

Recessed LED Downlights

Recessed downlights are commonly used for ambient and directional lighting in both residential and commercial buildings. One of the earliest applications of solid-state lighting for general illumination, LED downlights are now widely available in a range of sizes and lumen packages, offering a viable alternative to incandescent and compact fluorescent (CFL) products.

The recessed downlight category encompasses a broad range of luminaires, which share the common attribute of being installed above the ceiling and emitting light through an aperture. The market-wide portfolio of downlights includes products with either round or rectangular apertures ranging from approximately 2-inches to 12-inches in width. Many manufacturers use a modular system to offer customizable trim and reflector options, providing specifiers with many opportunities to meet design needs.

For traditional downlights, the installed lamp is a primary factor in product performance. Sometimes omnidirectional lamps (e.g., A, ED-17, triple tube) are used, but directional lamps (e.g., PAR, R, BR) are generally more appropriate. Integrated LED lamps can also be placed in conventional luminaires, but the emergence of LED technology has facilitated alternatives to this system, such as LED downlight retrofit units and integrated LED downlights. As the technology advances, future changes to the structure of LED downlights may emerge; already, some manufacturers offer recessed downlights that incorporate interchangeable LED modules.¹

Energy Impact

As of 2007, DOE estimated that there were roughly 800 million downlights installed in residential and commercial buildings, noting that in both settings, relatively inefficient incandescent lamps were the predominant light source. DOE also estimated that if all downlights nationwide were retrofitted with LED products, annual energy use could be reduced by 877 Tbtu, or roughly the annual energy consumption of 6.7 million typical U.S. households.² This estimate was based on an LED product efficacy of 61 lm/W, but with some LED downlights now exceeding 80 lm/W, even greater energy savings are possible today.

Especially when CFL or other omnidirectional lamps are used, the total luminaire efficacy of conventional downlights can be greatly limited by the efficiency of the luminaire—a significant portion (50% or more) of the lumens emitted by the lamp can



Clockwise from left: an LED downlight retrofit unit, an LED PAR replacement lamp, an integrated LED downlight luminaire, and an LED module. These four form factors are all used in LED downlights; although none is inherently superior, they each have unique characteristics that can be advantageous in certain applications. This fact sheet focuses on luminaires and retrofit units.

be trapped in the luminaire. Major factors affecting downlight luminaire efficiency include the optical system used to distribute the light and mitigate glare (e.g., lenses, baffles, or louvers), the finish of the reflector (e.g., clear or colored, specular or diffuse), and the orientation of the lamp (e.g., horizontal, angled, or vertical). When directional lamps are used, performance is more heavily dependent on the lamp itself, with some luminaires being more than 80% efficient. With the potential to diverge from the modular lamp-luminaire system, LED downlights can potentially achieve greater efficacy.

LED Downlight Performance

Summarily describing the performance of all varieties of recessed LED downlights can be difficult and potentially misrepresentative. In particular, integrated LED lamps have a wide range of performance characteristics—these products are discussed in other DOE publications. The CALiPER program recently documented the performance of LED downlight retrofit units and integrated LED downlights.³ Some key observations are as follows:

- **Lumen Output:** The range in output for conventional downlights can be substantial. As shown in Figure 2, the majority of LED downlights produce fewer than 2000 lumens. This covers the range of most incandescent lamps, but does not match the lumen package available from higher wattage CFL or metal halide lamps.
- **Luminous Efficacy:** With some products currently exceeding 80 lm/W, LED downlights can have considerably better efficacy than conventional downlight luminaires. A majority of

¹ Although the term LED module is defined in ANSI/IES RP-16-10, some manufacturers use the term to refer to other product types.

² Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications (2008), available at: http://www1.eere.energy.gov/buildings/ssl/tech_reports.html

³ Application Summary Report 14: LED Downlight Retrofit Units (2012), available at: <http://www1.eere.energy.gov/buildings/ssl/reports.html>

