

# CALiPER

## Snapshot MR16 Lamps

The LED Lighting Facts™ program continues to experience rapid growth, with a record number of new products listed for the third straight quarter. These products are more efficacious than ever before, with a mean of 83 lm/W, and generally deliver improved performance across the board in attributes that are tracked by the program. However, considering only these overall trends may mask the performance changes of any given category, such as MR16 lamps.

Used extensively in retail and display lighting, halogen MR16 lamps deliver focused illumination from their two-inch diameter aperture, have desirable color quality, are easy to use with controls, and are available with a range of different options (e.g., beam angle) and accessories (e.g., spread lenses). Given this combination of features, the conventional halogen MR16 lamp is one of the most difficult lamps for LED technology to successfully replicate. This is especially true for 12 V, 50 W halogen lamps, which are the highest-wattage that is commonly available.

Data from LED Lighting Facts shows that lumen output and center beam intensity of LED MR16s has been steadily increasing, but there are still few products that can claim to be truly comparable to a 50 W halogen MR16 lamp. While mean lumen output has approximately doubled in the past four years, mean efficacy has seen only modest gains (from 42 to 54 lm/W), unlike other lamp and luminaire categories. Since 2010, the percentage of MR16 lamps in the overall LED Lighting Facts database has steadily declined from 11% to 4%; while the total number of MR16 lamps listed has increased slightly, other products have been added at a much faster rate. It is possible that manufacturers are shifting focus away from MR16s while waiting for continued development of LED technology.

LED Lighting Facts lists MR16 products operating at 12 V (typically a GU5.3 base) and 120 V (typically a GU10 base). Importantly, the performance of low-voltage and line-voltage halogen MR16 lamps is not equivalent, even at the same wattage. Thus, it can be difficult for specifiers and consumers to make sense of equivalency claims. About 54% of the currently active MR16 lamps listed by LED Lighting Facts are 12 V lamps, whereas 11% are 120 V; the remainder does not list the voltage, which is an optional metric. Until August of 2013, base type was not requested. As of January 1, 2014, there were 505 LED MR16 lamps actively listed by LED Lighting Facts.



January 1, 2014

1,419 Partners

11,731 Total Active Products

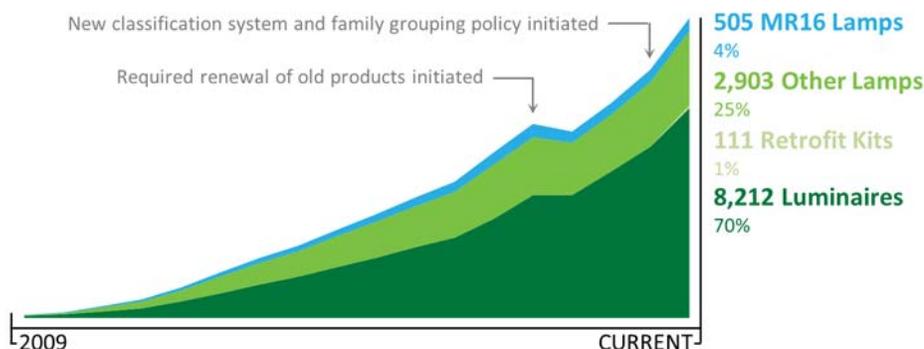
### Report Highlights

- Few MR16 lamps currently listed by LED Lighting Facts are comparable to a 50 W (12 V) halogen MR16 lamp. Of the small subset of MR16s that provided data for beam angle and center beam intensity, only one would meet the minimum ENERGY STAR® CBCP criterion for equivalence to a 50 W halogen MR16 at the same beam angle (40°).
- While the overall number of MR16s listed has increased slightly, over the past three years the percentage of MR16 lamps in the LED Lighting Facts database has declined by more than 60%. Over the past two years, the efficacy for newly listed products has shown minimal change.
- Both lumen output and input power have increased steadily in recent quarters. The net result has been little change in luminous efficacy.
- On average, the MR16 lamps listed by LED Lighting Facts have slightly better color quality than other lamp types, with a higher percentage of MR16 lamps having a CRI above 90.
- As with all categories, there is substantial variability in the performance of LED MR16 lamps listed by LED Lighting Facts. Specifiers and consumers should evaluate each product on its own merits.

