

CALiPER

Snapshot “Light Bulbs”

Featuring **LED A Lamps**

LED Omnidirectional Lamps

They may go by several names—household lamps, light bulbs, omnidirectional lamps, general service lamps—but A lamps are the quintessential light source to most people. As such, these products have received considerable attention from LED product manufacturers seeking to capitalize on the billions of existing sockets worldwide.

Traditional incandescent lamps in the ANSI-defined A shape¹ emit light in all directions, based on the omnidirectional emission of the filament itself. In contrast, bare LED packages typically emit light in one direction, but lamp-level optical systems have allowed some LED products to achieve luminous intensity distributions that effectively replicate incandescent A lamps. Some other LED A lamps—known colloquially as “snow cones”—exhibit a mostly directional emission, which may be better suited for some applications (e.g., downlights) than others (e.g., table lamps).

LED A lamps compete against compact fluorescent (CFL) and incandescent lamps, but the input power of general service lamps will soon be limited by government regulations, meaning only more energy-efficient halogen versions can be manufactured. Performance differences among the multitude of LED products are substantial, although many LED A lamps are more energy efficient than the other alternatives. The biggest differences between products tend to be luminous intensity distribution, color quality, dimming, and compatibility with controls.

This report covers products listed by LED Lighting Facts as either A lamps (new classification system) or Omnidirectional Replacement Lamps (old classification system). In August 2013, a new classification system was implemented for all new (or renewed) product submissions. The new classification system allows for searches that are more refined by creating fields for mounting type, use location, shape, size, and subcategory. Using both the new and old classification systems is the only feasible method for generating a current and historical list of A lamps listed by LED Lighting Facts, but it must be noted that including some products outside the intended category (e.g., G lamps, A21 lamps) is unavoidable. For this report, the group is simply referred to as A Lamps.

¹ Omnidirectional lamp shapes are defined by the American National Standards Institute in standard C78.20-2003.



October 1, 2013

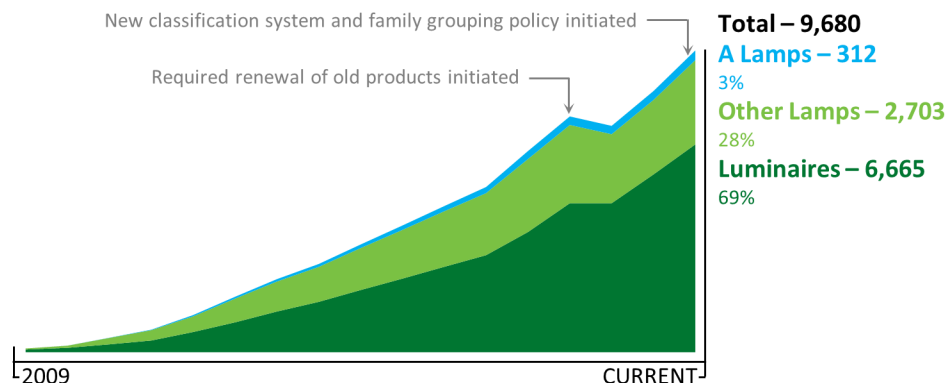
1,288 Partners

9,680 Total Active Products

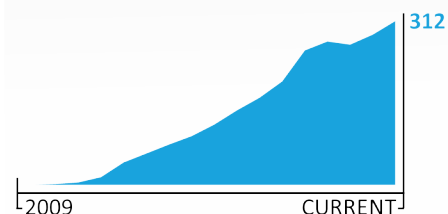
Report Highlights

- The efficacy of products added to the LED Lighting Facts database continues to rise, with products listed in the last quarter averaging 78 lm/W. Average efficacy has increased at a fairly consistent rate of 9.5 lm/W per year since the inception of the program.
- Of the A lamps currently listed by LED Lighting Facts, 95% meet the current ENERGY STAR efficacy criterion, and nearly 90% meet the new ENERGY STAR criterion set to take effect in September 2014.
- The overall numbers for efficacy are favorable, but there is still wide variation in efficacy for individual products. For example, lamps with lumen output equivalent to a 60 W incandescent lamp range from less than 60 lm/W to nearly 90 lm/W.
- Showing notable growth over the past two years, several LED A lamps are now available with lumen output equivalent to traditional 75 W and 100 W incandescent A lamps.
- Approximately 91% of currently listed LED A lamps have a CRI in the 80s, and most of those products have a nominal CCT of either 2700 K or 3000 K. It remains to be determined if this performance level will be acceptable to consumers, or if there will be significant demand for higher-CRI products.

