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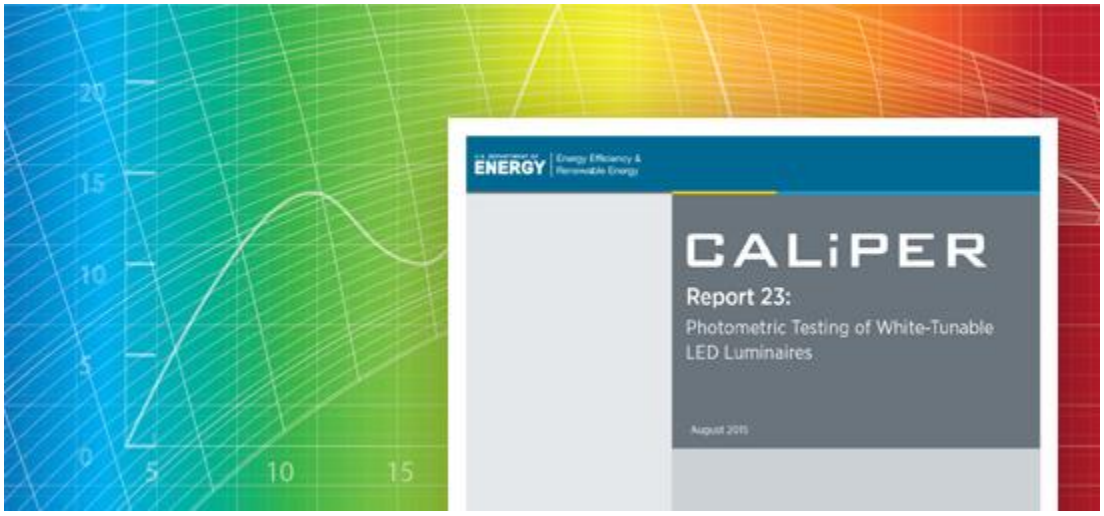
A Close Look at Color-Tunable LED Luminaires

The advent of SSL has already brought substantial change to the lighting industry, and one recent development that's especially intriguing is color-tunable luminaires—that is, luminaires that can change their spectral power distribution (SPD). Although versions of this product type have been around for years, LEDs make color-tunable luminaires much more practical, even though at present they remain a niche market segment. With potential benefits including improved health and well-being, increased productivity, enhanced mood or alertness, and higher occupant satisfaction, there's reason to believe that color-tunable luminaires will gain market share. But at this point it's important to understand the tradeoffs, limitations, and issues, so that the industry can work together to maximize the rate of product maturation. That's why DOE's CALiPER program has begun a series of investigations into this emerging product category. The first report in that series, *Report 23: Photometric Testing of White-Tunable LED Luminaires*, has just been released.



Traditional photometric testing procedures have already been disrupted by SSL technology, as new product capabilities and performance variables have required the development of new test methods. Measuring and reporting performance of color-tunable lamps and luminaires is the latest such challenge. With a variable SPD, color metrics and other performance attributes such as lumen output, power

draw, and efficacy extend across a range for any given luminaire, which makes reporting metric values more complicated than reporting the single values that characterize other products. A single photometric test following IES LM-79-08 procedures is no longer sufficient for characterizing color-tunable products — and in some cases, the range of possibilities is nearly limitless, complicating the development of new test procedures that won't place an unreasonable burden on manufacturers. To date, no standardized procedure for testing color-tunable products has been developed or proposed, but there are many ideas to consider — similar to the situation that existed prior to the adoption of IES LM-79-08, which standardized photometry of SSL products.

The main goal of the new CALiPER study was to understand the amount of testing required to characterize a white-tunable LED lighting product. In this case, determining a sufficient protocol required more extensive testing than would be feasible for widespread use. Eight white-tunable luminaires were tested at dozens of points covering the range of color tuning (CCT) and dimming (luminous intensity). The new report focuses on the full-intensity measurements, which were typically at 11 color set points covering a range of CCTs, and reveals substantial variation in input power, lumen output, efficacy, and D_{uv} over the color-tuning range for many of the products, which would not be captured with only a few test points. The results show that future test procedures will likely require at least five to seven measurement points to provide a reasonable characterization. The increase in testing burden on manufacturers could potentially be mitigated by specifying a relatively brief measurement stabilization process between readings at different settings, rather than requiring a lengthy warmup period between readings.

The secondary goal of the study was to investigate and document the performance of available color-tunable luminaires that are intended for architectural lighting rather than entertainment lighting — specifically, troffers and downlights. The data demonstrate a variety of approaches used to achieve variable CCTs. A key distinction is linear (produced by two color channels) versus nonlinear (produced by three or more color channels) white tuning. Linear-tuning products can't track the blackbody locus (i.e., they can't maintain a constant D_{uv} as CCT is adjusted), whereas the nonlinear-tuning products studied were effective at following the blackbody locus. The importance of this distinction with regard to subjective impression requires further investigation.

A second key distinction is how each luminaire manufacturer chose to treat lumen output, power draw, and efficacy over the dimming range. In some cases, one of the parameters was held constant while the others varied considerably, whereas in other cases, all three parameters were reasonably consistent. The balance of the products exhibited substantial variation across all three parameters. The different approaches are important to consider, not only because they affect subjective impressions, but also for practical reasons during specification or energy efficiency program qualification.

In most cases, color-tunable LED luminaires are currently not competitive with fixed-color products of the same type, if efficacy is the prime criterion. However, color-tunable products may offer non-energy benefits, such as the ability to shift spectrum to support human circadian cycles, affect mood and alertness, or provide a visually dynamic environment. For the downlight products in the study, the efficacy was substantially below the ENERGY STAR® qualification threshold, but in appropriate applications where aesthetics, wellness, or occupant satisfaction is very important, color-tunable luminaires are capable replacements offering features not practically available with any other lighting technology.

There are also others in the industry who study the issue of color-tuning luminaires, including a working group of the Illuminating Engineering Society LM-79 committee, and the new CALiPER report will help them in their efforts. But the report also raises a number of questions about existing test methodology and its application to this category of products — questions that will require further discussion and consideration in the near future. DOE has devoted a new section of its SSL website to this important topic, and is in the process of preparing additional guidance — including separate sets of forthcoming guidelines on specifying and controlling LED color-tunable products — as well as further reports in the CALiPER 23 series. So stay “tuned.”

As always, if you have questions or comments, you can reach us at postings@akoyaonline.com.