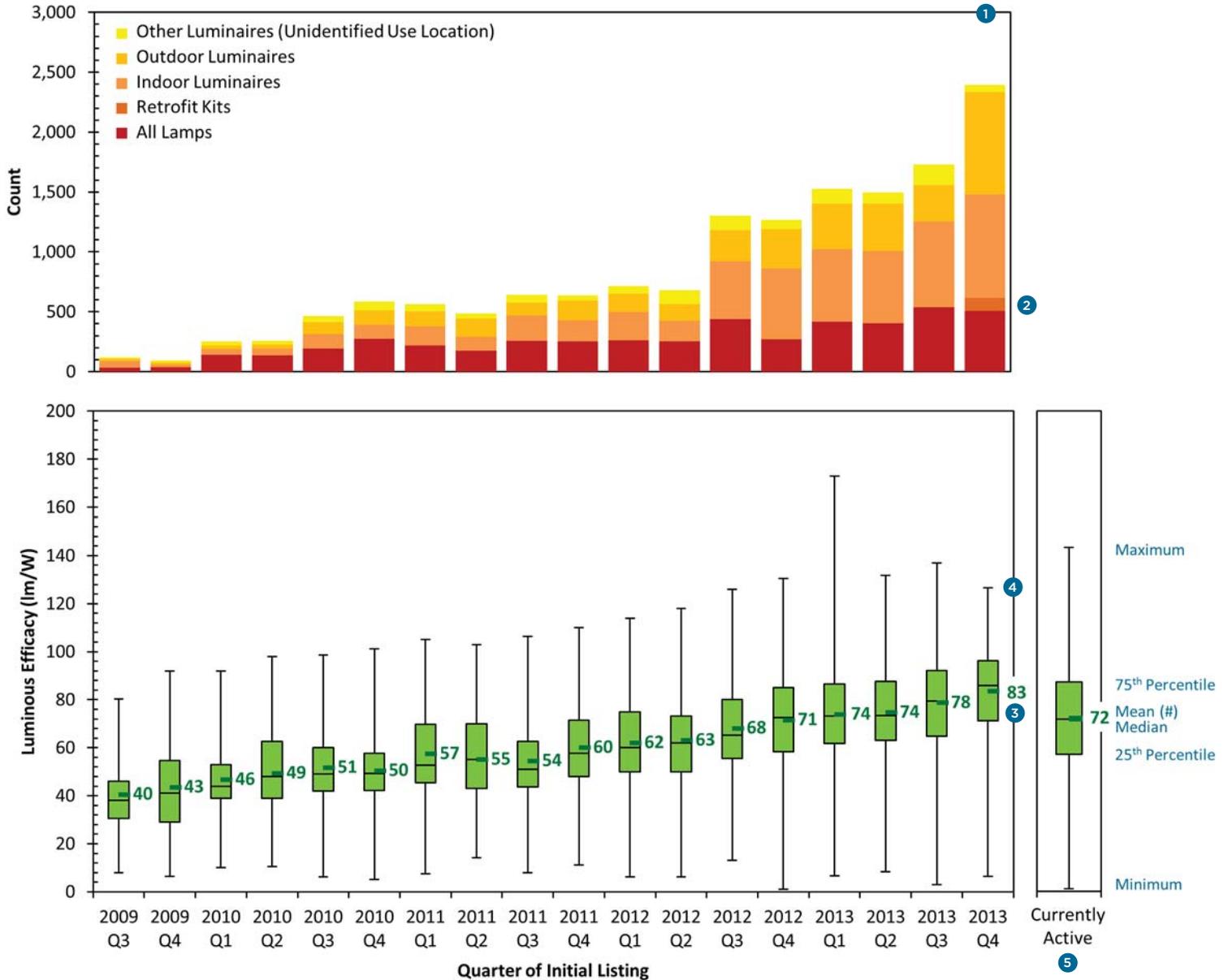
### News and Notes

- Products submitted to LED Lighting Facts may now be placed in the Retrofit Kit category. In the last quarter of 2013, 110 products were given that designation.

AT A GLANCE  
TOTAL NUMBER OF PRODUCTS LISTED BY LED LIGHTING FACTS



# All Products New Listings & Efficacy Performance by Quarter



1 The growth of the LED Lighting Facts database continues to accelerate, with more than 2,300 new products added in the fourth quarter of 2013 alone. That is nearly as many products as were listed in the first two years of the program, combined. Approximately 58% of the 11,731 currently active products were added to the list in 2013. Recent growth has predominantly come in the luminaire sector, as opposed to the lamp sector.