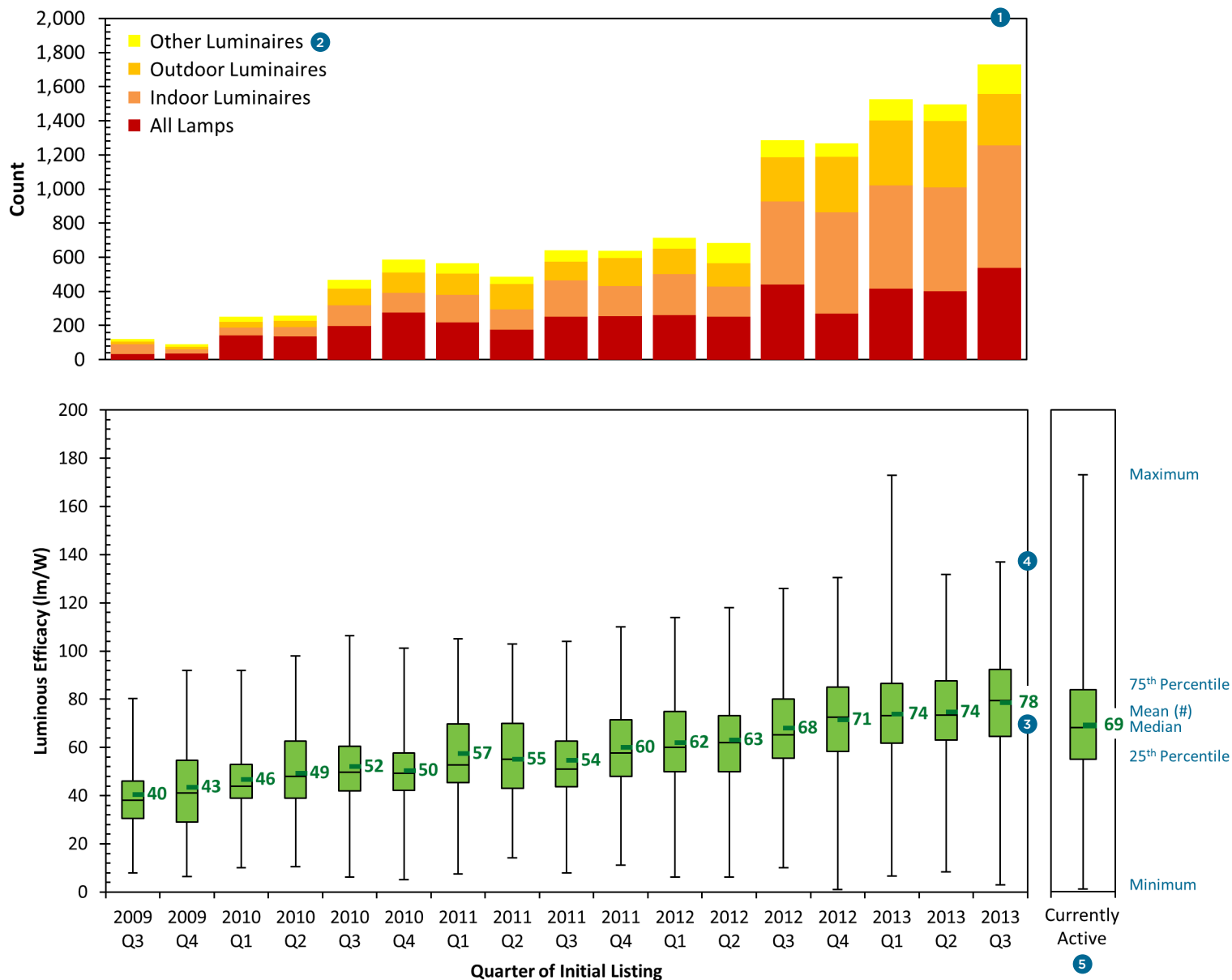
AT A GLANCE TOTAL NUMBER OF PRODUCTS LISTED BY LED LIGHTING FACTS



AT A GLANCE LISTED A LAMPS



All Products New Listings & Efficacy Performance by Quarter



1 The growth of the LED Lighting Facts database continues to accelerate, with more than 1,700 new products added in the third quarter of 2013 alone. Approximately 60% of the 9,680 currently active products were added to the list within the past year. It is expected that this growth will continue, and it is likely to accelerate further now that LED Lighting Facts' new family grouping policy has been implemented.

