IES TM-30 Offers Comprehensive System for Evaluating Color Rendition of Light Sources

DOE technical support and leadership assist industry efforts to develop new color-rendering methods and metrics.

The two different light sources in these photos have the same CRI.
Photo credit: Pacific Northwest National Laboratory.

While the International Commission on Illumination's (CIE) General Color Rendering Index R_a (CRI) has long enjoyed widespread use, its limitations are well recognized. Despite many past efforts to develop complementary or alternative ways to evaluate color rendition, none has been widely adopted. Yet with the proliferation of solid-state lighting (SSL)—which offers tremendous scope for spectral engineering and optimization—the need for such a method is greater than ever before.

The U.S. Department of Energy (DOE) provides technical support to numerous standards-setting organizations, and played a key role in the development of the Illuminating Engineering Society's (IES) technical memorandum TM-30-15 ("Method for Evaluating Light Source Color Rendition"). TM-30 was developed by an IES task group chaired by a member of DOE's SSL team.

What TM-30 Brings

Built on the progress made by many other researchers over the past two decades, and synthesizing many of their concepts, TM-30 describes a new method for evaluating light-source color rendition. That method encompasses several individual measures and graphics that complement one another and, together, provide a comprehensive characterization of how the light will affect the color appearance of objects.

The scope of TM-30 is greater than in other previously proposed metrics or methods. It goes beyond average color fidelity and average gamut area measures and thus can improve the correlation between quantifications and human judgments. In contrast, CRI is purely a method for evaluating color fidelity, which is not always correlated with the color rendering that people prefer.

TM-30 includes multiple measures and graphical representations. It relies on improved color science and a more comprehensive set of color samples. Unlike CRI, whose eight color samples are pastel, TM-30 uses 99 color samples that come in all levels of hue, saturation, and lightness. They were chosen to cover the range of typical materials, and include textiles, printed materials, natural objects, skin tones, and more. The three highest-level components of TM-30 are the Fidelity Index (R_f), the Gamut Index (R_g), and the Color Vector Graphic. Numerous sub-indices can provide more-detailed information about such things as the color fidelity of specific hues, the chroma shift of specific hues, and the fidelity of skin tones. The variety of measures can be used together to find the best source for a given context; TM-30 does not include a universal measure for preference.

MARKET IMPACTS
of IES TM-30-15

Leading LED manufacturers are already incorporating TM-30 calculations into their design process, and researchers are using it to inform new areas of investigation:

- Xicato began publishing TM-30 results for its entire product range of XTM and XIM modules within a month of TM-30's publication.
- Soraa publicly announced its support for TM-30 and posted related educational information on its website.
- In July 2016, Lumileds came out with its LUXEON Stylist Series of LEDs, which emphasizes chip-on-board LED color performance and incorporates TM-30 calculations into the design process.
- An article in *The Journal of Materials Chemistry C* cited TM-30 as a useful tool in the development of new red phosphors.

These new color metrics [of TM-30] and LER criteria provide guidelines with which many material and chemistry researchers can develop new red phosphors by optimizing the crystal structure, crystal rigidity, local symmetry, the number of available sites for activators, the selection of the host and activator, and other factors.

"Evaluation of new color metrics: guidelines for developing narrow-band red phosphors for WLEDs," *Journal of Materials Chemistry C*, June 28, 2016

Building Awareness

Since the publication of TM-30, DOE has focused on facilitating its use by clarifying the complex technical issues involved. TM-30 provides much more detailed information than CRI, but it is also quite a bit more complex, which is why DOE has been working with IES to educate industry about TM-30 so that manufacturers, specifiers, and others understand and know how to use it. Webinars and presentations at major lighting conferences are augmented by online resources, including fact sheets and extensive FAQs.

Market Impact

TM-30 is not a required standard, but it's already gaining significant adherence. Manufacturers such as Xicato, Soraa, and Lumileds have begun incorporating TM-30 measures into their design processes and are publishing TM-30 data for their product offerings. Even if TM-30 data are not available for a given product, they can be calculated from a spectral power distribution. Researchers are using TM-30 to inform new areas of investigation.

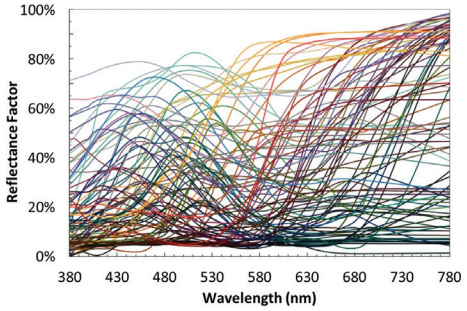
The new system will bring significant progress in quantifying color rendition. The more comprehensive characterization, as well as the improved accuracy underlying the computations, will not only help purchasers and specifiers select products that are more appropriate for their needs, but will also help in designing future light sources that more properly optimize the complex tradeoffs and interactions between efficacy, chromaticity, and color rendition. This, in turn, should lead to greater value per watt of radiation, greater acceptance of energy-saving measures, and, ultimately, improved human wellbeing. But it will require significant effort to achieve widespread adoption. ■

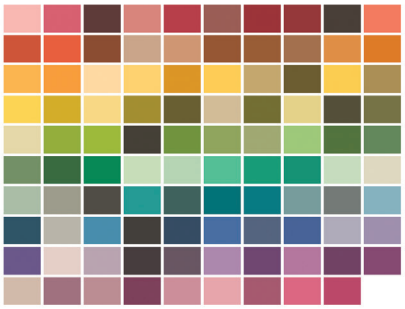
Metrics and Test Methods

To accelerate the development and implementation of needed metric and test methods for SSL products, DOE works closely with a network of standards-setting organizations, providing technical assistance, analysis, and support. Such support has been instrumental in the development of many standards that set the foundation for SSL product development and adoption, including:

- **IES LM-79-2008**, "Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products"
- **IES LM-80-2015**, "Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules"
- **IES TM-21-2011,** "Projecting Long Term Lumen Maintenance of LED Light Sources"
- **IES TM-30-2015**, "IES Method for Evaluating Light Source Color Rendition"
- **IEEE 1789-2015**, "IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers"
- **ANSI C78.377-2015**, "American National Standard for Electric Lamps—Specifications for the Chromaticity of Solid-State Lighting (SSL) Products"

In most cases, these standards reflect years of technical support and committee meetings to forge industry consensus.





At the core of TM-30-15 is a set of 99 color samples used to characterize the difference between the test source and reference illuminant. In the calculation procedure, the samples are represented by their reflectance function (left), which is the percent of radiant flux reflected at each wavelength. The color swatches on the right illustrate the approximate appearance of the samples under the 5000 K reference illuminant.

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

For more information, visit: energy.gov/eere/solid-state-lighting

DOE/EE-1480 • October 2016