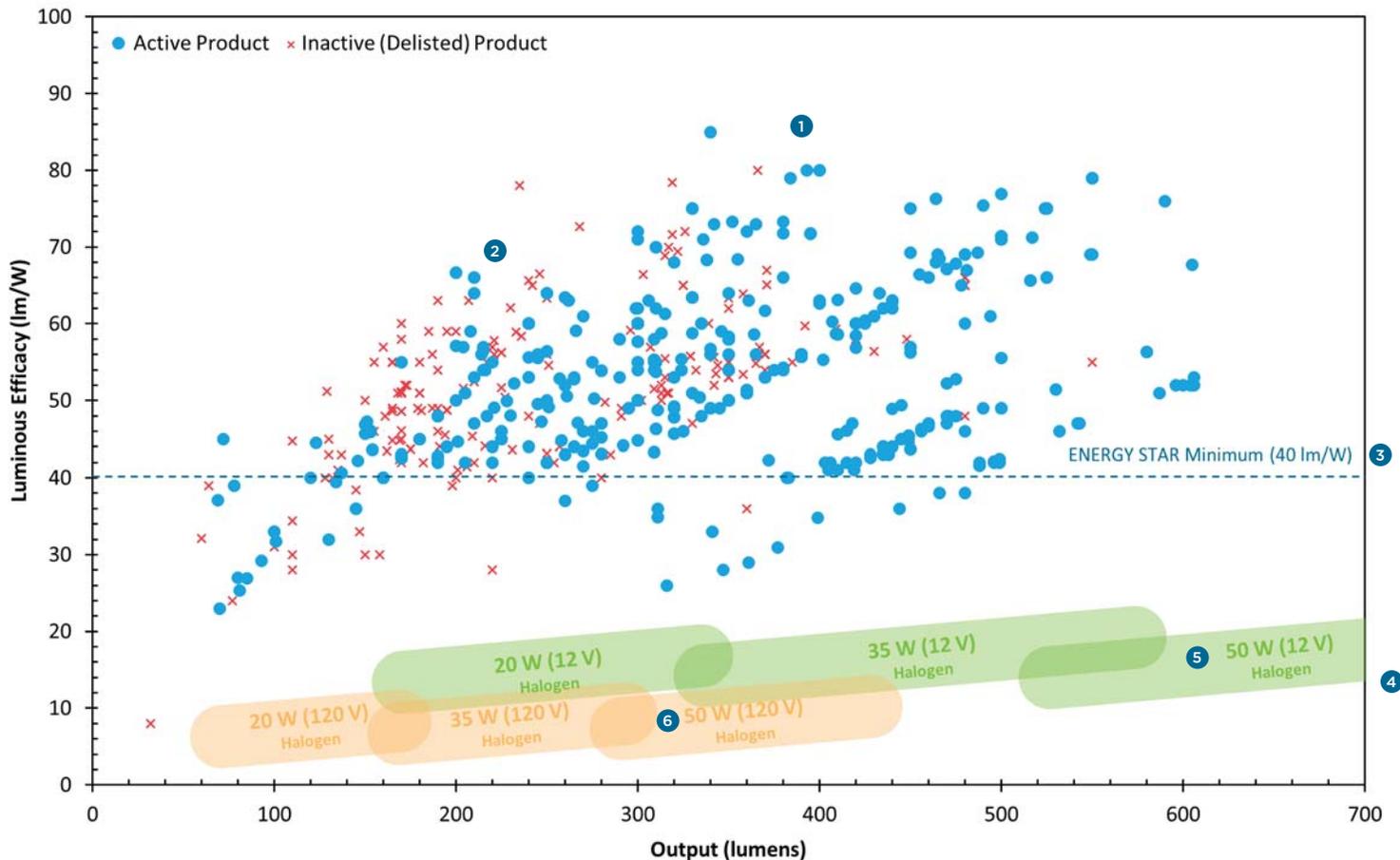
2 As part of the new categorization scheme, LED Lighting Facts now allows a product to be designated as a retrofit kit. In the fourth quarter of 2013, 110 products with that designation were added.

3 The mean efficacy for products initially listed in the fourth quarter of 2013 (83 lm/W) is the highest to date. The efficacy of newly listed products has more than doubled since the inception of the LED Lighting Facts program, with an average increase of about 10 lm/W per year. In fact, the mean efficacy for products listed in the past quarter is higher than the maximum efficacy for products listed in LED Lighting Facts' first quarter.

4 With the exception of one anomalous product listed in the first quarter of 2013 (now delisted), increases in maximum efficacy have slowed over the past year. This will be an important trend to watch going forward.

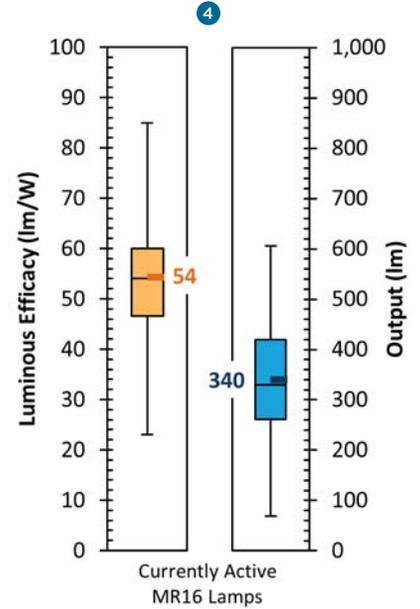
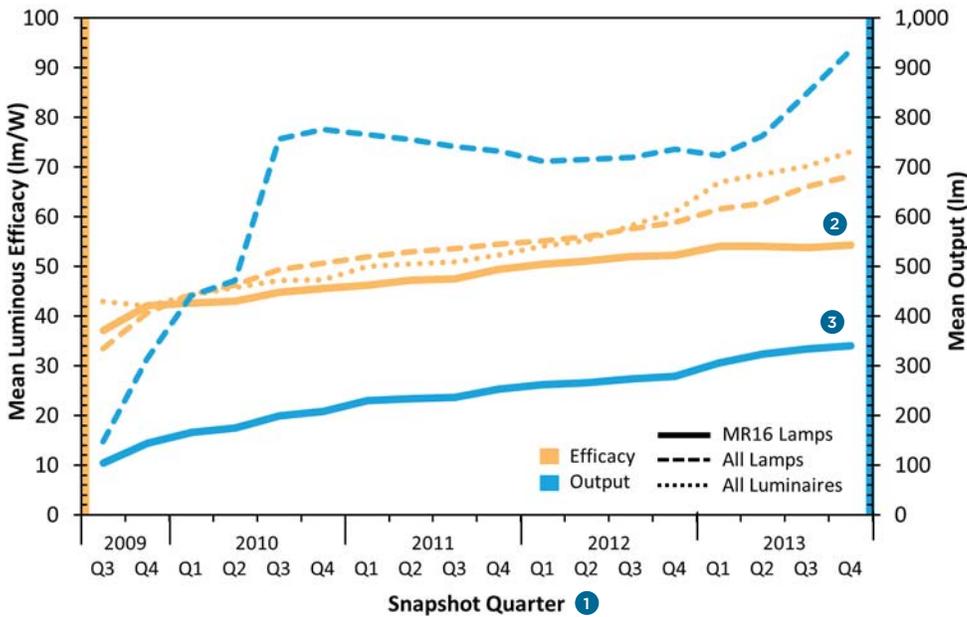
5 As would be expected given the age of some of the products that remain active in the database, the overall mean efficacy of currently active products (72 lm/W) remains slightly below the performance from recent quarters. However, it is higher than the mean efficacy for all products ever listed (69 lm/W), which indicates that lower efficacy products are being deactivated, and it has risen every quarter that a Snapshot Report has been issued.

