Upgrading CFL Downlights to LED

As of 2012, 700 million downlight luminaires were installed in residential and commercial buildings in the United States; light-emitting diode (LED) luminaires represent less than 1% of this installed base according to estimates from the U.S. Department of Energy (DOE). If LED downlight luminaires were wholly adopted, about 278 trillion British thermal units (tBtu) could be saved annually, equating to an annual energy cost savings of $2.6 billion.[1] Luminaire manufacturers offer many dedicated LED downlight luminaires with high efficacy and with numerous options for controlling the light output and distribution. But for facilities with existing downlights that use compact fluorescent lamps (CFLs), replacing those luminaires with new LED luminaires may not always be a viable economic option. As alternatives, a number of companies offer LED products that directly replace CFLs and operate on existing CFL ballasts, while others offer LED retrofit kits that replace existing CFL sockets and ballasts with dedicated LED components. How do you decide which alternative is best for your facility? This report discusses the benefits and drawbacks of each, with examples of real installations from recent DOE case studies.

Why upgrade from CFL to LED?

CFLs offer reduced energy use, higher efficacy, and much longer lifetimes than incandescent and halogen lamps, but they also have drawbacks. CFLs usually have a warm-up period before they reach their full light output, they vary in color consistency and have lower color rendering index (CRI) values compared to incandescent lamps, and they are difficult or impossible to dim. LEDs offer additional energy savings, longer lifetimes, instant "on" at full light output, and improved dimming and other control capabilities. Many LED products offer warranty periods that far exceed the expected lifetimes of CFL products, enabling operating savings in replacement and labor costs.

LED Options

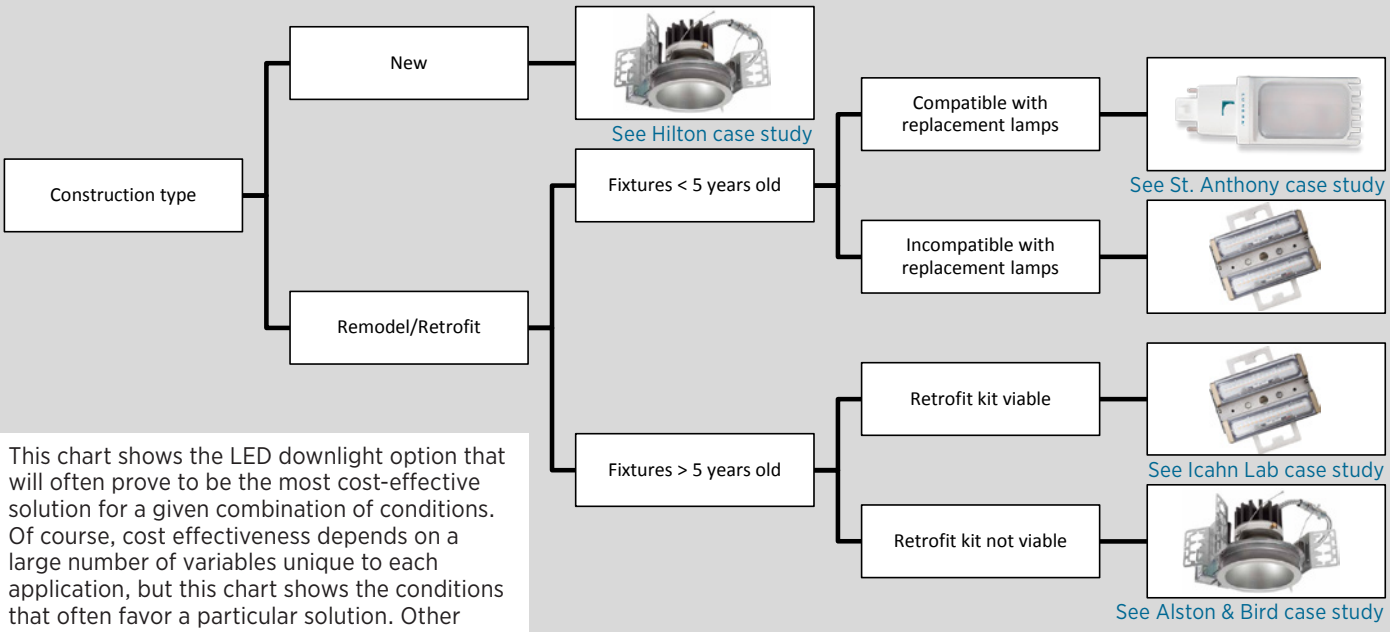
Replacement lamp

Retrofit kit

New luminaire

Photo credits (from the top): Lunera® Lighting; TerraLUX®, Inc.; Eaton's Cooper Lighting Business

