BEST PRACTICES FOR UPGRADING FLUORESCENT TROFFERS TO LED

Upgrading Troffer Luminaires to LED

Lighting accounts for between 10 and 20% of the electricity use in a typical commercial building.[1] Historically, the workhorse in these indoor applications has been the linear fluorescent lamp. In 2018, lighting systems using linear fluorescent lamps accounted for over 68% of the lighting service in commercial buildings.[1] Recessed troffer luminaires, commonly available in 1′ × 4′, 2′ × 4′, and 2′ × 2′ sizes, provide the majority of this lighting. This fact sheet provides guidance on the various factors to consider when deciding on an LED upgrade for a fluorescent system.

Introduction

Three primary LED options exist for upgrading lighting systems that use fluorescent troffers:

1. replacing the fluorescent lamps with LED replacement lamps,
2. replacing the fluorescent lamps and other luminaire components with an LED retrofit kit, or
3. replacing the fluorescent luminaires with new luminaires designed with LED light sources.

Selecting the best option for an installation depends on the current lamp and ballast types, 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.

System Factors to Consider

An evaluation of LED upgrade options includes assessing the system costs and the effects on the lighting system performance. Table 1 summarizes a number of key factors to consider, 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, Table 1 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 that each individual product must be evaluated on its own merits.*

System Factors to Consider	Description	Lamps	Kits	Luminaires
Initial costs	Equipment purchase costs	●	▲	■
	Installation labor costs	●	▲	■
	Safety certification costs	▲	▲	●
Operating costs	Energy costs for equal light output	■	▲	●
	Replacement costs over system life	▲	▲	▲
Current light levels	Acceptable; should not be reduced at all	▲	▲	▲
	Reductions of 10% or more are okay	●	●	●
Dimming requirements	Dimming is not required	●	●	●
	Dimming is required	■	▲	▲

Table 1. System factors to consider for LED upgrades

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 has the highest associated cost.

Installation Labor Costs

Replacement lamps that simply snap into the existing fluorescent lamp sockets provide the lowest labor costs for installation. However, some 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 costs for installing new LED luminaires. Labor costs for replacement lamps and retrofit kits are sometimes underestimated, such as when the electrician must perform additional wiring modifications and component removal. Some older systems have ballasts that contain PCBs (polychlorinated biphenyls), hazardous substances that require proper handling and disposal, which can add to the installation costs.[2]

Safety Certification Costs

New luminaires should already have required safety certifications (UL, Canadian Standards Association [CSA], Intertek Testing Services [ETL]), and the cost of those certifications is included in the purchase price of the luminaire. With replacement lamps and retrofit kits, the original safety certification and warranty for the luminaire may no longer be valid, depending on the specific details of the product and modifications to the luminaire. A 2013 DOE report found that more than 50% of the replacement lamp and retrofit kit products evaluated could have been rejected by a local inspector because of issues with the certifications. An on-site inspection and certification would then be required, at additional cost.[3]

Operating Costs

Energy Costs

For retrofit projects that retain the existing number of luminaires and the control scheme, energy costs depend on the wattage of the luminaire with the new components installed relative to the existing luminaire. In some cases, the retrofit products offering the greatest wattage reductions also deliver much less light than the existing system. This may be acceptable—see the discussion on light levels—but to compare across the categories of LED options, Table 1 assesses energy costs for equal luminaire output. New LED luminaires generally provide the greatest energy savings for equal luminaire output, followed by LED retrofit kits.

Replacement Costs

Ongoing replacement costs depend on the product and labor costs and frequency for replacing the light sources (fluorescent or LED) and the related auxiliary equipment (ballasts or drivers). Because the expected replacement frequency and costs require careful assessment for each application, the LED options are shown as yellow in Table 1 for this item.

Current Light Levels

Some LED products reduce the light output as well as input power, based on the assumption that many installed fluorescent systems provide more light than current standards require. Selecting an appropriate LED option depends on an assessment of current light levels and the extent to which they may be reduced. In cases where the existing light levels must be maintained, LED options require a full evaluation of the effect on the light levels. In cases where the light level can be reduced, the greatest savings may result from reconfiguring the layout to use fewer luminaires. The light distribution also needs to be evaluated because many of the LED options produce different distribution characteristics than typical fluorescent troffers. In addition to increasing the chance of glare from the luminaire, this altered distribution may also result in uneven light levels in task areas and reduced light on the walls. Detailed calculations or measurements of a mock-up installation are needed to assess the light levels beneath and between luminaires.

