

## LED Directional Lamps

Directional lamps are a key component of focal lighting and are most often used in retail, hospitality, residential, and museum applications. Conventional directional lamps are practical and relatively inexpensive, but higher efficacy LED alternatives have emerged. This fact sheet discusses the attributes of conventional PAR-, AR-, BR-, and R-shaped lamps and compares the performance of LED products to that of incandescent, halogen, CFL, and CMH lamps.

### Introduction

The extensive range of conventional directional lamps includes products with different lumen output, different luminous intensity distributions, and different beam characteristics, allowing specifiers to choose the right product for the job. Directional lamp designations (e.g., PAR38, BR30, or AR111) arise from the specific shape and size of the bulb, but they have also come to be associated with other performance parameters. The most common directional lamps are described in Table 1, although many other specialized types are also available.

Although they are effective and relatively inexpensive, the energy inefficiency of incandescent and halogen lamps is a limitation that has prompted the introduction of several alternatives, including compact fluorescent (CFL), ceramic metal halide (CMH), and LED versions. The alternative, energy efficient products mimic the performance of traditional lamps in many aspects—with varying degrees of success—but often have different physical attributes. Thus, their designation as a particular type of lamp is largely at the discretion of the manufacturer.

LEDs are well suited for directional light emission, and of the energy efficient alternatives, they have the potential to offer performance attributes most similar to incandescent or halogen lamps. While there are many excellent LED products currently available, it is important to remember that performance is still highly variable.

This fact sheet provides a broad overview of directional lamp performance. For more detailed information, please see three recent CALiPER reports on LED BR30/R30 Lamps, LED AR111 and PAR36 Lamps, and LED PAR38 Lamps. These reports can be found at [ssl.energy.gov/caliper.html](https://ssl.energy.gov/caliper.html). Also, note that MR16 lamps are covered in a separate fact sheet, which is available at [ssl.energy.gov/factsheets.html](https://ssl.energy.gov/factsheets.html).

### Conventional vs. LED Directional Lamps

**Form Factor and Lamp Appearance:** Integral LED lamps must include a driver and thermal management system, and thus appear different from traditional incandescent or halogen products. Some currently available products meet ANSI standards for size and shape, whereas others fail to varying degrees. The importance of small discrepancies is dependent on the fixture in which the product will operate.

**Quantity of Light and Efficacy:** Some currently available LED directional lamps can meet or exceed the lumen output of 90 W halogen lamps (1,300+ lm), but few products are equivalent to the highest output traditional lamps—this will likely change in the future. Notably, many manufacturers offer LED products in only one wattage (lumen package) instead of an entire family, which may make replacing a variety of existing halogen lamps more difficult. In terms of efficacy, a vast majority of LED directional lamps exceed 50 lm/W, which is more than three times the efficacy of typical halogen lamps and on par with CFL and CMH lamps. Some LED lamps exceed 80 lm/W. Lumen output and efficacy data are shown in Figure 1.

Table 1. Descriptions of the most common types of directional lamps. MR16 and other specialty lamps are not included.

Type	Common Sizes <sup>1</sup>	Typical Distribution	Notes
Parabolic Aluminized Reflector (PAR)	38, 30, <sup>2</sup> 20	Spot through Flood	<ul style="list-style-type: none"> <li>- Pressed glass</li> <li>- More precise optics used for display and object lighting</li> <li>- Sealed beam provides weather resistance</li> <li>- Medium screw base</li> </ul>
Reflector (R) Bulged Reflector (BR)	30, 20	Flood	<ul style="list-style-type: none"> <li>- Blown glass</li> <li>- Produce soft pools of light</li> <li>- Primarily used for residential and hospitality downlighting</li> <li>- Medium screw base</li> </ul>
Aluminized Reflector (AR)	111, 50	Spot	<ul style="list-style-type: none"> <li>- Filament cap and open reflector</li> <li>- Narrow, controlled beams</li> <li>- Screw terminal base, pin base, or bayonet base</li> </ul>

1. The size designations for PAR, BR, and R lamps are based on the nominal diameter in eighths of an inch. The size designations for AR lamps are based on the nominal diameter in millimeters.