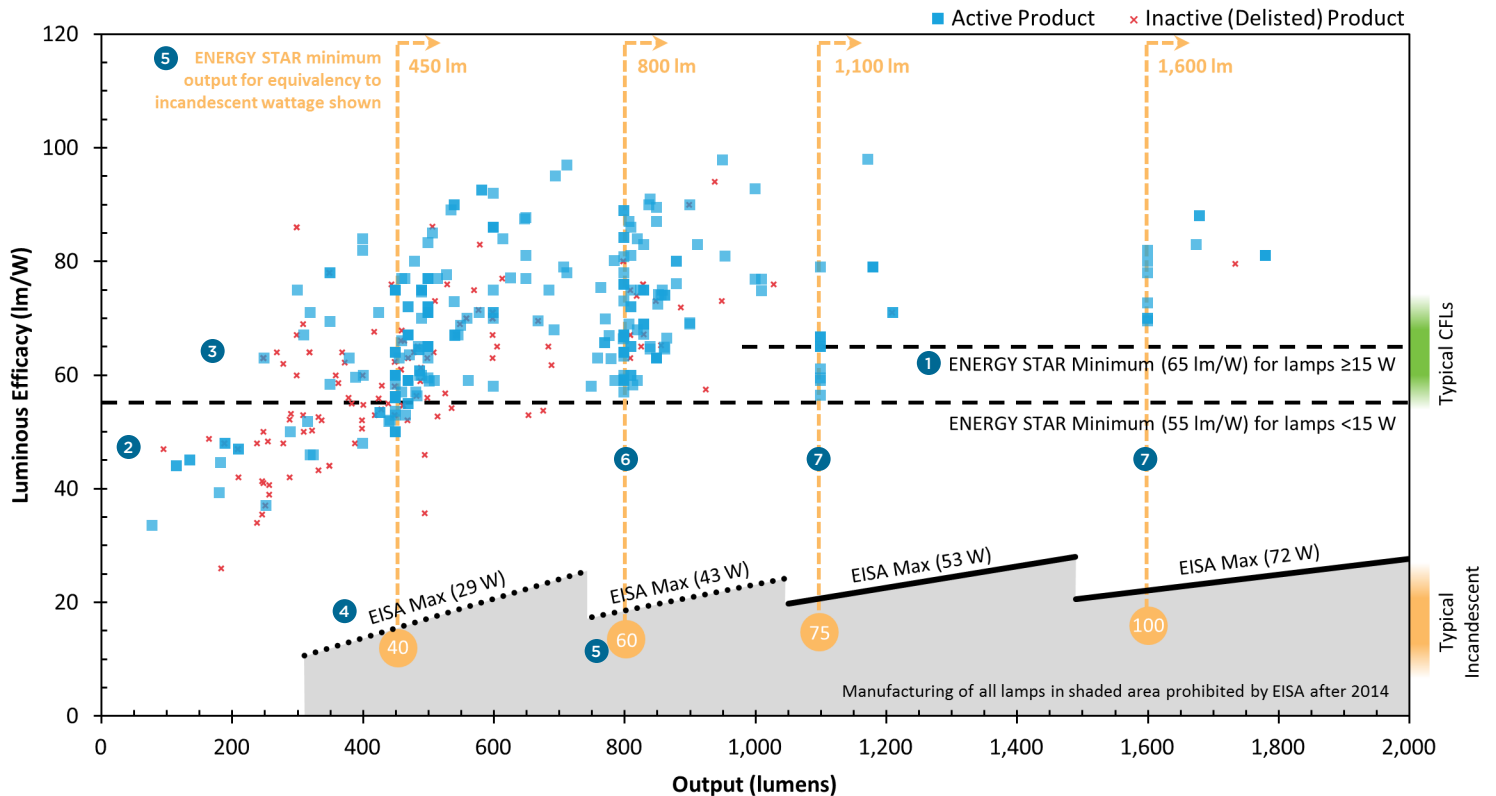
2 For products in the "Other Luminaire" category, the use location and/or luminaire type was unspecified.