Selecting the Most Cost-Effective LED Option



This chart shows the LED downlight option that will often prove to be the most cost-effective solution for a given combination of conditions. Of course, cost effectiveness depends on a large number of variables unique to each application, but this chart shows the conditions that often favor a particular solution. Other considerations that can affect the option chosen are shown in Table 1.

[1] *DOE, Adoption of Light-Emitting Diodes in Common Lighting Applications, May 2013, (http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/led-adoption-report_2013.pdf).*

Factors to Consider

Replacement lamps usually have the lowest product cost and can be replaced by facilities maintenance staff. Retrofit kits and new luminaires require fixture and/or building wiring changes, increasing installation labor costs. In some cases, the labor costs of a retrofit kit can exceed those for a new luminaire.

Lamps and kits can offer very attractive energy savings but determining their equivalency for equal light output can be difficult, since it depends on the specific application conditions. Similarly, replacement costs for lamps and kits can be affected by the specific electrical and thermal properties of the application. For all options, product warranty information and conditions should be carefully assessed.

At the time of this report, replacement lamps were only available for operation on non-dimming CFL ballasts. While kits and luminaires can be dimmed, compatibility of specific LEDs, drivers, and dimmers should be verified before installation.

Replacement lamps and retrofit kits use the existing luminaire housing and components; the viability of these options may be questionable if the existing equipment has degraded. Some retrofit kits offer new optical components with their kits, which can cover or replace the degraded materials in the existing fixtures.

In some existing buildings, accessing fixtures and wiring above the ceiling is not desired or possible due to the type of ceiling, the nature of the space, or the possible presence of hazardous materials in or above the ceiling. When these concerns exist, installation of retrofit kits and new luminaires need to be carefully assessed for possible access issues.

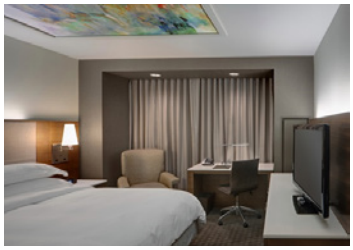
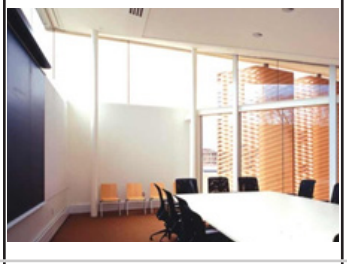
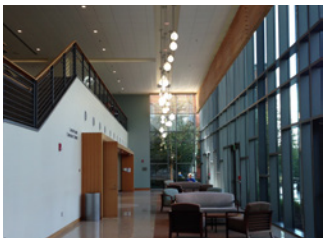
Table 1. This table compares the three LED options for downlights based on several factors. For each of the options, the table provides a color-coded identification of whether a factor is favorable for the related LED option (green circle), whether there may be reasons to exercise caution based on this 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 each individual product must be evaluated on its own merits.

	DESCRIPTION			
INITIAL COSTS	Equipment purchase costs	●	▲	■
	Installation labor costs	●	▲	■
OPERATING COSTS	Energy costs for equal light output	▲	▲	●
	Replacement costs over system life	▲	▲	●
TYPE OF BALLAST + CONTROL	Non-dimming	●	●	●
	Dimming ballast + control	■	▲	▲
CONDITION OF LUMINAIRE HOUSING AND LENSES	Looks new; very little wear apparent	●	●	●
	Some minor color variations in lenses or scratches in surface	▲	▲	●
	Looks old, obvious cracks or yellowing in lenses, paint peeling from surfaces	■	■	●
CEILING/PLENUM 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	●	▲	■