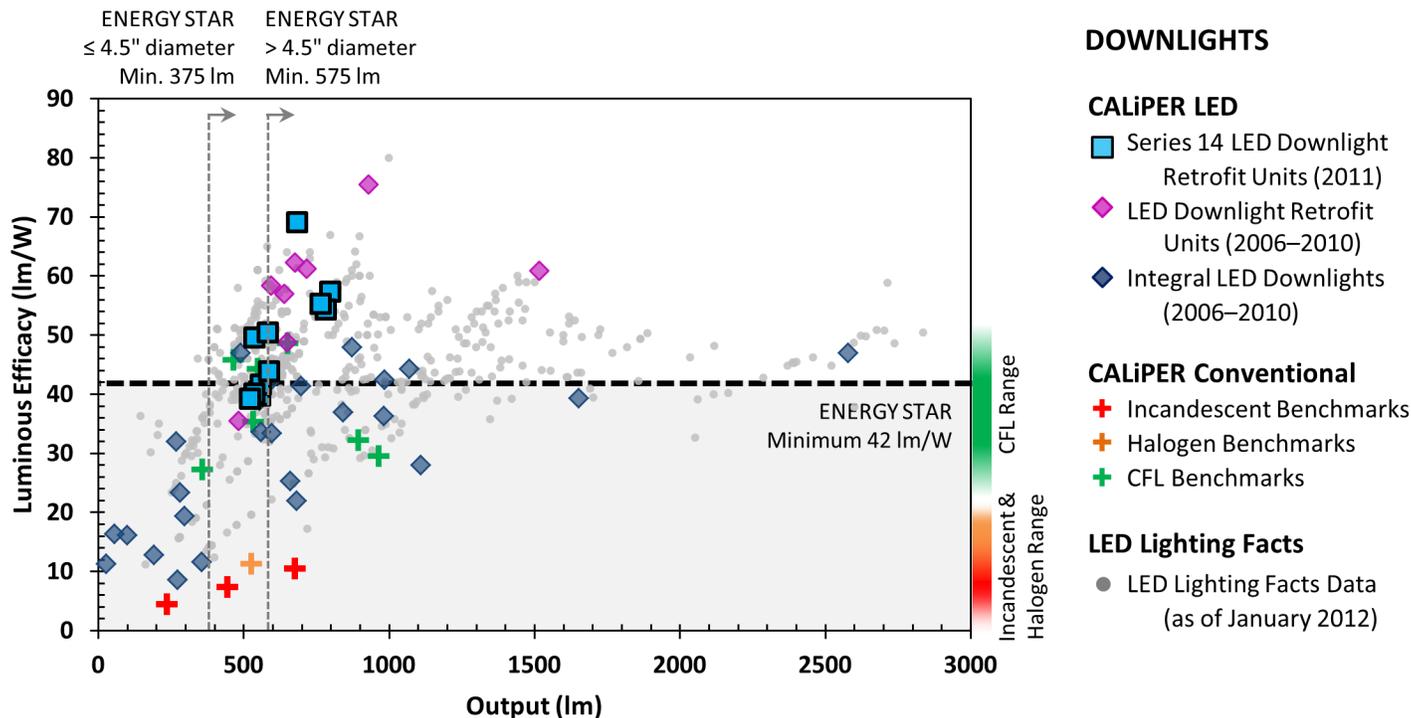


Figure 2. Luminous efficacy versus lumen output for LED downlights and conventional downlights. As the technology has advanced, LED downlights have (in many cases) become superior to conventional downlights in terms of energy efficiency. The conventional benchmarks listed here are for traditional lamps tested in a sample housing. The LED Lighting Facts data includes both LED downlight retrofit units and integral LED downlights.

products listed by LED Lighting Facts exceed the minimum of 42 lm/W required for ENERGY STAR® qualification.

- **Luminous Intensity Distribution:** The range of distribution characteristics for LED downlight retrofit units and integrated LED downlights can be more limited than conventional downlights. Integrated LED lamps may offer a greater variety of very narrow or very wide distributions.
- **Color Characteristics:** A vast majority of LED downlights have a color rendering index (CRI) greater than 80 and a correlated color temperature (CCT) between 2700 K and 4100 K, but products with characteristics outside this range are also available. It is always important to verify that the color characteristics match the needs of the intended application.
- **Cost and Useful Lifetime:** The rated lifetime of LED products is typically much longer than for conventional lamps. A complete life-cycle cost analysis, which can be more informative than comparing initial cost, should be undertaken if cost is an important factor.

Choosing the Best Product

As of May 2012, more than 350 recessed LED downlight products were ENERGY STAR qualified, and more than 590

LED downlights were listed by LED Lighting Facts. Add the large variety of integrated LED lamps and the options for the specifier are daunting. Choosing the best option for a specific application will likely include evaluating:

- Lumen output and light distribution
- Color quality
- Energy use, lifetime, and life-cycle cost
- Product appearance and visual comfort for users
- Dimming characteristics, flicker, and audible noise
- Compatibility with new or existing luminaires and building systems

There is substantial variation between LED downlights, and performance is often dependent on the specific application. Although it is difficult to make generalized evaluations, many currently available LED alternatives to conventional downlights feature high luminous efficacy and offer striking energy savings, while providing a similar (or even improved) quality of light.

Additional information on specifying recessed downlights is published by the New Buildings Institute (www.algonline.org) or the Illuminating Engineering Society (www.iesna.org).

