LED TROFFER INSTALLATIONS

A guide for contractors and specifiers to replacing fluorescent troffers with new LED troffers or retrofit kits.

Summary

This document provides guidance on selecting suitable LED troffers or retrofit kits to replace existing fluorescent troffers. In retrofit applications, a one-for-one replacement at existing troffer locations is most cost effective. Look for an LED troffer or retrofit kit that:

- provides the same light output as the existing troffers or an output that is sufficient to meet a target light level agreed upon with the occupant of the space,
- has one of the highest luminaire efficacies available,
- does not cause glare,
- and has a low enough installed cost to achieve a reasonable payback period.

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LIGHTING ENERGY ALLIANCE

Step 1 Provide adequate illuminance

When evaluating LED troffers or retrofit kits, first identify products that will provide adequate light levels.

Make sure that the new lighting will provide adequate light levels for the work being done there. For offices, an average maintained illuminance of 30 footcandles is often considered appropriate.

Agree with the occupant of the space to either maintain the current illuminance level or to provide a typical light level for that space type, such as an average of 30 footcandles (fc) for offices. (This is the maintained illuminance level, which takes into account that the light levels will decrease from initial light levels over time.) To find the current (maintained) illuminance level, use a calibrated illuminance meter at night or with opaque shades drawn to measure the values on work surfaces (e.g., desks), and average the readings. If the room is over-lighted compared with the recommendations by Illuminating Engineering Society of North America (IESNA), consider reducing the light level in consultation with the occupant.

Some claim that lower light levels are needed from LEDs, perhaps due to higher correlated color temperature (CCT), pupil lumens, or other reasons. These factors do not apply for visual tasks in office environments; the lighting should be based on photopic illuminance levels.

Consider ambient-task lighting as a strategy to save energy. Use low ambient light levels in combination with task lighting where it is needed, such as desktops. This should be done in collaboration with a professional lighting designer or engineer to make sure that the space avoids looking gloomy from underlighting (especially on vertical surfaces) and that suitable illuminance ratios are maintained.

When considering a retrofit product, use photometric software to make sure the target illuminance level will be met.

Use photometric software, such as AGi32, Visual, DIALux, etc., to determine if an LED troffer will meet the target illuminance level. Many lighting manufacturers or their representatives will perform these photometric simulations, or the contractor can work with lighting engineers or designers. They should be provided with the room geometry, including the fluorescent troffer locations, so that accurate models can be constructed.

An alternative method is to match the light output, in lumens (lm), of the existing fluorescent troffers. This requires accessing an existing troffer to identify the fixture model and the installed lamps and ballast. Quantify the initial light output (the lumens from the fixture when newly installed) from the specifications for the lamps and ballast, and derate that value by the fixture's optical efficiency, which is listed on its cut sheet. Using an LED troffer with the same initial lumens should provide roughly the same illuminance levels as the current installation.

It is risky to simply look at a troffer from the ground and estimate its light output. The light produced by two troffers of the same type and using the same lamps can differ by over 70% due to variations in optical efficiencies and ballast factors.

Step 2 Maximize energy savings

The goal is to use the lowest power demand while providing adequate light levels.

Choose a product with a high luminaire efficacy.

Use an LED troffer with a high luminaire efficacy. This is the light output from the luminaire per unit of power demand, in lumens per watt (lm/W). Both fluorescent and LED troffers have wide ranges of efficacies. On average, using a troffer with an efficacy 15 lm/W greater than another troffer can decrease the lighting power by about 20% in an open office.

Don't over-light the space.

While it is important to provide an adequate illuminance level, avoid exceeding it. On average, increasing the illuminance level by 5 fc can increase the lighting power by over 15% in an open office. In some cases the lowest lighting power demand might actually be achieved with a lower-efficacy troffer if it can better match the target light levels.

Consider a tunable LED driver, and plan to adjust it annually.

