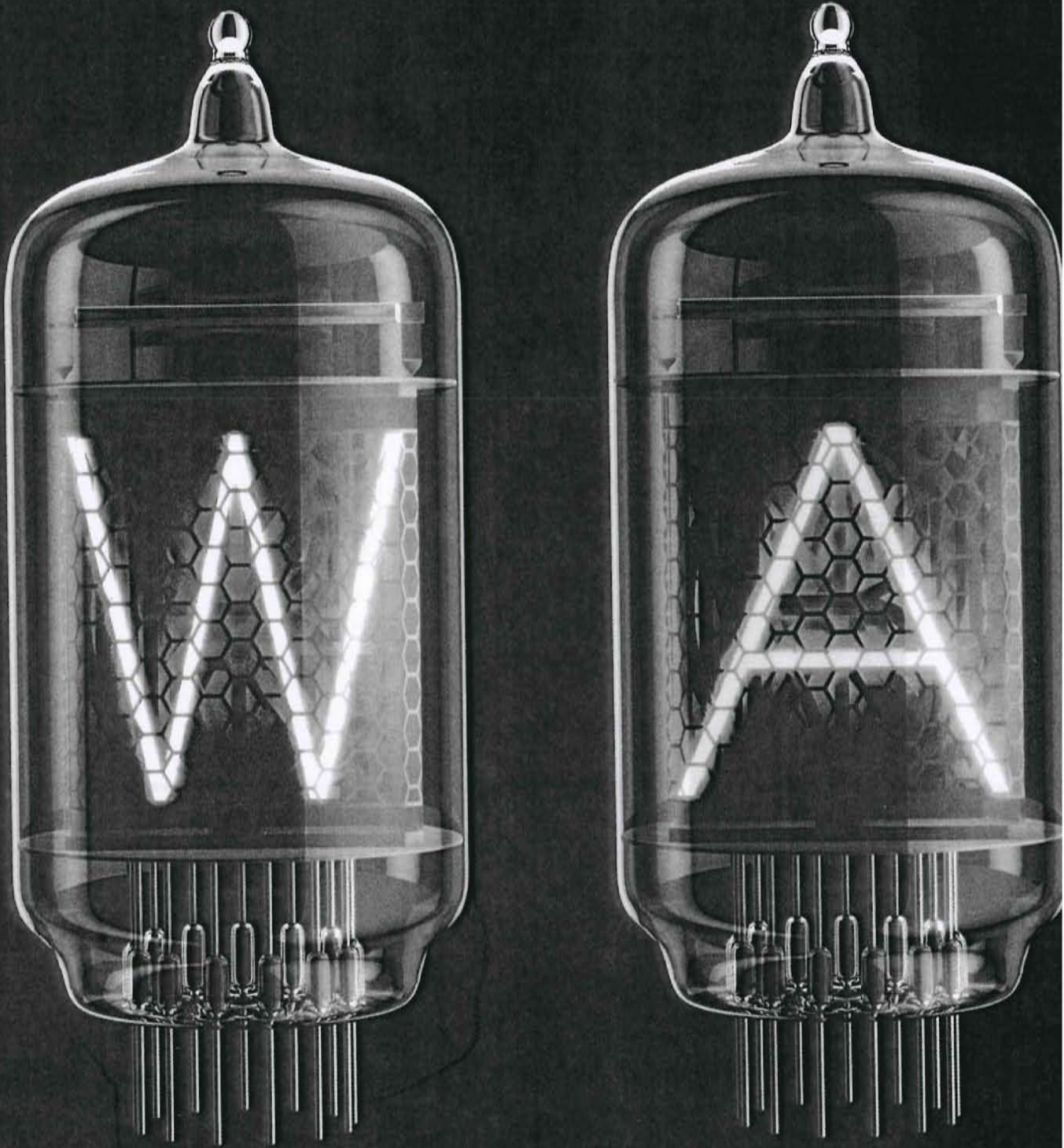


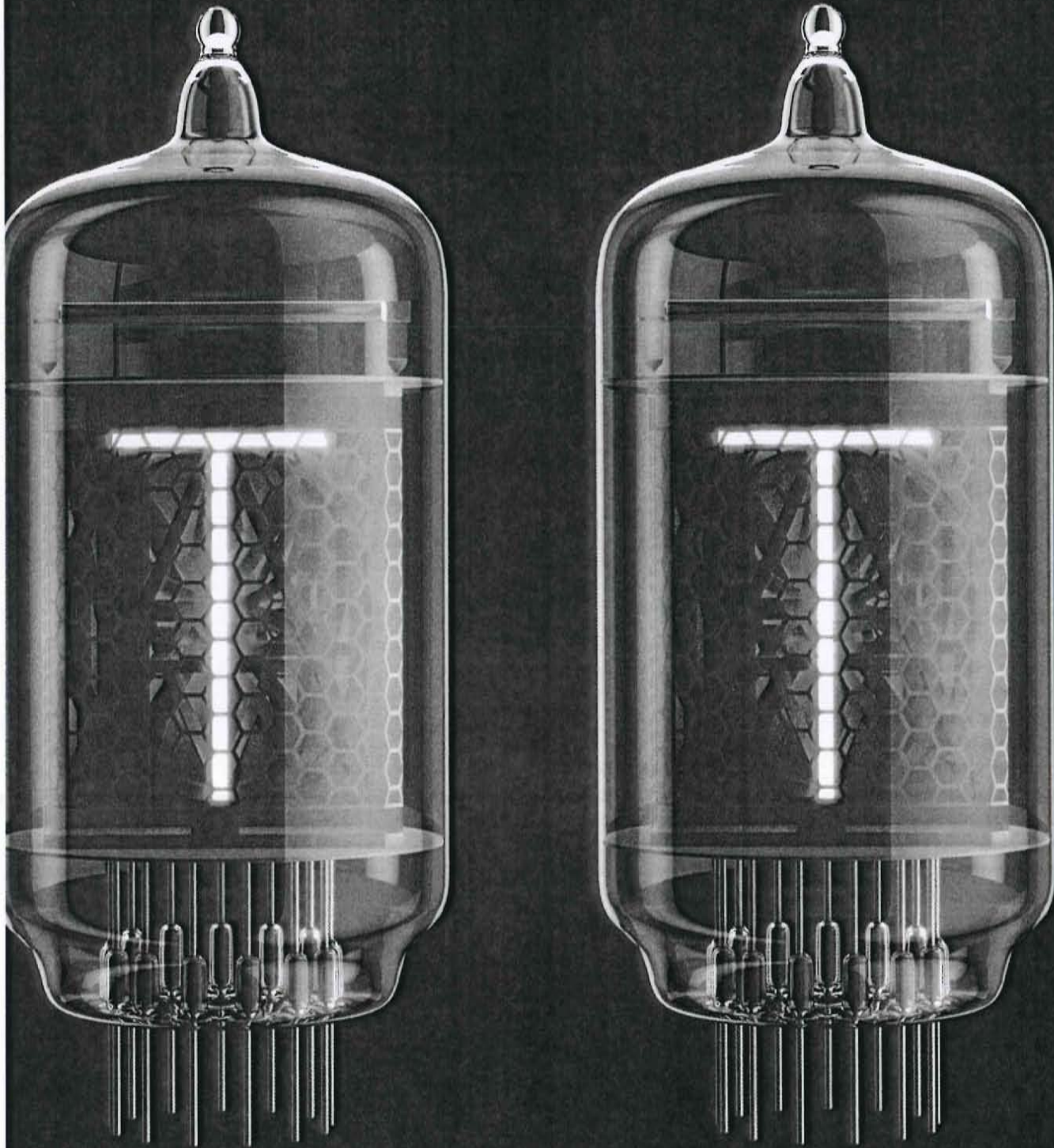
THE IRRELEVANT BUT PERSISTENT...



(AND OTHER ARCHAIC TERMINOLOGY)

By Kevin Willmorth, contributing writer

...in technology terms founded on prior evolutionary steps will fail adequately describe the next. The first hurdle to understanding is dissemination of meaningful information to a population unfamiliar with the technology. Similar to describing color to a blind person, defining a new technology using conventional terms often produces limited effectiveness and erroneous assumptive connections. The greater the change, the more difficult the issue becomes.



The explosion of solid-state lighting has challenged many previously assumed quantitative and qualitative definitions in use. From laws in the Color Rendering Index to procedures used to test luminaires, the disruption of LEDs has an impact on every aspect of the industry's core discourse. Further, new discussion surrounding color consistency, product life rating and optical performance demands introduction of new terms and revisiting familiar paradigms.

Regardless of the success LEDs in the application of general illumination, the impact of the technology on lighting discussion is profound. The amount of new information entering the market has not been this significant in a century. However, there has been a disturbing redirection of attention toward the hardware and product metrics of lighting.

In an effort to deploy solid-state technology at an accelerated pace, communications have focused on promoting hardware superiority. Compounding this is the entry of new product providers with no lighting knowledge, as well as governmental agencies assuming active promotion and regulatory roles.