2 The mean efficacy for products initially listed in the third quarter of 2013 (78 lm/W) is the highest to date. The efficacy of newly listed products has nearly doubled since the inception of the LED Lighting Facts program four years ago, with an average increase of 9.5 lm/W per year.

3 With the exception of one anomalous product listed in the first quarter of 2013, maximum efficacy has increased at a steady rate, comparable to the increases in mean efficacy. The minimum efficacy has not changed much, however, and is likely tied to specialty products.

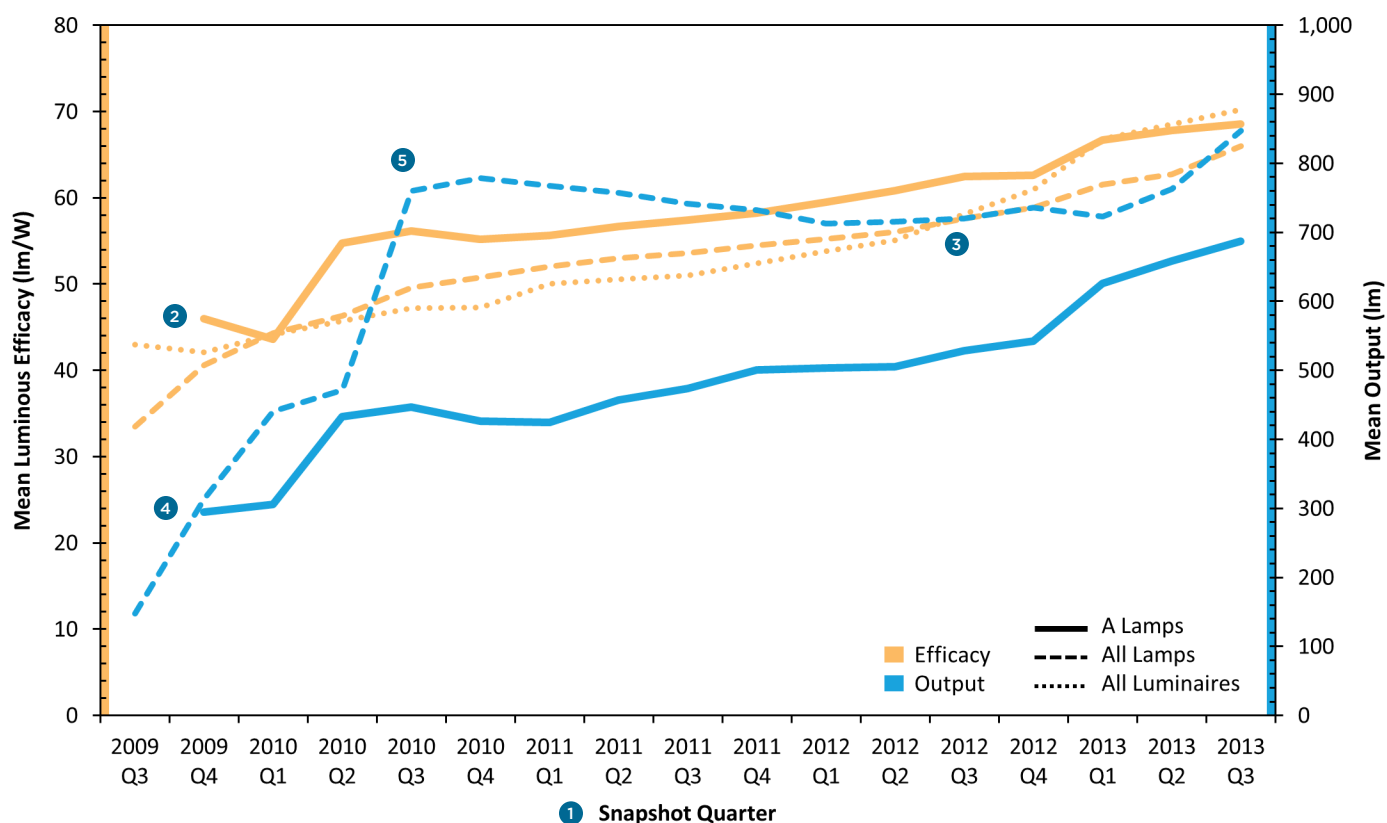
4 As would be expected given the age of some of the products that remain active in the database, the overall mean efficacy of currently active products (69 lm/W) remains slightly below the performance from recent quarters. However, it is higher than the mean efficacy for all products ever listed (66 lm/W), which indicates that lower efficacy products are being deactivated. It is also notable that the overall range in efficacy within the database remains extremely large, as does the middle 50% (55 lm/W to 84 lm/W).

