What’s the difference between *retrofit* & *replacement*?

**LED replacement lamps**

**LED retrofit kit**
LED Retrofit Options: Terminology & Safety Certifications

LED PRODUCTS FOR TROFFER RETROFITS
Does the product use the existing lamp sockets?

NO

YES
LED Retrofit Options: Does it use existing sockets?

- **NO**
  - **DLC:** Retrofit Kit
  - **UL:** LED Luminaire Conversion Retrofit Kit
  - Eligible for NRTL Classification
LED Retrofit Options: Does it use existing sockets?

YES

DLC: *Four-foot Linear Replacement Lamp*

UL: Does the product require electrical modifications to the luminaire?
LED Retrofit Options: Does it use existing sockets?

- **DLC:** *Four-foot Linear Replacement Lamp*
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    - **YES**
    - **NO**

*Very few such products were available as of Dec. 2013*
LED Retrofit Options: Uses the existing sockets

DLC: *Four-foot Linear Replacement Lamp*

UL: Does the product require electrical modifications to the luminaire?

*Very few such products were available as of Dec. 2013*

- **NO***
  - UL: *Self-ballasted LED Lamp*
    - Eligible for NRTL *Listing*

- **YES**
  - UL: The lamp and associated components comprise an *LED Luminaire Conversion Retrofit Kit*
    - Eligible for NRTL *Classification*
LED Retrofit Options: Terminology & Safety Certifications

**LED PRODUCTS FOR TROFFER RETROFFITS**
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*Very few such products were available as of Dec. 2013*
# System factors to consider for LED upgrades

<table>
<thead>
<tr>
<th>SYSTEM FACTORS TO CONSIDER</th>
<th>DESCRIPTION</th>
<th>LAMPS</th>
<th>KITS</th>
<th>LUMINAires</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial costs</strong></td>
<td>Equipment purchase costs</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
</tr>
<tr>
<td></td>
<td>Installation labor costs</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
</tr>
<tr>
<td></td>
<td>Safety certification costs</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
</tr>
<tr>
<td><strong>Operating costs</strong></td>
<td>Energy costs for equal light output</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
</tr>
<tr>
<td></td>
<td>Replacement costs over system life</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
</tr>
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**System factors to consider for LED upgrades**

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</thead>
<tbody>
<tr>
<td>Current light levels</td>
<td>Acceptable; should not be reduced at all</td>
<td>🟢🟢</td>
<td>🟢🟢</td>
<td>🟢🟢</td>
</tr>
<tr>
<td></td>
<td>Reductions of 10% or more are okay</td>
<td>🟢🟢</td>
<td>🟢🟢</td>
<td>🟢🟢</td>
</tr>
<tr>
<td>Dimming required</td>
<td>No, dimming is not required</td>
<td>🟢🟢</td>
<td>🟢🟢</td>
<td>🟢🟢</td>
</tr>
<tr>
<td></td>
<td>Yes, dimming is required</td>
<td>❌🟢</td>
<td>❌🟢</td>
<td>❌🟢</td>
</tr>
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# Existing conditions to consider for LED upgrades

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</tr>
</thead>
<tbody>
<tr>
<td>Condition of sockets</td>
<td>Look like new</td>
<td><img src="image" alt="Green" /></td>
<td><img src="image" alt="Green" /></td>
<td><img src="image" alt="Green" /></td>
</tr>
<tr>
<td></td>
<td>Some wear but no major cracks</td>
<td><img src="image" alt="Yellow" /></td>
<td><img src="image" alt="Green" /></td>
<td><img src="image" alt="Green" /></td>
</tr>
<tr>
<td></td>
<td>Look old, blackened, cracks apparent</td>
<td><img src="image" alt="Red" /></td>
<td><img src="image" alt="Green" /></td>
<td><img src="image" alt="Green" /></td>
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</thead>
<tbody>
<tr>
<td>Condition of interior surfaces</td>
<td>Nice and white</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td></td>
<td>Slightly worn but no major scratches or peeling paint</td>
<td>⬤</td>
<td>⬤</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very worn, scratches in paint, some peeling paint</td>
<td>🟥</td>
<td>⬤</td>
<td>⬤</td>
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## Existing conditions to consider for LED upgrades

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</thead>
<tbody>
<tr>
<td>Condition of lens or louvers</td>
<td>Looks new; very little wear apparent</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td></td>
<td>Some minor color variations or scratches in surface</td>
<td>▲</td>
<td>▲</td>
<td>●</td>
</tr>
<tr>
<td></td>
<td>Looks old, obvious cracks or yellowing</td>
<td>■</td>
<td>■</td>
<td>●</td>
</tr>
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### Existing conditions to consider for LED upgrades

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<tbody>
<tr>
<td>Ceiling access</td>
<td>No concerns with working above the ceiling; easy access</td>
<td><img src="image" alt="Green circle" /></td>
<td><img src="image" alt="Green circle" /></td>
<td><img src="image" alt="Green circle" /></td>
</tr>
<tr>
<td></td>
<td>Some concerns about working above the ceiling; limited access</td>
<td><img src="image" alt="Green circle" /></td>
<td><img src="image" alt="Green circle" /></td>
<td><img src="image" alt="Yellow triangle" /></td>
</tr>
<tr>
<td></td>
<td>Working above the ceiling should be avoided</td>
<td><img src="image" alt="Green circle" /></td>
<td><img src="image" alt="Yellow triangle" /></td>
<td><img src="image" alt="Red square" /></td>
</tr>
</tbody>
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Tubes, Kits, Luminaires: Should you Upgrade?

Bob Davis & Naomi Miller
Pacific Northwest National Laboratory
LED Tubes, Kits, Troffers: Should You Upgrade?