The inevitable result is likely to be a persistence of conventional single numeric terminology, which, unfortunately, falls short of accurately describing terms of value to applied lighting performance.

The Irrelevant But Persistent Watt

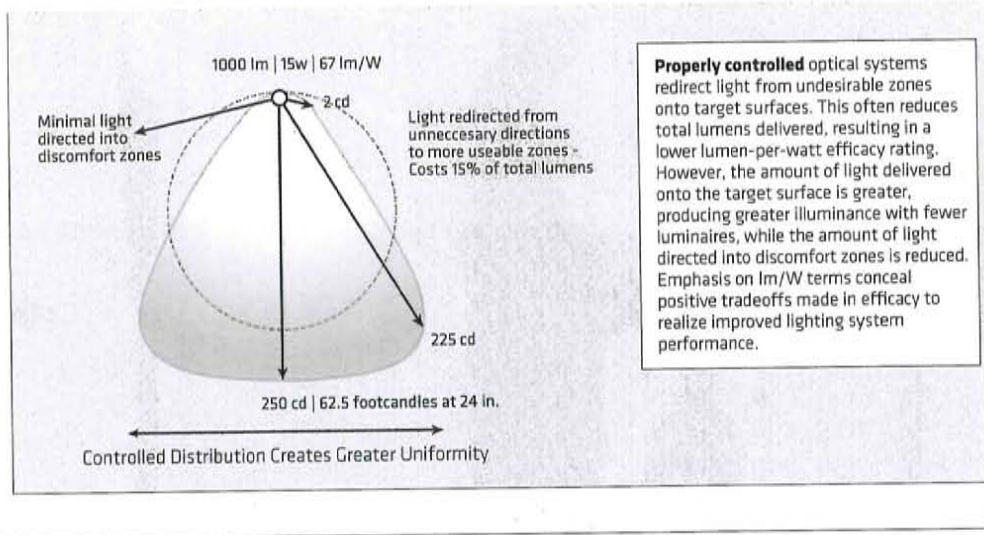
When all light sources were incandescent, with virtually identical conversion efficiency and general form factor—use of watts to differentiate product performance was relevant. Based on the assumption that all sources being compared delivered a similar amount of light for each watt consumed, a 60-watt lamp, could be assumed to provide half the light output of a 120-watt lamp, while a 100-watt lamp could be assumed to rest between the two, and a 150-watt lamp was above them all. Watts simply served the dual purpose of describing relative light and load placed on an electrical system.

The use of watts as a light source description, however, proved inadequate almost as soon as it was adopted. In other words, the rapid emergence of higher- and higher-efficiency light sources challenges the relationship with light delivery.

In solid-state lighting, the connection between watts consumed and light output varies widely, and the relationship is fundamentally irrelevant. Yet, a large portion of LED product literature in the market today insists on presenting watt information in context of light performance, either within a specific product line or between old and new technologies.

FIGURE 1.

Controlled Distribution—Creating Greater Uniformity



Shedding Light on the Lumen

Not only is the watt improperly invoked, but so is the lumen. The latter has served as a generalized term for describing the gross light output of a light source for decades. While a more direct description of light output than the watt, the term still produces a vague description of light potential. By definition, a light source that delivers one candela per steradian in all directions delivers 12.57 lumens. The term, however, delivers no directional information whatsoever. Because of this, the further a light source strays from being a spherical emitter, the less relevant lumens are in communicating useful light generated.

For example, an omni-directional light source producing a uniform 100 candela per steradian in all directions will be rated at 1257 lumens. Meanwhile, an LED device having a total distribution of 130 degrees, delivering the same 1257 lumens delivers roughly 277 candelas per steradian, or 2.7 times the light of the omni-directional source within the light pattern. Yet, the lumen description for each product would be identical.

MEASUREMENT LANGUAGE STILL NEEDS WORK

In an effort to create a familiar comparative description of light source conversion efficiency, or efficacy, the descriptive term lumens-per-watt is used. However, because lumens are an averaged spherical value, while LEDs are decidedly directional in character, the result is a description of a light source that does not actually exist. The term also provides no information related to optical effectiveness to deliver a usable lighting result. The DOE/Energy Star FTE calculation is a much better measure.