A Lamps Efficacy & Output



- Effective September 30, 2014, the minimum efficacy requirements for ENERGY STAR qualification of A lamps will increase to 55 lm/W or 65 lm/W (depending on input power). These values were increased from 50 lm/W and 55 lm/W (with the input power bifurcation previously at 10 W instead of 15 W). **The new requirements are shown on this chart.**
- A majority of the A lamps under 55 lm/W that were ever in the LED Lighting Facts database have been deactivated (47 of 74, 64%). Of the 27 products that are less than 55 lm/W and currently active, only five were first listed in the past year, and all are less than 466 lumens.
- Of the 312 currently listed A lamps, 30 draw 15 W or more. Of those products, 87% meet the new ENERGY STAR efficacy requirement, and all 30 meet the old efficacy requirement. Similarly, 90% of the listed A lamps under 15 W meet the new ENERGY STAR criterion, and only 15 products (all under 10 W) would not qualify using the old criterion.
- The Energy Independence and Security Act of 2007 (EISA) established input power limits for four categories of lumen output for general service lamps, which correspond to common wattages of traditional incandescent lamps. The limits for the lumen output categories based on 100 W and 75 W incandescent lamps have already taken effect, whereas the limits for the 60 W and 40 W categories are set to take effect in 2014. By 2020, EISA will require that all general service lamps exceed 45 lm/W.
All of the LED A lamps listed by LED Lighting Facts easily meet the EISA criteria, as do typical general service CFLs. Six currently active products would not meet the 2020 criterion.
- The orange circles represent typical performance for basic incandescent lamps with the wattage shown. ENERGY STAR requires LED A lamps to emit a minimum number of lumens to claim equivalency to a specific wattage incandescent lamp: 450 lm (40 W), 800 lm (60 W), 1,100 lm (75 W), or 1,600 lm (100 W). As a result, LED A lamps tend to cluster around these lumen output values.
- A large number of lamps have lumen output equivalent to a 60 W incandescent A lamp (800 lumens), but the range in efficacy for those products is sizable. The lowest efficacy lamps in the 800-lumen category are about 57 lm/W, with the best approaching 90 lm/W. All of the LED products have a far higher efficacy than traditional incandescent A lamps. A similar situation exists in the 450-lumen category (40 W equivalent).
- Of the 312 currently active A lamps, 14 lamps have lumen output exceeding 1,600 lumens (100 W incandescent category), and 18 emit between 1,100 and 1,599 lumens (75 W category). The first lamps listed by LED Lighting Facts to meet these thresholds did not appear until the third quarter of 2012 and the second quarter of 2011, respectively. This is a notable recent achievement for LED A lamps.

A 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.