# MR16 Lamps Efficacy & Output



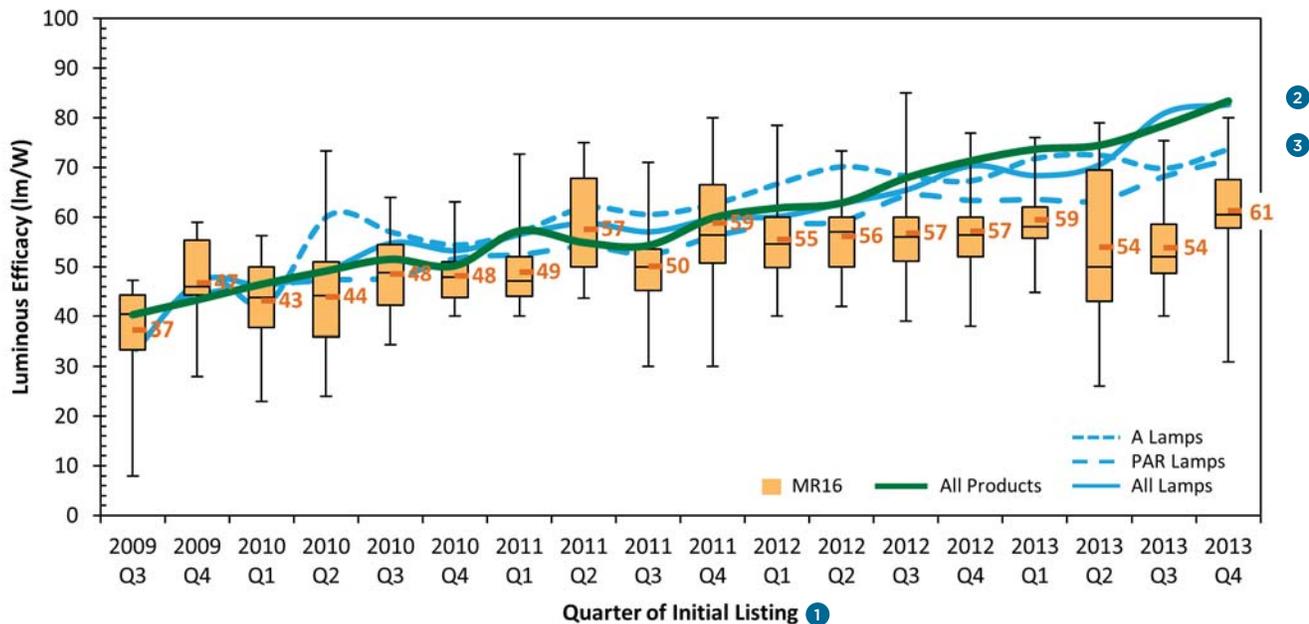
- There are few trends or groupings for lumen output or efficacy of LED MR16 lamps. Unlike A lamps, there are no obvious lumen output thresholds for MR16 lamps, in part because specification is usually considered based on beam angle and center beam intensity.
- More than 60% of the currently active MR16 lamps emit between 200 and 400 lumens. Few delisted products, which tend to be older, exceeded 400 lumens.
- The minimum efficacy requirement for ENERGY STAR qualification of MR16 lamps is 40 lm/W. Notably, 36 products currently listed by LED Lighting Facts (7% of the total) fall below that threshold.
- The typical output ranges for halogen lamps, shown in orange for 120 V products and green for 12 V products, are estimated by CALiPER from surveys of manufacturer data.
- Few of the MR16 lamps listed by LED Lighting Facts offer comparable lumen output to typical 12 V 50 W halogen MR16 lamps. Lower wattage categories are well represented, however. A vast majority of MR16 products that listed voltage were 12 V, which is typical of commercial applications.
- At a given wattage, line-voltage halogen MR16 lamps (120 V) typically have lower lumen output than their low voltage counterparts. Many of the MR16 lamps listed by LED Lighting Facts offer comparable output to all three types of line-voltage products, but only about 10% of products were listed at 120 V. Regardless of voltage, LED MR16 lamps offer superior efficacy compared to their halogen counterparts.