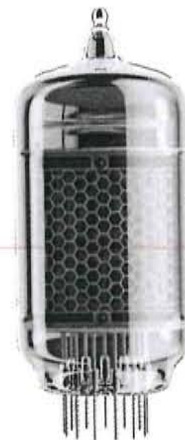
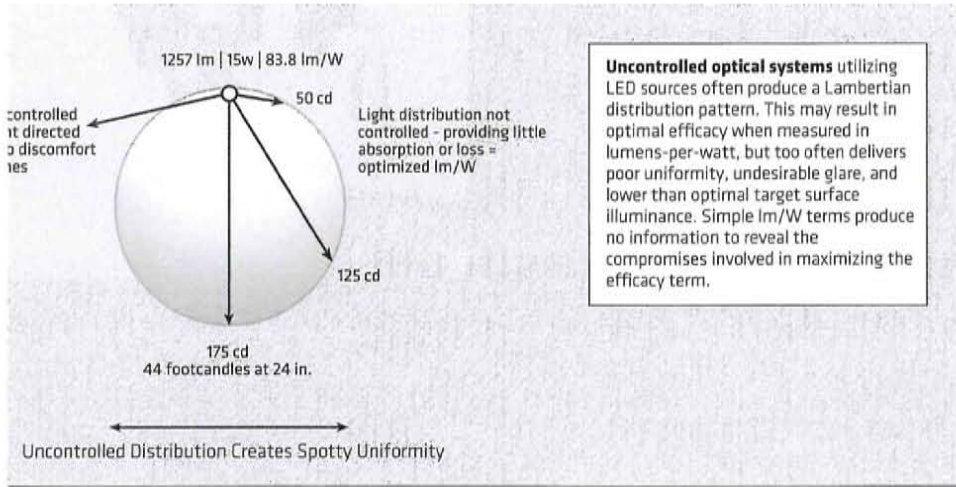


FIGURE 2.

Uncontrolled Optical System—Creating Spotty Uniformity



THE USE OF WATTS AS A LIGHT SOURCE DESCRIPTION PROVED INADEQUATE ALMOST AS SOON AS IT WAS ADOPTED. THE RAPID EMERGENCE OF HIGHER AND HIGHER EFFICIENCY LIGHT SOURCES CHALLENGES THE RELATIONSHIP WITH LIGHT DELIVERY.

In addition to the values applied to describe source output, the manipulation of light within a luminaire system can either impart a diffusing or directing of source light to create an altogether different distribution with greater or less candela intensity than the base source itself. Yet, solid-state product literature of all types maintains the use of lumens as the core value in describing light output. This erases a key differentiation the technology has against conventional omni-directional light sources, while producing a value of limited utility for customer evaluation.

Lumens + Watts = Chicken?

In an effort to create a familiar comparative description of light source conversion efficiency, or efficacy, the joining of two measures into a descriptive term called lumens-per-watt is used. Since lumens are an averaged spherical value, while LEDs are decidedly directional in character, the result is a description of a light source that does not actually exist.

Shaping light emitted from a source imparts some amount of loss, either from refractive inefficiencies, reflective loss, diffused absorption, or

internal re-reflection. Even if the composite result produces a significant improvement in applied light performance, there will be some lumen loss overall. Because of this, products that deliver the least amount of optical control will present the greatest lumens per watt efficacy number. For example; a theoretical spherical light source suspended in space will produce nearly 100% efficiency, as there are no obstructions to its output. If this spherical source produces 1257 lumens, it will also deliver 100 center beam candela. Comparatively, a directional source with an 85% efficient optic, directing 90% of its light equally over a 10 degree beam pattern, will produce only 1068 lumens, and roughly 2754 center beam candela. Further, the spherical light source will produce the same 100 candela at all angles, useful or not, including presenting significant visual glare. This means the source with the lower efficacy will produce greater target illuminance, less glare and lower surrounding unwanted brightness for the same input power. Yet, when judged by its lumens per watt efficacy, it is the poorer performer.

Just as the term lumens erases directionality from a light source characterization, lumens-per-watt provides no information related to optical effectiveness to deliver a useable lighting result. Further, the widespread adoption of this term to describe product efficiency provides opportunity for marketers of solid-state product to deliver products with minimal optical control, with minimal attention to lighting quality, to attain the coveted high lumens per watt efficacy result. Further, focus on this simplified, application typhlotic term produces full emphasis on product performance in isolation from application of light to deliver optimal human visual performance.

In recognition of this, EPA's Energy Star Program Requirements couple lumens per watt efficacy for luminaires and sources with zonal density requirements. This prescriptive approach recognizes the failure of lumens per watt to deliver application-relevant information.