A third way to increase energy savings is to use a tunable LED driver that allows the maximum light level to be adjusted through a remote control, wireless wand, or building lighting control system. After installation, tune the light level to meet, but not exceed, the target initial illuminance level using a calibrated illuminance meter. If the system will be tuned annually, then the light level can be adjusted to the target maintained illuminance level.

Step 3 Maximize occupant satisfaction

Make sure that the color appearance and other qualities of the light are acceptable to the occupant.

Select a suitable color temperature, typically 3,000 K to 4,000 K.

There is no best color temperature, and it is a matter of preference of the occupant. If the occupant is satisfied with the current CCT, match it with the new troffers. All of the light sources in a space should have the same CCT for aesthetic purposes. Higher CCTs provide a greater perception of brightness, but do not improve visual performance.

Install a sample luminaire and evaluate it for glare, color rendering, dimming, and flicker.

Install a sample luminaire and judge, along with the occupant of the space, whether the luminaire provides acceptable light quality. Evaluate the glare, color rendering, dimming (using the actual dimmer it will be installed with), and flicker.

Step 4 Determine the payback period

Calculate how long it will take for the energy savings to equal the initial cost to upgrade the lighting.

Calculate the simple payback period.

The simple payback period is the cost of the installation divided by the operating cost savings per year.

LED troffer retrofit kits may be more economical than replacing the entire fixture. This solution can have a lower capital cost and avoids the need to work above the ceiling.

The operating cost savings from LED troffers will most likely come from electricity savings. Some long-life fluorescent lamps can last as long as LED troffers, and both LED and fluorescent troffers need to be cleaned periodically, so do not assume that LED troffers will have lower maintenance costs than fluorescent troffers without further investigation.

Whenever possible, obtain a warranty that lasts at least as long as the payback period in order to minimize financial risks. The warranty should cover typical failure scenarios (color shift, low light output, power electronics failures, etc.).

Consider luminaires that allow component replacement to minimize unforeseen maintenance costs and potentially allow energy-saving upgrades in the future.

The simple payback period is the cost of the installation divided by the operating cost savings per year. The following equation determines how much lower the power demand of the LED troffer must be compared with the original fluorescent troffer in order to achieve a particular payback period, assuming one-for-one replacement:

$$\text{Required power reduction (W)} = \frac{\text{Luminaire installed price (\$)} \times 1000\ \text{(W/kW)}}{\text{Target payback period (years)} \times \text{Cost of electricity (\$/kWh)} \times \text{Annual operating time (h/year)}}$$

Step 5 Consider lighting controls

Automated lighting controls can reduce the hours of operation.

Consider vacancy and daylight sensors.

Installing vacancy sensors and photosensors can be an effective method of further reducing energy use. The energy savings from vacancy sensors depends on the type of space, from about 10% in open offices to over 60% in copy rooms. The average energy savings in private offices is about 30%.

Some LED luminaires can be ordered with integrated sensors pre-installed. Integrated sensors can reduce installation costs since no additional wiring is required and the controls are often pre-set.