# MR16 Lamps Efficacy and Output Trends



- 1 This “Snapshot” chart documents the performance of products active in the LED Lighting Facts database at any given time. It is different from charts that show the performance for products newly listed in any given quarter. Under this scheme, old products that remain listed will partially mask increases for newly listed products, but it may be a better representation of what was on the market at a given point in time.
- 2 The mean efficacy of MR16 lamps listed by LED Lighting Facts has increased, but has remained lower than other lamp types since 2009. In the past year, there has been little increase in mean efficacy for MR16 lamps, whereas the rate of improvement has increased for other lamp types and luminaires. More detail is provided on page 5.
- 3 Despite stagnation of efficacy increases, the mean lumen output of LED MR16 lamps has continued to increase at a relatively constant rate. As is expected due to their size and the performance of their conventional counterparts, the mean lumen output of LED MR16 lamps listed by LED Lighting Facts is much lower than for other lamp types.
- 4 Considering only mean efficacy can mask the substantial variability in products. Examining only currently active lamps, efficacy ranged from less than 30 lm/W to more than 80 lm/W, with output ranging from less than 100 lm to more than 600 lm. Such a range of performance can make product selection tedious, although “typical” products tend to fall in a much narrower range.

# MR16 Lamps Efficacy versus Other Product Types



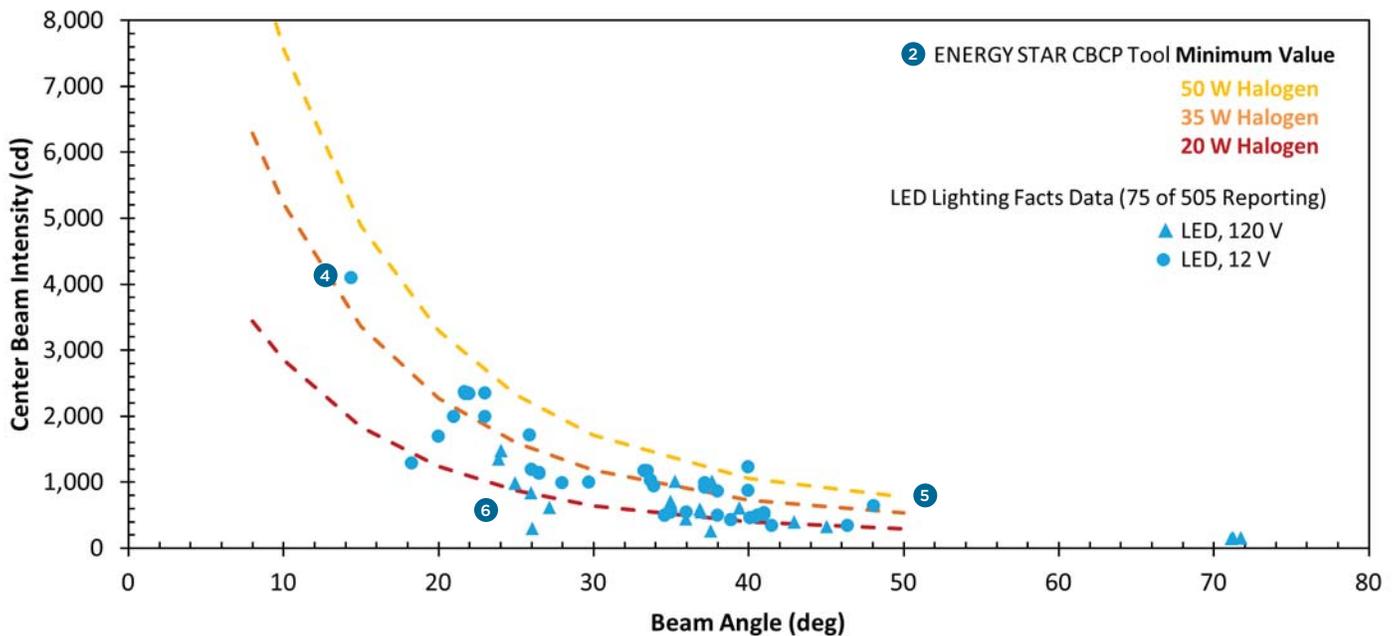
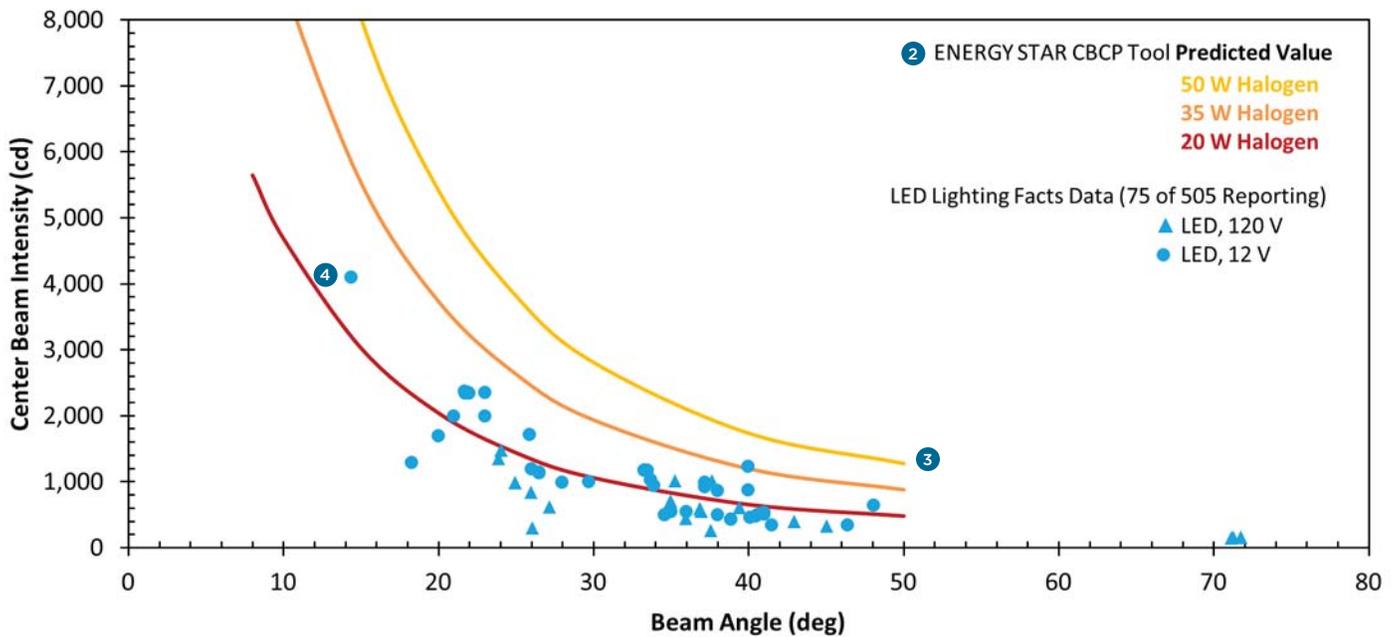
1 This chart documents the performance of products newly listed by LED Lighting Facts in each quarter. The series of orange data for MR16 lamps is analogous to the series for other products on Page 2. The green line shows the quarterly average for all products newly listed in each quarter, which corresponds to the mean efficacy for the MR16s.