Further, DOE's Fitted Targeted Efficacy (FTE) calculation takes this a step further in evaluating outdoor luminaire performance in application, by evaluating the efficiency of the optical system to deliver light into the targeted field. Both of these approaches are superior

to the isolated lumen per watt values with no applied performance consideration.

Candles, Power and Candela

From the earliest use of the term candle to describe light output, to lumens today, the struggle to define light delivery has been ongoing. Candela, now used to describe the measured directional intensity, is a more scientific derivative of the term candlepower, which first attempted to create familiar comparison of intensity to pre-electric light sources.

Current application of the term center beam candela (CBCP) appears on the surface to present a description of the energy within a light pattern. Yet, upon close examination, this value only represents the amount of energy at one distribution angle, at the very center of the beam pattern. There is no evidence of how quickly this energy level falls off to the half maximum value to either side; how uniform the beam pattern is; or how much light is wasted in the field area surrounding the pattern. SSL products that employ tightly focused optical systems may create the same beam pattern as a comparable halogen source, yet exhibit such sharp pattern cutoff, or overly intense center beam energy, that the resemblance of the SSL product to a comparable conventional source is minimal.

Energy Star requires the calculation of Center Beam Intensity for PAR and MR16 lamps. Based on a statistic sampling of 432 PAR and 122 MR16 lamps, mathematically deriving calculated data provides guidance for solid-state replacement lamps. Unfortunately, nothing in this approach indicates beam shaping or uniformity, which allows products with center hot spots, or poor distribution appearance to pass, while those with superior optical performance that fail to produce the target center beam intensity by a small margin will fail.

The Underlying Failure of Assumptions

Conventional and familiar terms and descriptions carry certain assumptions founded on original use. While these descriptions might provide a level of comfort, their use must be tempered with the need to associate the new technology with its differentiation. The assumption that all

systems can be compared uniformly, across all technologies, using simple standardized terms, requires redefining older products within freshly developed new descriptions as much as applying remaining legacy descriptors to the emerging product. In order to separate inaccurate assumptions to enable new understanding, there is a need to establish new terminology to defy and break down nonproductive assumption.

A significant example of this is the need to redeploy the color accuracy rating system. CRI is in need of update, whether to CQS or another standard, in order to provide a new look at color performance of all lighting products. This may also be a good time to revisit the use of a color rating system that relates only to the specific CCT of a product being evaluated, and deploy one that is CCT agnostic. Rather than attempt to maintain similarities with the older standard, with its associated assumptions, a new descriptor provides an opportunity to reprogram market assumptions to reflect current understanding.

Time for New Descriptive Terminology

In the effort to bring the innovation of LEDs and SSL into general illumination, a great deal of work is needed to redefine lighting terminology as a whole. The first step should be to eliminate the lack of information provided by the current overly simplistic terminology. The second step will be to apply a disciplined approach in putting the new terms to work, and communicating their meaning to lighting decision makers at all levels.

Just as color performance values include calculation processes to return a singular numeric color accuracy description, so can other descriptive values. The goal should be to eliminate non-sequitur comparisons between products with very different distribution characteristics. For example, the term "Distribution Integrity" might be defined by computing the ratio of light within the beam angle and its surrounding field angle, compounded by the uniformity within the beam pattern in relation to the CBCP.

The DOE/Energy Star FTE calculation approach to optical efficacy, in the context of application, should be expanded to include all directional lamp and luminaire types. This



approach illustrates the effectiveness of a product's optical system in the context of its intended use, adding a great deal of valuable information to the discussion and evaluation process. As a determinant of applied performance, this approach adds to the older coefficient of utilization descriptions already available and in need of refreshing.

SSL has presented a significant enough development in technology, to require terms founded on prior evolutionary steps to be reassessed, if not completely dismantled and rebuilt. To enable real understanding and dissemination of meaningful information to a population not fully familiar with the technology, the redress of language use is unavoidable. More importantly, the time has come to repair many of the failures of current terms and descriptions, even when applied to conventional sources, in order to enable more accurate evaluation of the incoming technologies in appropriate context. There is also a need to re-direct the language from simplistic product-centric descriptors, to an applied human-factors focus.

In the end, all conversations of energy and product performance aside, it is how lighting enables effective human vision and comfort that are the most critical factors of all. ■

PROGRESS IN ACTION

(Above) EPA Administrator Lisa Jackson recently toured the facilities of the Lighting Science Group, which celebrated the production of its millionth LED "bulb" in the first quarter of this year alone. EPA's Energy Star zonal density requirements should help create better descriptive values for lighting. Image: Lighting Science Group