Dimming

LED options are available for lighting systems requiring a dimming capability. Some combinations of LEDs, drivers, and dimmers can produce noticeable flicker, so retrofit kits and new luminaire options have been designated yellow in Table 1. Product samples of the exact configuration desired should be evaluated throughout the dimming range to assess the possibility of flicker and color shift.[4]

Color Quality and Appearance

Although not included in Table 1, the color quality of the LED upgrade is an important consideration. All the LED categories offer products with a selection of correlated color temperatures (CCTs), and all offer products with color rendering index (CRI) values in the 80s and higher, similar to fluorescent lamps. Although CCT is an indication of the light appearance and not of quality, it should evaluated to avoid unpleasant surprises. Many of these products should also have TM-30-based color rendering information (R_f and R_g) available to help evaluate the color quality. Still, LED products with poor color quality are available,

often at low cost, so CCT, CRI, or Rf and Rg values should be evaluated and product samples should be compared visually to the existing fluorescent products to assess any noticeable differences in color quality.

Existing Conditions to Consider

Lighting systems change over time. Many of these changes degrade the performance of the system, usually resulting in a reduction in light output. Some of these light losses are recovered through routine maintenance. For example, the light output of fluorescent lamps slightly decreases over their lifetime but is restored to the initial levels when the lamps are replaced. Similarly, the light output from the luminaire will be reduced by the normal accumulation of dust and particulates on the luminaire; these light losses can be restored through simple cleaning.

Other factors that may degrade lighting system performance over time cannot be addressed through routine maintenance. Mechanical degradation of reflector, lens, and louver surfaces may result in a reduction in the amount of light being reflected or transmitted. This is sometimes accompanied by a yellowing of the materials or by painted surfaces becoming scratched or peeling. Electrical components such as lamp sockets and wiring also degrade, in some cases affecting the long-term performance of the lighting system. Normal replacement of lamps and cleaning of fixtures does not address these long-term degradations in system performance.

In addition to the system factors shown in Table 1, the existing conditions of the installed lighting system can affect which LED upgrade option may be most suitable. Table 2 identifies some of the important parameters and uses the same column headings and color-coding scheme described for Table 1. 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.

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 clean, like new	●	●	●
	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	●	▲	■

Table 2. Existing conditions to consider for LED upgrades (green circle = best / yellow triangle = acceptable / red square = difficult).

Condition of Sockets

Many replacement lamp products are designed to be installed in the existing fluorescent sockets, which may or may not be in suitable condition for those lamps. If the condition of the sockets causes any doubt about using replacement lamps, a visual inspection of the sockets by an electrician is often sufficient to determine whether socket replacements or other modifications are necessary as part of the upgrade.

Condition of Interior Surfaces

The interior finished surfaces of older luminaires may have been significantly degraded or damaged over time, and some LED upgrade options will not correct those issues. LED replacement lamps may be viable as a short-term solution if the interior degradation is not severe, but replacement lamps are not recommended if there is significant degradation. Some LED retrofit kits provide new reflector surfaces that mostly or completely cover the existing surfaces; the yellow designation in Table 2 indicates that a sample should be evaluated to assure that the new reflector completely covers the degraded surfaces. The costs of any additional components need to be included in the economic analyses for the system. Again, a visual inspection of the luminaires can usually determine the extent of the modifications needed.

Condition of Lenses or Louvers

Similar to the interior surfaces of the existing luminaires, optical media such as lenses or louvers also may degrade or be damaged over time. Some of these materials turn yellow after years of use, some specular materials show color separation and variations in specularity, and some materials become scratched from improper cleaning techniques or from handling during relamping. If the degradation is minor, consider replacing or removing these components as part of an installation of replacement lamps or retrofit kits if new components are not included as a standard part of the upgrade. With more significant deterioration, replacement lamps or retrofit kits are only viable if the degraded components are also replaced. The costs of these additional components need to be included in the economic analyses for the system.