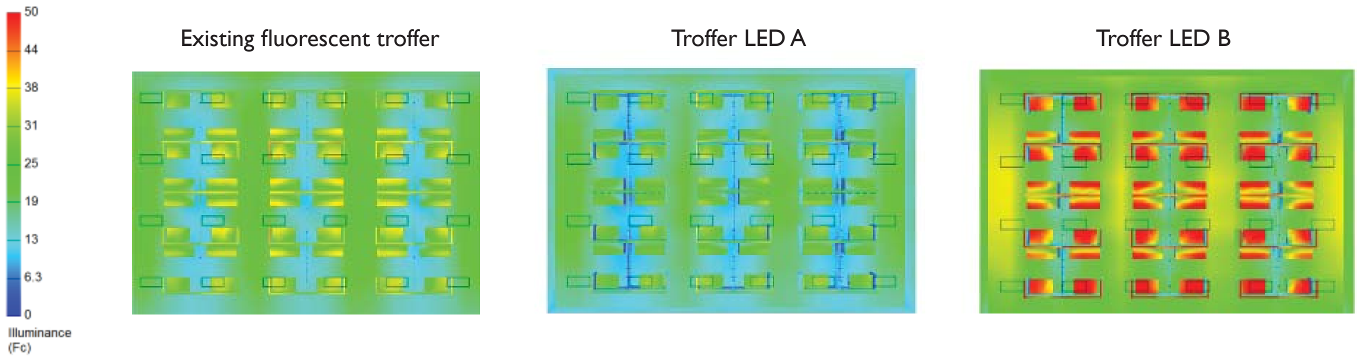
Example Calculations

Step #1: Provide adequate illuminance

An open office measuring 60 ft x 40 ft x 10 ft is filled with 4 ft high cubicles with shelves mounted over the desks. Lighting is provided by 24 2 ft x 4 ft recessed volumetric troffers, each containing two T8 lamps. As shown in the diagram below, the average illuminance at desk height is 30 fc. You are considering two 2 ft x 4 ft LED troffers as replacement options, called "LED A" and "LED B." Your first step is to determine if they will provide adequate illuminance.

Contact the manufacturer's representative and request that photometric software be used to calculate the light levels with each troffer. Provide the dimensions of the room and the quantity and layout of the current troffers. Specify that you would like to do a one-for-one replacement and that they should calculate maintained illuminance (not initial illuminance) by using a light loss factor of 0.77 for LED troffers. (This comprises lamp lumen depreciation of 0.86 and a dirt depreciation factor of 0.90, based on published recommendations. However, some manufacturers recommend using a higher lamp lumen depreciation value.)

The representative runs the simulation and tells you that LED A will provide a maintained illuminance of 26 fc and LED B will provide a maintained illuminance of 42 fc. The illuminance level provided by LED A is lower than the recommended 30 fc, while that provided by LED B is significantly higher. LED B at least meets the illuminance requirements. However, it is not a recommended solution because it over-lights the space. As shown in step #2 below, there are better options for saving energy.



Step #2: Maximize energy savings

The room and existing fluorescent troffers are the same as in Example #1. The existing installation provides an average maintained illuminance level of 30 fc, and the lighting load for the room is 1.4 kW. As discussed in Step #1, above, you have identified LED B as a candidate replacement troffer, but you are concerned about over-lighting, and you recognize that there are other LED troffers with higher efficacies.

You identify troffer LED C, which has a similar maintained light output as the fluorescent troffer but has a higher efficacy. Using this product will reduce the lighting load to 1.2 kW, a 14% reduction compared with the existing fluorescent troffers. The maintained illuminance level is approximately the same as the existing installation, and meets the typical office light level of 30 fc.

Troffer	Initial luminaire light output (lm)	Light loss factor	Maintained light output (lm)	Average illuminance, maintained (fc)	Power demand per troffer (W)	Power demand of room (kW)	System efficacy, maintained (lm/W)
Fluorescent	4270	0.81	3460	30	58	1.4	59.6
LED B	6400	0.77	4930	42	74	1.8	66.5
LED C	4740	0.77	3650	31	48	1.2	76.1

Step #4: Determine investment payback period

Operating time	3830 hours/year
Cost of electricity	$0.15/kWh
LED C luminaire price	$100/luminaire
Installation cost	$40/luminaire
Rebate	$50/luminaire

The luminaire installed price is the luminaire price plus the installation labor cost minus any rebate, or $90 in this case.

LED B has a higher power demand than the installed fluorescent troffer, so it will not provide savings. LED C provides savings with a payback period of 16 years, which is longer than is typically sought. Strategies to consider for obtaining a shorter payback period include:

- Target fluorescent T8 troffers with lower-than-average efficacy.
- Target fluorescent T12 troffers.
- Identify LED troffer retrofit kits with a lower installed cost.