2. Available in long neck and short neck.

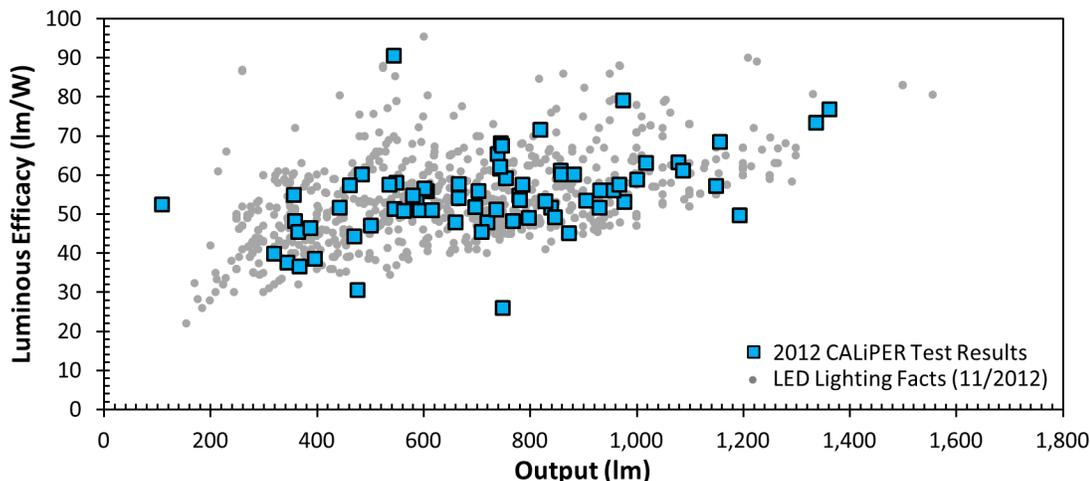


Figure 1. Luminous efficacy and lumen output for LED PAR, R, BR, and AR lamps. The bulk of LED lamps are between 50 and 60 lm/W, with output ranging from 350 to 1,200 lumens. This efficacy level is comparable to CFL and CMH lamps, and much higher than halogen lamps, which are typically less than 20 lm/W.

**Distribution of Light:** Although creating narrow distributions was a challenge for early generation LED products, it is no longer a limitation. LED lamps are available in a wide range of beam angles (from less than 10° to more than 60°), and a majority of products carry a name designation that is broadly representative of their performance (i.e., PAR, R, BR, etc.).

**Color Quality:** Most integrated LED lamps are offered with a nominal CCT of 2700 or 3000 K, which are similar to incandescent and halogen, and some are available in higher CCTs that may be preferred by certain people or in certain applications. Most products also have a  $D_{uv}$  value within the tolerances established by ANSI, meaning they should not appear pink or green. Additionally, most LED directional lamps have a CRI in the 80s—usually considered acceptable for general ambient lighting—and some products with a CRI in the 90s are available.

**Spectrum:** A benefit of integrated LED lamps is the substantial reduction of energy radiated in the ultraviolet (UV) and infrared (IR) regions of the electromagnetic spectrum. This is particularly advantageous in museum lighting applications where material degradation has serious consequences or in supermarkets where emissions outside the visible spectrum may cause produce to ripen more quickly.

**Life Expectancy:** Almost all LED products offer a substantial improvement in rated lifetime compared to conventional sources, which along with reduced energy use can lead to lower life cycle costs. Most LED directional lamps have claimed lifetimes between 20,000 and 50,000 hours. Three or five year warranties are typical, with a few products carrying a 10-year warranty.

**Dimming:** Most, but not all, currently available LED lamps have dimming capability. Like CFLs, the range for some products may be limited, and most products do not visually match the dimming characteristics of incandescent and halogen lamps.

**Compatibility:** Integrated LED lamps are electronic devices that may or may not work properly with other system components, such as dimmers or transformers (if applicable). Incompatible lamp and dimmer combinations may result in flicker, color shift, audible noise, premature lamp failure, very limited or no range of dimming, or failure to light. These problems may manifest themselves at full output and/or when dimmed; furthermore, they are typically dependent on the number of lamps connected to the dimmer. Care must be taken to match compatible products.

**Flicker:** The output of all light sources modulates over time, but variation may or may not be visible. Whereas incandescent lamps do not produce noticeable flicker, a number of LED products do, and the problem may be exacerbated by dimming. In-person evaluation may be necessary where flicker is a serious concern.

**Environmental Operating Characteristics:** Many currently available LED lamps cannot be used in totally enclosed fixtures and/or are only rated for interior use. In contrast, sealed beam PAR lamps are often used in exterior applications.

## Conclusions

A wide variety of LED directional lamps are now available, including products designated as PAR, R, BR, and AR lamps. In many cases, these lamps compare favorably to conventional directional lamps, having higher efficacy, acceptable color quality, and a range of available luminous intensity distributions. However, variations in performance are substantial, requiring that specifiers be careful to match performance with a given application. Further, care must be taken to ensure compatibility with other system components, especially in retrofit applications. Finally, a number of products tested by CALiPER had inaccurate claims for performance or equivalency, and not all products carried the designation that best represented its performance.