In addition to the factors shown in Table 1, several questions must be considered as part of any LED upgrade:

- Do you want to dim the downlights? Not all options are compatible with dimming. Testing samples of all dimming control components in a mock-up is recommended.
- Are the existing light levels adequate? Some options may reduce the light levels. These impacts can be evaluated by requesting photometric data from the manufacturer, but be sure the data provided are for the specific fixture in your building. Otherwise, a small-scale mock-up can help evaluate these impacts.
- Is lighting uniformity important? Lighting distribution can change with different LED solutions. This can also cast less light onto the walls, which can make spaces appear dim and unpleasant (sometimes called the "cave effect"). Again, this can be assessed using detailed photometric data or with a mock-up.
- Are the downlights used for emergency lighting? Some options may not be compatible with emergency circuits.

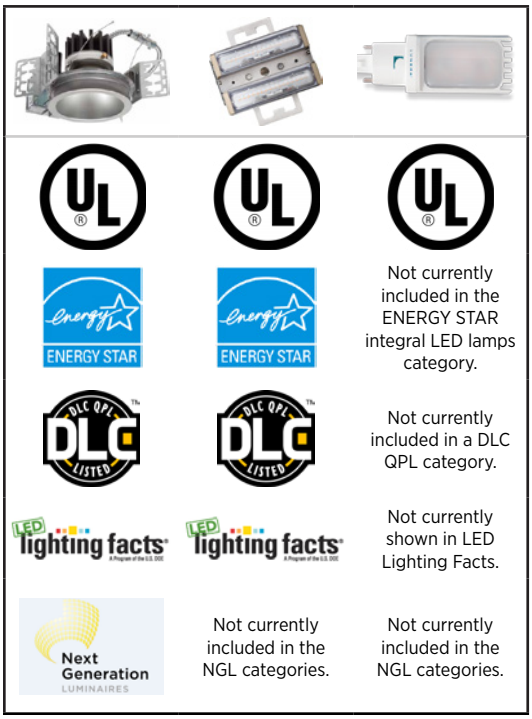
Case Studies

				
	HILTON COLUMBUS DOWNTOWN COLUMBUS, OH	**ALSTON & BIRD, LLP ATLANTA, GA**	**ICAHN LABORATORY PRINCETON, NJ**	**ST. ANTHONY HOSPITAL GIG HARBOR, WA**
BUILDING DETAILS & ANNUAL ENERGY SAVINGS[A]				
	• Occupancy in 2012 • 450,000 ft^2	• Remodel completed in 2014 • 365,000 ft^2	• Retrofit completed in 2015 • 98,000 ft^2	• Retrofit completed in 2014 • 250,000 ft^2
	203,331 kWh; $14,233 50% savings versus CFL	**111,713 kWh; $11,395 50% savings versus CFL**	**55,350 kWh; $6,090 60% savings versus CFL**	**131,279 kWh; $10,424 59% savings versus CFL**
LIGHTING INSTALLATION	• Eaton's Cooper Lighting Business Portfolio® LED downlights • 15 W; 3,000 K; 900 lm; 60 lm/W • 3,700 installed	• USAI BeveLED® 2.0 and NanoLED® downlights • 16 W; 3,000 and 3,500 K; 1,316 lm; 82 lm/W • 2,342 installed	• TerraLUX® DR8 LED retrofit kits • 34 W; 3,500 K; 2,950 lm; 87 lm/W • 205 installed	• Lunera® Helen lamps • 13 W; 3,500K; 900 lm; 69 lm/W • 1,262 installed
CONTROLS	• Wall-mounted switches and dimmers • Passive infrared ceiling-mounted vacancy sensor	• 0-10V dimming controls • Touchscreen AV and lighting controls in conference rooms • PIR and microphonic motion sensors (used after hours)	• On-off switches	• On-off switches for LEDs • CFL downlights in a few dimming applications were not converted to LED
PHOTOMETRIC PERFORMANCE	• Light levels satisfied or exceeded IES task requirements	• Excellent facial modeling in all spaces, especially conference rooms and videoconference rooms	• Light levels satisfied or exceeded IES recommended levels (horizontal and vertical)	• Overall light levels increased although distribution of light was changed
COLOR PERFORMANCE	• CRI values of 80+ • Higher R_9 values than CFLs • More consistent color than CFLs	• 3,500 K CCT with 80+ CRI in most space • 3,000 K CCT with 90+ CRI for art collection	• CRI values of 80+ • Higher R_9 values than CFLs • More consistent color than CFLs	• CRI values of 80+ • Higher R_9 values than CFLs • More consistent color than CFLs
LINKS	• Full report: https://www4.eere.energy.gov/alliance/activities/technology-solutions-teams/lighting-electrical/downlight	• Fully report: https://www4.eere.energy.gov/alliance/activities/technology-solutions-teams/lighting-electrical/downlight	• Upcoming report: http://energy.gov/eere/ssl/gateway-demonstration-university-projects	• Full report: https://www4.eere.energy.gov/alliance/activities/technology-solutions-teams/lighting-electrical/downlight