2 The mean efficacy of MR16 lamps listed by LED Lighting Facts tracked similarly to the average for all products between 2009 and 2011. Since then, however, the mean efficacy of MR16 lamps has remained relatively constant—with some quarter-to-quarter fluctuation—while the mean efficacy for all products has continued to increase steadily at approximately 10 lm/W per year. Recently, the *maximum* efficacy for MR16 products has been lower than the *mean* efficacy for all products.

3 Since the fourth quarter of 2011, the three-quarter moving average for MR16 lamps has increased by only 1 lm/W. In contrast, the three-quarter moving average for other groups has increased as follows:

- A lamps – 5 lm/W (67 to 72 lm/W)
- PAR lamps – 10 lm/W (58 to 68 lm/W)
- All lamps – 17 lm/W (61 to 78 lm/W)
- All products – 19 lm/W (59 to 78 lm/W)

# MR16 Lamps Beam Angle and Center Beam Intensity<sup>1</sup>



**1** Beam angle and center beam intensity (CBCP) are optional metrics for listing to LED Lighting Facts. Of the 505 MR16 products that are currently active, only 75 provide data for both beam angle and CBCP (29 at 120 V, 46 at 12 V).

**2** ENERGY STAR provides a tool for calculating the predicted CBCP for a given wattage and beam angle halogen MR16, as well as the minimum for claiming equivalency. It is available at: <http://www.energystar.gov/LampsCBCP>

