replacing fluorescent lamps in a de-lamped fixture where the ballast is rated for use with more lamps than are replaced by LED
CLTC conducted a market assessment of linear lamps:

- Linear fluorescent lamps (found 774 individual lamps for sale)
- Linear LED lamps (found 3537 individual lamps for sale)

- Average manufacturer claimed performance:

<table>
<thead>
<tr>
<th></th>
<th>Average Rated Power (W)</th>
<th>Average Efficacy (lm/W)</th>
<th>Average Light Output (lm)</th>
<th>Avg. Rated Life (Hrs.)</th>
<th>Average Warranty (Yrs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LFL</td>
<td>31.5</td>
<td>94</td>
<td>2970</td>
<td>33,000</td>
<td>Unknown</td>
</tr>
<tr>
<td>LED</td>
<td>17.8</td>
<td>119</td>
<td>2120</td>
<td>50,000</td>
<td>4.5</td>
</tr>
<tr>
<td>Delta (%)</td>
<td>44%</td>
<td>27%</td>
<td>29%</td>
<td>52%</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>UL Type A</th>
<th>UL Type B</th>
<th>UL Type C</th>
<th>Type AB - Hybrid</th>
<th>Type AC - Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED</td>
<td>33%</td>
<td>35%</td>
<td>14%</td>
<td>18%</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>
Linear LEDs: **Relative Light Output** compared to Linear Fluorescent Baseline
## Non-Energy Benefits – Manufacturer Provided Data

<table>
<thead>
<tr>
<th>Nominal CCT (K) Rating</th>
<th>2,200</th>
<th>2,500</th>
<th>2,700</th>
<th>3,000</th>
<th>3,500</th>
<th>4,000</th>
<th>4,500</th>
<th>5,000</th>
<th>5,700</th>
<th>6,500</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LFL</strong></td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>13%</td>
<td>20%</td>
<td>23%</td>
<td>0%</td>
<td>29%</td>
<td>1%</td>
<td>5%</td>
<td>8%</td>
</tr>
<tr>
<td><strong>LED</strong></td>
<td>0%</td>
<td>0%</td>
<td>1%</td>
<td>19%</td>
<td>19%</td>
<td>24%</td>
<td>12%</td>
<td>23%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CRI Range</th>
<th>70-79</th>
<th>80-100</th>
<th>Unknown</th>
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<tbody>
<tr>
<td><strong>LFL</strong></td>
<td>47%</td>
<td>50%</td>
<td>3%</td>
</tr>
<tr>
<td><strong>LED</strong></td>
<td>0%</td>
<td>98%</td>
<td>2%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source Type</th>
<th>Dimmable? Yes</th>
<th>Dimmable? No</th>
<th>Unknown/Not Yet Tested</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LFL</strong></td>
<td>4%</td>
<td>2%</td>
<td>94%</td>
</tr>
<tr>
<td><strong>LED - Total</strong></td>
<td>21%</td>
<td>74%</td>
<td>5%</td>
</tr>
<tr>
<td><strong>LED – Type A</strong></td>
<td>4%</td>
<td>96%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td><strong>LED – Type B</strong></td>
<td>7%</td>
<td>86%</td>
<td>7%</td>
</tr>
<tr>
<td><strong>LED – Type C</strong></td>
<td>79%</td>
<td>17%</td>
<td>4%</td>
</tr>
</tbody>
</table>
Fluorescent lamps currently dominate the commercial sector, where they account for 80 percent of installed lamps. LED lighting products are receiving a great deal of attention for their potential to replace fluorescent lighting, reduce energy use and improve lighting quality in a variety of indoor commercial applications, including offices, classrooms and retail stores.