Economic questions:
• Electric rate? 6c, 12c, 18c, 24c per kWh? (Demand charges?)
• Annual hours of operation? (2000, 4000, 8000?)
• Cost of relamping?
  • Hard-to-reach or hazardous areas
  • Visually prominent areas
  • Places with expensive labor
If any of these numbers are high, efficient LEDs make more sense
Return on investment highly related to before/after power difference.

What’s your existing troffer?
• Find out exactly what make/model is installed in your building.
• T12 or T8 lamps? Lamp wattage?
• Magnetic or electronic ballast?
• Rapid-start, Instant-start or programmed rapid-start ballast?
• What are the input watts and light output?
The answers are needed to investigate options.
More questions about your troffers....

- Do you want a reduction in light output? If so, can this be more easily and inexpensively accomplished with a low-output fluorescent lamp change, a low-output ballast change or delamping?
- What is the condition of the luminaire and its sockets? If it is in very poor shape, consider a new LED troffer or a full LED retrofit kit instead of lamp retrofits.
- Is this a troffer type where T8 LED lamps make sense?
LED Tubes, Kits, Troffers: Should You Upgrade?

Do your homework:

- Study the product literature of the LED troffers/kits/lamps. Look for wiring diagrams (for compatibility with existing troffers), lumen output, input watts, color rendering index, CCT, light distribution from the lamp or luminaire, NRTL Listings, and warranties.
- Check for DLC listing.

![Product Image]

MK2 TUBE SERIES
TB LED Lamp Specifications

- Features and Specifications
  - Media: T12, T8, and T5 fluorescent lamps
  - Shortest: 22" (56 cm) luminaires
  - Available in medium (1300K, 4000K, and 8000K)
  - Suitable for wall-washing or wall wash
  - ETL Listed for residential and commercial use
  - UL listed
  - Paintable

- Patent Numbers
  - Pending

- Factory Contact
  - TOGLED
  - 1310 Scott Road
  - Troy, Michigan 48093 USA
  - Telephone: (248) 964-5555
  - Fax: (248) 964-5555
  - info@toyled.com
  - toggled.com

![Product Image]
LED Tubes, Kits, Troffers: Should You Upgrade?

LED T8 Wiring/electrical characteristics

1. Line voltage single end wired (**)  
2. Line voltage double end wired (*)  
3. Line voltage double end wired with additional wire between two opposite-end pins (**)  
4. Remote driver with single-end wiring (**)  
5. Remote driver with double-end wiring (*)  
6. Operates with existing instant-start fluorescent ballast and sockets (*)  
7. Operates without fluorescent sockets

* Instant-start or shunted sockets req’d  
** Rapid-start or unshunted sockets req’d
LED Tubes, Kits, Troffers: Should You Upgrade?

Do your homework:
- Get enough lamps/kits/troffers for 4-8 luminaires and bring in electrician to rewire the luminaire (if needed). Get electrician feedback on the ease of the retrofit and the time/cost involved. Also get feedback from staff on the appearance/glare/color quality of the modified luminaires. Is it an acceptable change? Is it ugly? Is it glaring? Does it look nifty?
- Check for flicker, especially if it’s dimmed.
- Do the Life Cycle Cost analysis.
If you use **T8 LED tubes**:  
- **Rules-of-thumb:** If you want roughly equivalent performance to 28W T8 FL lamps, choose LED tubes that deliver >1900 lm, >100 LPW, >80 CRI, diffuse finish, beam angle >133°.  
- **Modify every troffer/luminaire in the building with the same lamp and wiring type.** Keep 5% spares on hand, so that if one or more lamps fail, you will have the identical wiring lamp on hand. **You do not want maintenance staff mixing up fluorescent and T8 LED lamps, or single-end-wired with double-end-wired LED lamps.**
LED Tubes, Kits, Troffers: Should You Upgrade?

If you use **LED troffer kits:**

- LED kits can be good if well-engineered, but MAY NOT save you much energy unless you drop light levels
- Check that the kit is NRTL approved and complies with UL1598C
- Check to see if there is any limitation on which manufacturers’ troffers can be used, or depth of troffer
- Look for **70LPW** or higher on kit as installed
LED Tubes, Kits, Troffers: Should You Upgrade?

If you use new **LED troffers**:

- Luminaire efficacy is very high. Look for 90+ LPW
- Dramatic brightness patterns on lenses can be very distracting (AND glaring) from some products, so see them first
- Color ranges all over the map, but most products are as good *or better* than FL
- Flicker is a problem with some LED DRIVERS when dimming and there is no complete metric at this point in time
- Dedicated LED troffers are an excellent option for new installations

**See ‘em, mock ‘em up, before you buy a bunch of them**
Better Buildings Alliance – LED Troffer specification

- Target minimum luminaire efficacy of 85 LPW
- 5 year warranty
- PF >.90   THD <20%
- Driver efficiency >80% for <50W
- Minimum luminaire lumens:
  - 1 × 4 - 1,500 initial lumens
  - 2 × 2 - 2,000 initial lumens
  - 2 × 4 - 3,000 initial lumens
- Minimum SC of 1.0-2.0 in both planes
- CRI >80 with R₉ >0
- Lumen maintenance >77.4% @ 36,000 hours

BBA spec available at:
Questions? Discussion?

For Tubes, Kits, Luminaires: Weighing the Options for Troffer Upgrades

Link to

Upgrading Troffer Luminaires Fact Sheet

Links to CALiPER reports on

LED Troffer Lighting and Linear LED tubes

Bob Davis (robert.davis@pnnl.gov) & Naomi Miller (naomi.miller@pnnl.gov)

Pacific Northwest National Laboratory