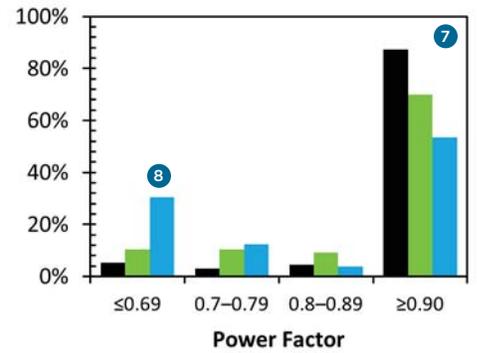
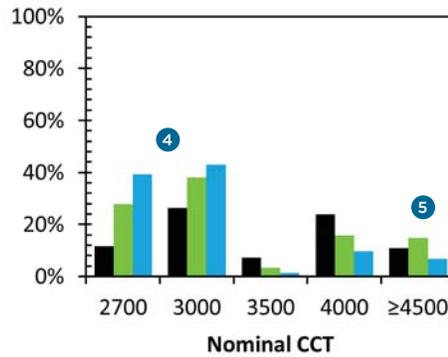
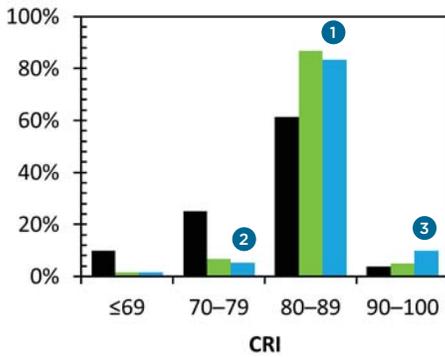
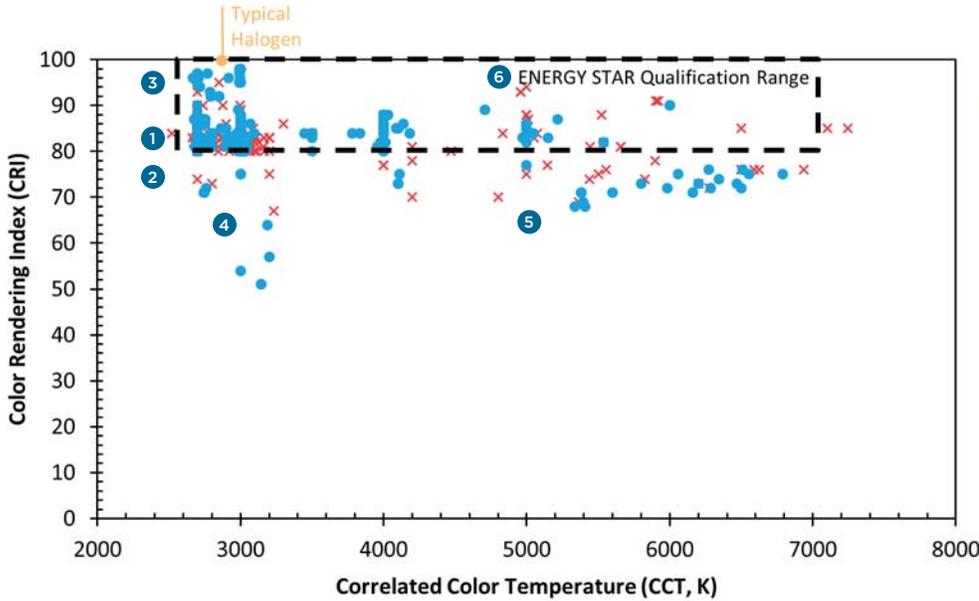
**3** None of the 75 LED MR16 lamps that provided distribution data to LED Lighting Facts could provide the predicted CBCP for a 50 W halogen MR16 at its listed beam angle. Only one of the listed products could provide CBCP comparable to what ENERGY STAR predicts for a 35 W halogen MR16 with a 40° beam angle

**4** Only one lamp that listed a value had a beam angle less than 15°.

**5** One lamp met ENERGY STAR's lower limit threshold for equivalency to a 50 W halogen MR16, and several met the threshold for a 35 W halogen MR16. The lower limits are two standard deviations below the predicted value at a given beam angle.

**6** Several of the 75 lamps that listed distribution data failed to meet even the minimum CBCP value for a 20 W halogen MR16 lamp.

# MR16 Lamps Color Quality & Power Quality



1 A vast majority of MR16 lamps listed by LED Lighting Facts (83%) have a CRI in the 80s, with a majority of those between 80 and 85.

2 A small number of currently active MR16 Lamps (7%) have a CRI less than 80. These products would not be appropriate for most applications. More than two-thirds of these products have a CCT greater than 3500 K, which is not typical of halogen lamps.

3 About 10% of currently active MR16 lamps have a CRI greater than 90, including products from seven different manufacturers. This is notably higher than the percentage for all lamps combined. In general, the currently listed MR16 lamps tend to have better color quality than other lamps, as well as luminaires—which are skewed by outdoor products that have less stringent color quality needs.

4 A vast majority of the listed MR16s have a nominal CCT of either 2700 K or 3000 K, with slightly more at 3000 K. These CCTs are the closest to halogen lamps, which often have CCTs around 2800 K to 3000 K.

5 A small number of MR16 lamps currently listed by LED Lighting Facts have a nominal CCT of 3500 K or higher, which is noticeably different than conventional MR16 lamps. Many of these lamps also have a CRI below 80.

6 ENERGY STAR requires lamps to have a CRI of at least 80 and a nominal CCT between 2700 K and 6500 K. A vast majority of the currently active MR16 lamps (93%) met both criteria.

7 A majority (53%) of MR16 lamps currently listed by LED Lighting Facts (that report the optional metric) have a power factor of 0.90 or greater. However, the percentage is noticeably lower than it is for all active products (87%), or just all lamps (70%). Only 32% of currently listed MR16 lamps reported power factor, compared to 54% for all active products. Importantly, the transformer to which low voltage lamps are connected affects the electrical characteristics of the system, making the power factor of low voltage MR16s an unreliable predictor of system performance.