LED alternatives to fluorescent lighting products fall into three main categories: tubular lamps, retrofit kits and dedicated luminaires. This guide provides the latest available information on each of these three rapidly developing lighting product categories, including safety precautions and labor requirements.
Choosing the Right Light

Buying Guidelines

A growing number of LED products are entering the market, adding to the many choices consumers already face. By 2020, 80 percent of residential lighting across the U.S. will be LED-based. While nearly all LED light sources offer energy savings, not all LED products are created equal, and LEDs may not always be the best fit for your application. Consider the following key features before buying your next light source.

Lighting Facts Per Bulb

<table>
<thead>
<tr>
<th>Brightness</th>
<th>800 lumens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Yearly Energy Cost</td>
<td>$1.18</td>
</tr>
<tr>
<td>Based on 3 hrs/day, 11c/kWh</td>
<td></td>
</tr>
<tr>
<td>Cost depends on rates and use</td>
<td></td>
</tr>
<tr>
<td>Life</td>
<td>Based on 3 hrs/day</td>
</tr>
<tr>
<td>Light Appearance</td>
<td>Warm, Cool</td>
</tr>
<tr>
<td>Temperature</td>
<td>2700 K</td>
</tr>
<tr>
<td>Energy Used</td>
<td>9.8 watts</td>
</tr>
</tbody>
</table>

Energy Costs and Dimming

The estimated annual energy cost to operate your light source, as shown on product packaging, is based on use of 3 hours per day and $0.11 per kWh. These values are standard across all products.

Dimming allows you to easily adjust light levels—and it saves even more energy! If you are replacing track lights, downlights or accent lights, you should be aware that some components designed for colorless, less efficient light sources can cause dimmable LED light sources to flicker or dim poorly. Make sure the components you select are all compatible. Check product packaging or product literature to ensure compatibility. You might also look for products labeled “dimmer free” or “plug and play.” Always use manufacturer-recommended dimmers with your light sources. Light source packaging will often list or provide links to find compatible dimmers.

Purpose

Light sources are generally either omnidirectional (lighting off light in all directions or directional (focusing light in one particular direction).

Omnidirectional light sources include screw-base A-lamps—found in most of our table lamps. These distribute light uniformly in all directions and are ideal inside shaded lamps, wall sconces, post lights, and porch lights.

Common directional light sources such as those used for accent lighting (Mr. 16), floodlights or track lights (PAR), and downlights (R) need a specific angle of light. The “beam spread” or “beam angle” will help you estimate the coverage or spread of the light.

Download here:
cltc.ucdavis.edu/sites/default/files/files/publication/How%20to%20Choose%20the%20Right%20Light.pdf

I’m in the Aisle, Now What?

- Aisle signage for retailers
- Basic lighting concept overview
- Using the FTC label
Points to Remember!

1. **Average 44% power reduction!** However most linear LED lamp products do not emit equivalent light output to linear fluorescent lamps!
   - Ensure your application has adequate light levels when using selected linear LED lamp product

2. **Critical to ensure that the lamp, driver/ballast, and dimmer are all compatible!**
   - Check the manufacturer specification sheets for the compatibility lists

3. **Clear markings on the lamp and/or fixture will be necessary for Type B linear LED lamp products!**
   - Indicate that line voltage has been supplied to the lamp holder (not typical!)

4. **Distribution matters!**
   - Not all linear LED lamps utilize the same design, resulting in a variety of light distributions.
Questions?

Contact Information

Nicole Graeber, Senior Development Engineer
negraeber@ucdavis.edu
California Lighting Technology Center
University of California, Davis
Nicole Graeber, LC  
Senior Development Engineer  
California Lighting Technology Center  
University of California, Davis  
negraeber@ucdavis.edu

Taylor Jantz-Sell  
ENERGY STAR Lighting Program Manager  
U.S. Environmental Protection Agency  
Jantz-Sell.Taylor@epa.gov

Jeff Quinlan  
VP of Engineering and Illumination  
Acuity Brands  
Jeff.Quinlan@AcuityBrands.com
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Residential Lighting: Controls – December 7, 2017

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Thank you for attending!