[A] *Savings are shown relative to a comparable CFL downlight and do not include any savings from controls. The values may differ from those shown in the full reports due to the assumptions used in the calculations.*

Table 2. Comparison of LED upgrade options: pros and cons.

	PROS	CONS
	• High efficacy and good potential energy savings • Long rated life (50,000+ hrs) • Lower product and installation cost than other LED options • Easy to replace / upgrade • Access above the ceiling not required for installation	• Current products are not dimmable • Determining equivalency can be difficult • May affect light distribution and overall aesthetics • Compatibility limitations with different CFL ballasts • Old housing and ballast remain in place and require future maintenance or replacement • Potential for snap-back to CFL • Uncertain compatibility with controls and emergency system • Actual lifetime may be affected by the specific application conditions
	• High efficacy and good potential energy savings • Long rated life (50,000+ hrs) • Access above the ceiling not required for installation • Some products offer dimming and control options • Results in dedicated LED fixture with little snap-back risk • Replaces older CFL ballast with new LED driver	• Higher product and installation cost • Determining equivalency can be difficult • May affect light distribution and overall aesthetics • May affect safety listing (UL) of fixture • Actual lifetime may be affected by the specific application conditions • Uncertain compatibility with controls and emergency system • Old housing remains in place and may require future maintenance or replacement
	• High efficacy and good potential energy savings • Long rated life (50,000+ hrs) • Many options for meeting aesthetic and performance goals • Often have integrated dimming and control options • Upgrading the light engine possible with some products	• Higher product and installation cost • May affect light distribution and overall aesthetics • Future upgrades may be difficult with some products • Generally require access above the ceiling for installation



Resources for Final Product Selection

Several information and qualification programs exist for LED lighting products, and the applicability of these programs for the three LED upgrade options discussed in this report is shown in Table 3. A product listed with a Nationally Recognized Testing Laboratory (NRTL) such as Underwriters Laboratories[1] (UL) indicates compliance with safety standards but does not verify performance. However, a product must satisfy certain performance specifications to achieve ENERGY STAR®[2] certification or inclusion on the DesignLight Consortium™'s (DLC) Qualified Products List[3] (QPL). Both new luminaires and retrofit kits are included in ENERGY STAR's downlight luminaire category. LED Lighting Facts®[4] provides the verified performance information for each product, but does not establish performance criteria for inclusion on the list. The Next Generation Luminaires™ SSL design competition[5] (NGLDC) recognizes excellence in the design of energy-efficient LED luminaires and includes a downlight category.

Manufacturer-specific product information can be found using each of the links provided in Table 3, which can enable comparisons between different product offerings in each category. LED replacement lamps with CFL bases are not currently included in most of these programs; at the time of this report, replacement lamps were available from GE Lighting, Light Efficient Design, and Lunera Lighting.

[1] *UL: http://industries.ul.com/lighting*
[2] *ENERGY STAR: https://www.energystar.gov/productfinder*
[3] *DLC: https://www.designlights.org/qpl*
[4] *LED Lighting Facts: http://www.lightingfacts.com/Products*
[5] *NGLDC: http://www.ngldc.org*

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