8 Slightly more than 30% of the currently active MR16 lamps (that report the optional metric) have a power factor below the ENERGY STAR minimum of 0.70—markedly more than for other product categories. The small form factor of MR16 lamps, which leaves little room for a power factor correction circuit, is likely a contributing factor.

## Discussion **How do LED MR16 lamps stack up?**

Despite noted performance improvements and many claims to the contrary, few LED MR16 lamps listed by LED Lighting Facts are one-for-one replacements for a 12 V, 50 W halogen MR16 lamp. Such equivalency claims may be applicable if comparing a GU5.3 base LED lamp to a GU10 base halogen lamp, but those comparisons are misleading. While the 50 W halogen category may not be fully covered yet, an increasing number of LED MR16 lamps listed by LED Lighting Facts are comparable in lumen output to 12 V, 35 W halogen MR16 lamps. This is further evidenced by the range in lumen output for recently listed products, which continues to rise; the middle 50% of products has been between 300 and 500 lumens for the past year, firmly into the range of a 12 V, 35 W halogen MR16 lamp.

While lumen output can provide some comparison between directional lamp types, MR16 lamps are best evaluated using CBCP and beam angle, which were only reported for a small fraction of the lamps listed by LED Lighting Facts. Of those products, few provided the CBCP predicted (or accepted) by ENERGY STAR for 35 W or 50 W MR16 halogen lamps at a given beam angle. Further, only one currently active MR16 lamp listed a beam angle less than 15°; this is especially concerning given that accent lighting is a primary use for MR16 lamps.

Long-term increases in lumen output have corresponded to an increase in power draw, with only modest increases in luminous efficacy. The rate of increase for efficacy of LED MR16 lamps listed by LED Lighting Facts has been much lower than for other lamp types. In fact, it has essentially leveled out over the past two years. Potential contributing factors to this trend are the small form factor, thermal management constraints, price pressure, need to increase output, and lack of other high-efficacy alternatives to halogen lamps. For MR16 lamps, it is probable that increases in LED package efficacy are being used to provide improvements other than lamp efficacy, such as increased lumen output, while maintaining a substantial energy-efficiency advantage over conventional halogen lamps. Nonetheless, increasing lamp efficacy remains important not only for reducing energy use, but also for reducing high operating temperatures when lamps are used in enclosed or partially enclosed luminaires. Use of LED MR 16s in these luminaires may result in unacceptable levels of color shift and lumen depreciation, or in catastrophic failure. Such potential outcomes are not captured by LED Lighting Facts data.

LED MR16 lamps require an integral driver, which means electronic components must be fit into the small, ANSI-defined MR16 form factor. Additionally, almost all MR16 lamps used in commercial applications operate at 12 V, which means they require a transformer. The combination of size limitations and multiple interconnected electronic components may result in compatibility issues, where performance is degraded in one or more areas (e.g., flicker). This is sometimes a result of tradeoffs that must be made, such as between flicker and power quality. More information can be found in the DOE SSL Fact Sheet on MR16 lamps.<sup>1</sup>

Despite the challenges that remain, LED MR16 lamps offer substantially higher efficacy than halogen MR16 lamps. They offer good to excellent color quality, and have operating characteristics (e.g., dimmability) that cannot be matched by other energy-efficient MR16 lamps (e.g., metal halide).

<sup>1</sup> Available at: [http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/led\\_mr16-lamps.pdf](http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/led_mr16-lamps.pdf)

### The Fine Print **About LED Lighting Facts Snapshot Reports**

Snapshot Reports analyze the dataset—or subsets—from DOE's LED Lighting Facts product list. They are designed to help lighting retailers, distributors, designers, utilities, energy efficiency program sponsors, and other industry stakeholders understand the current state and trajectory of the solid-state lighting market. Product classifications are at the discretion of the manufacturer, and Snapshot Reports generally reflect the raw data listed in the LED Lighting Facts database. Minimal action is taken to adjust for inconsistencies.

The LED Lighting Facts database is not a statistical sample of the overall market. LED Lighting Facts is a voluntary reporting program where manufacturers submit data for products tested in accordance with IES LM-79-08. Within any category, the data may be skewed by what is submitted, but also by the reporting practices of different manufacturers (e.g., reporting each small variation of a product). Given the broad nature of some of the predetermined categories, not all individual products may be directly comparable (i.e., the form factor may be substantially different). Despite these limitations, the LED Lighting Facts database is the largest of its kind, and is generally considered indicative of market trends. The product list includes a wide variety of product types, from manufacturers large and small, lighting industry veterans and brand new companies alike.

LED Lighting Facts and the Snapshot Reports focus on five core metrics: lumen output, input power, luminous efficacy, color rendering index, and correlated color temperature. Data for other performance metrics can be voluntarily submitted, and all data is available on the LED Lighting Facts website. Specifiers should thoroughly consider all aspects of performance when evaluating different products.