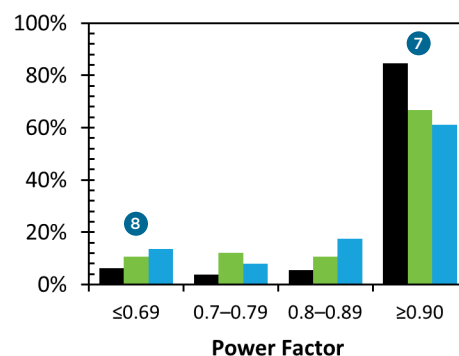
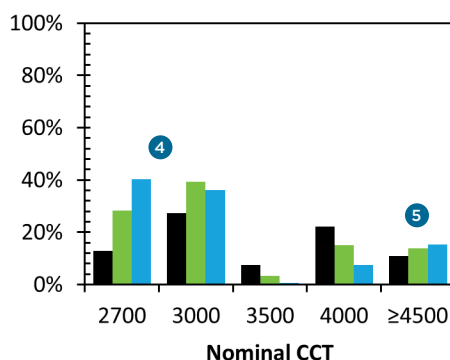
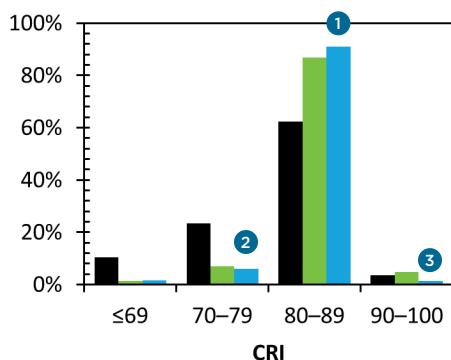
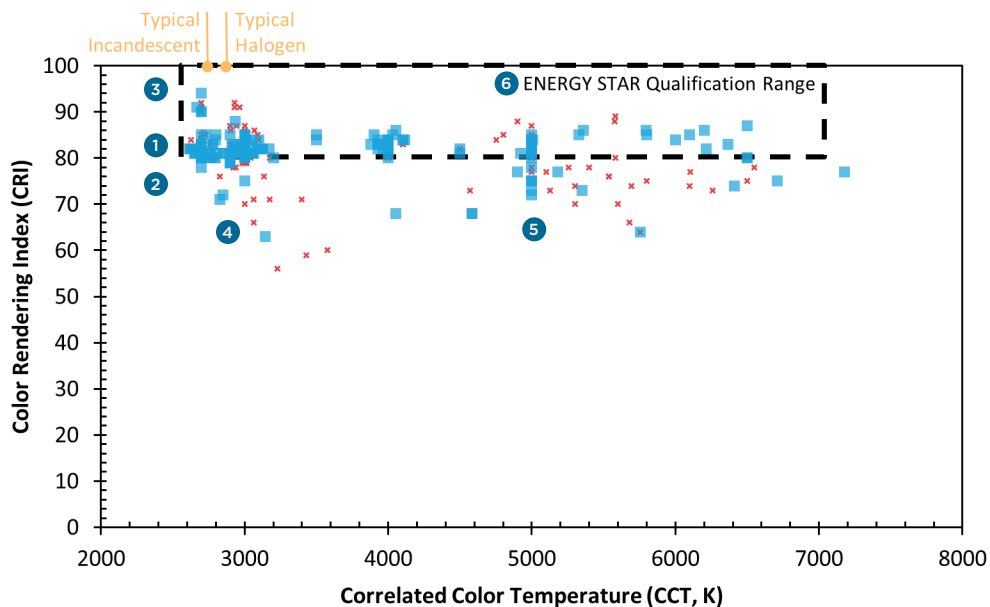
2 The mean efficacy of all A lamps listed by LED Lighting Facts has steadily increased, and is now at 69 lm/W. The rate of increase is similar to many other product categories, and to broader groups such as all lamps and all luminaires. Of course, mean efficacy is only one representation of performance over time, and the substantial variability in efficacy should not be overlooked.

3 In late 2012, the mean efficacy for luminaires listed by LED Lighting Facts exceeded the mean efficacy for lamps listed by LED lighting Facts for the first time since early in the program’s existence.

4 Increases in mean lumen output for A lamps listed by LED Lighting Facts have followed a similar trend to that seen for other categories, approximately doubling in the past four years. This trend will likely abate at some point, however, as LED lamps achieve lumen packages equivalent to all typical incandescent A lamps, requiring no further increases.

5 The mean lumen output for LED A lamps has always been less than for all of the listed LED lamps. In 2010, the mean output for lamps listed by LED Lighting Facts increased sharply, mostly due to the growing number of linear LED lamps (e.g., T8s), which require higher lumen output. The mean output of all LED lamps listed has remained relatively steady since 2010, dropping slowly before rising in the past six months. Given the target output for LED A lamps (most often 800 lumens), this result is unlikely to change in the future.