Ceiling Plenum Access

In some existing buildings, lighting system upgrades that require access to the ceiling plenum raise a number of concerns, from convenience and ease of access to health concerns related to potentially harmful materials that may be present in the ceiling. In these cases, replacement lamp and retrofit kit solutions that can be installed completely from below the fixture may be suitable, while installing new luminaires may be difficult if the above-ceiling access is restricted. In cases where any access or disturbance of the existing ceiling is prohibited, new luminaires may not be viable. Installation instructions for the upgrade options being evaluated should be reviewed to determine the extent of access that may be required.

Troffer Performance Criteria

Several groups establish performance criteria for troffer luminaires that use LED technology. The DesignLights Consortium (DLC) develops specifications for high-efficiency, high-quality commercial troffer lighting solutions and maintains listings of qualified products that satisfy the following specification requirements:[5]

- Warranty of at least 5 years
- Minimum luminaire efficacy of 110 lm/W
- Color rendition can be reported as CRI (minimum of 80) or using IES TM-30 (minimum R_f of 70 and minimum R_g of 89)
- Minimum of 50,000 operating hours with lumen maintenance greater than 70% of initial lumens.

The DLC establishes minimum lumen output levels for different size troffers. The DLC uses the same performance criteria whether the product is a dedicated LED luminaire, a fluorescent luminaire with an LED retrofit kit installed, or a fluorescent luminaire with LED replacement lamps installed. For LED replacement lamps, the DLC also requires a minimum bare lamp efficacy of 120 lm/W.

Safety Certifications

Manufacturers typically have their luminaires certified for electrical safety by a Nationally Recognized Testing Laboratory (NRTL) such as the Canadian Standards Association, Intertek Testing Services (ETL), or UL. If the NRTL determines that the luminaire meets the relevant safety requirements,[6] the luminaire is *Listed* by the NRTL. The manufacturer acquires and affixes the NRTL Mark to each luminaire, according to the requirements of the listing. LED replacement lamps that replace a fluorescent lamp without making any modifications to the luminaire are eligible for *Listing* as Self-Ballasted LED Lamps,[7] even those that do not have an integral driver but operate on the fluorescent lamp ballast. Products in this category can be used in a *Listed* luminaire without requiring further investigation.

When the electrical or thermal characteristics of a *Listed* luminaire are modified in the field, it is uncertain whether the modified luminaire continues to meet the relevant safety requirements unless the field modifications are investigated by an NRTL. Many tube-style LED replacement lamps require modifications such as installation of a driver and/or rewiring of the lamp sockets; the lamps and other components are categorized by UL as "LED Luminaire Conversion Retrofit Kits." (The LED retrofit kits discussed in this fact sheet also fall in this UL category.) LED luminaire conversion retrofit kits are eligible for NRTL *Classification*.[8] When a luminaire modification is performed using an NRTL *Classified* LED conversion retrofit kit, the modified luminaire is considered to meet the same level of safety that was present before the retrofit, without requiring an in-field investigation.

As part of the retrofit using an NRTL *Classified* LED luminaire conversion retrofit kit, the luminaire must be labeled indicating that the luminaire has been modified from its original condition and that it will no longer support operation from a light source other than the specific tube-style LED replacement lamp with which it has been fitted. The label must be prominent, and the information on the label must match corresponding information on the installation instructions and other documents. If the labels are missing or do not match other documentation, or if the LED product used is not NRTL *Classified*, the local inspector can reject the installation as non-compliant with electrical safety requirements. A rejected installation usually requires an on-site inspection and field safety certification by an NRTL.

So, when evaluating LED upgrades to fluorescent lamp troffers, remember that an in-field safety investigation should not be needed for:

- A replacement lamp that requires no further electrical modifications to the luminaire and is NRTL Listed;
- A replacement lamp that requires electrical modifications to the luminaire, such as installing a driver, and that is part of a properly installed NRTL *Classified* LED luminaire conversion retrofit kit; or
- A properly installed retrofit kit that is NRTL *Classified*.

Published March 2022 | DOE/EE-2583

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