A Lamps Color Quality & Power Quality



1 A vast majority of A lamps listed by LED Lighting Facts (91%) have a CRI in the 80s, with a majority of those between 80 and 85. This matches the typical level for fluorescent lighting, and is just above the minimum threshold for ENERGY STAR qualification. The ratio of products in different CRI bins (e.g., 70-79 or 80-89, as shown above) for the currently active A lamps is similar to the ratio for all lamps, but somewhat different than the ratio for all products currently listed by LED Lighting Facts. This is likely due to the large number of LED streetlights, which generally have lower CRIs (and higher CCTs).

2 A small number of currently active A Lamps (8%) have a CRI less than 80. These products would not be appropriate for most interior applications. Two-thirds of these products have a CCT greater than 4000 K.

3 Only four A lamps currently listed by LED Lighting Facts (1%) have a CRI of 90 or higher, which would meet the recently adopted Voluntary California Quality LED Lamp Specification. It is expected that the number of LED lamps with a CRI of 90 or higher will rise in the future, but some efficacy must be sacrificed unless different types of LEDs (e.g., color-mixed) are used.

4 A vast majority of products have a nominal CCT of either 2700 K or 3000 K, with slightly more at 2700 K. These CCTs are the closest to halogen lamps, which often have CCTs around 2850 K.

5 Buyers should be aware that 22% of the A lamps currently listed by LED Lighting Facts have a nominal CCT of 4000 K or higher, which is noticeably different than incumbent A 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. Although some products currently listed by LED Lighting Facts fall outside this range, a large number of products with lower CRIs have been delisted.

7 A majority of A lamps currently listed by LED Lighting Facts have a power factor of 0.90 or greater. However, the percentage is noticeably lower than for all active products. LED luminaires with larger form factors provide more space for the components needed for power factor correction, and are typically sold into markets demanding high power quality performance.

8 Slightly more than 10% of the currently active A lamps have a power factor below the ENERGY STAR minimum of 0.70.

Discussion **How do LED A lamps stack up?**

Although A lamps comprise only 10% of the lamps currently listed by LED Lighting Facts—in contrast with over 60% that are directional lamps—they remain a key market segment, predominantly because they are the most consumer-oriented product type. The shelves at retail stores are filled with a wide variety of A lamps, and many people will get their first experience with LEDs through A lamps installed in their home.

Undoubtedly, the A lamp shape and luminous intensity distribution is not the best suited to the directional emission of LED packages. Many early LED A lamps were inadequate for many uses because they could not match the omnidirectional emission of traditional A lamps, around which a vast array of luminaires has developed (e.g., table lamps, sconces). Further, many early LED A lamps did not provide enough lumen output for many uses, and inflated equivalency claims were problematic.

Much has changed in the past several years, however. Although not an attribute captured by LED Lighting Facts' required metrics, many LED A lamp products now have an omnidirectional luminous intensity distribution. This has been aided in part by efficacy increases—as shown in the LED Lighting Facts data—which allow for reduced mass in thermal management systems, which in turn allow more flexibility in optical systems. LED Lighting Facts data also shows that lumen output has increased—with new availability of 75 W and 100 W incandescent lamp lumen-output equivalents. As a testament to the quality of products now available, nearly every A lamp currently listed by LED Lighting Facts meets current and future ENERGY STAR requirements—at least in terms of efficacy and lumen output—and those that don't tend to be low-output specialty lamps.

LED A lamps have not necessarily reached full maturity. There are still only a handful of products that can effectively replace 75 W and 100 W incandescent lamps, which already fall under EISA restrictions. More important, however, may be the question of color quality. A vast majority of currently available products have a CRI in the low 80s. This matches what is common with CFLs (although the actual appearance of colors will vary), but is different from what consumers are familiar with from incandescent lamps. Moreover, CFLs are often criticized for their color quality, which many adopters found unsatisfactory. Increasing the color quality of LED A lamps may be detrimental to the cost and efficacy of products, but it may also ensure consumer satisfaction. The Voluntary California Quality LED Lamp Specification,¹ and the expected availability of products meeting the specification in that state, should create opportunities for studying adoption rates of products with differing combinations of color quality, efficacy, and price.

¹ Available at <http://www.energy.ca.gov/2012publications/CEC-400-2012-016/CEC-400-2012-016-SF.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.

