Is White Light a White Knight?

By John D. Bullough

Although the majority of outdoor and roadway lighting in North America currently uses high pressure sodium (HPS) lamps with their characteristic "yellowish" light output, the past two decades have witnessed a growth in the proportion of metal halide (MH) lamps, producing "white" light, used outdoors. There's no doubt that HPS and MH are presently the two top contenders for the outdoor throne. Nonetheless, other light source choices are available for outdoor lighting, in particular, fluorescent lamps[1] and more recently, light emitting diodes (LEDs).[2] Interestingly, however, these other options seem to be mainly amplifying the chorus touting white light as the "white knight" of outdoor lighting.

There are a number of reasons for the recent increase in popularity of white light, not the least of which is the fact that lamps such as MH have lately received the lion's share of the outdoor lighting "press" in our industry's trade literature.[3] Indeed, some would suggest that standards and regulations should be changed to favor white light in outdoor applications. In this column, we'll explore some of the technical arguments that have been put forth regarding white light, and discuss whether these arguments might warrant a change in the way we light our exterior environments.

ENTERING THE MAINSTREAM?

By now, most readers of LD+A are familiar with the idea that at low, so-called mesopic light levels, the ability to detect things using peripheral vision is not predicted very well by the readings from our light meters. The idea that a white light source could result in improved peripheral vision over a yellowish one, even if the light meter says they're equivalent, seemed a bit "out there" a decade ago. But after the publication of dozens of laboratory and field studies consistently verifying these effects,[4] the idea now seems almost mainstream. The IESNA has a committee, on which I am privileged to serve, that is deliberating on a technical report that would, if it is approved, document this evidence formally for consideration by application committees and interested lighting practitioners.

Building upon the growing, and global, body of research results that have been issued, my colleagues at the Lighting Research Center (LRC) and I have developed a system of photometry to quantify light levels under different spectra (colors) at low light levels.[5] This system could serve as a bridge to link the two current systems of photometry, which now consist of quantities either based loosely on vision using the cone photoreceptors (photopic vision), or based upon vision using the rod photoreceptors (scotopic vision). All of our light quantities like lumens, candelas, or lux can be defined in terms of one of these two systems.[6] Photopic quantities are mainly applicable at high, daytime and indoor light levels. Scotopic quantities, which are hardly if ever used outside of the vision science community, are applicable to light levels that are very low.

MESOPIC PHOTOMETRY: UNITER OR DIVIDER?

At some light levels found in a few IESNA recommendations,[6] both the rods and cones contribute to vision, but there is no formal definition of light under these mesopic conditions. What we did was to provide a framework to unify photopic and scotopic photometry across the mesopic region, based on the observation that the peripheral visual system's functioning could be predicted reasonably well by a linear combination of photopic and scotopic spectral sensitivity.[5]

White light sources such as MH, as well as fluorescent and LED sources, tend to have relatively greater rod-stimulating output for the same (photopic) light level than yellower sources such as HPS. This effect can be quantified in terms of a lamp spectrum's scotopic/photopic (S/P) ratio.[7] Since whiter sources are often those with higher S/P ratios, does this mean that the system of unified photometry[5] could be used as a basis for recommending outdoor light levels? Could we light roads and parking lots to lower (photopic) light levels, thereby reducing light pollution and energy use, while at the same time maintaining or even improving visibility? There is certainly a great deal of controversy and debate surrounding these questions. But in some cases, the answer might well be "yes."

For example, my LRC colleagues recently undertook a study that involved switching the conventional HPS lighting on a residential street in a New England town to white light using fluorescent lamps.[1] The resulting (photopic) light levels were reduced but the unified luminances remained the same. The electrical energy use was reduced by roughly 30 percent. Reactions by the residents on this street were positive regarding their ability to see along the roadway, despite the unique appearance of fluorescent luminaires on their street, something that's not an everyday sight in most neighborhoods!

Now, not every roadway or outdoor lighting installation would necessarily benefit from a switch to white light based on unified photometry. The residential street studied by my colleagues[1] is one where the driving task is probably conducted at relatively low speeds. Visibility for driving in this situation might be adequately provided by vehicle headlamps, and the street lighting in this case might serve more to illuminate areas adjacent to, but not directly on, the roadway. Such areas might contain neighbors walking during the evening, and certainly these individuals would benefit from improved peripheral visibility of drivers predicted by lighting quantities based on unified photometry.

Again, I am not arguing that using white light based on unified photometry is the answer to all outdoor lighting questions. There are likely many situations, especially when on-axis visibility is of utmost importance, where HPS lighting would, and should, remain a viable choice for outdoor and

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roadway lighting. One example is a highway rest area that was evaluated by the LRC through the Demonstration and Evaluation of Lighting Technologies and Applications (DELTA) program.[8] This outdoor installation used HPS in an attractive, comfortable and energy-efficient manner, with resulting good visibility and low glare. I don't think anyone would argue that the use of HPS in that installation was anything but a success.

What the promising results from my coworkers[1] show us, for some applications, is that even with reductions in light level and energy use, the use of white light could lead to lighting that is perceived as just as good, or even better, than conventional lighting (and at the same time, could help to reduce light pollution).

A RESPONSIBILITY TO TRY?

The IESNA and the lighting community as a whole should not be paralyzed by the ongoing healthy debate about if and how unified photometry, or a concept like it, could be implemented into practice. Indeed, a consortium of researchers and national laboratories in Europe has undertaken research to develop a mesopic photometry system that is identical in framework to the one developed by my colleagues and me, and with only minor differences in the actual numbers used.[9] I see that international effort as an opportunity to show that the LRC's basic approach to unifying photopic and scotopic photometry can be validated and eventually embraced by a diverse lighting community.

Some lighting specifiers have taken these ideas to heart and begun implementing them in their designs for outdoor lighting. Will every example be a resounding success? I don't think anyone expects so. But such examples can show when using white light sources based on a unified system of photometry might serve as a reasonable approach to outdoor lighting design, and just as importantly, when it might not. After all, why change lighting practice unless there are practical and tangible benefits to doing so? Specifiers who have tried approaches such as these should be encouraged to evaluate, and document, their designs.

However, as someone who has been lucky enough to participate in some of the research in this area, I really do think that the lighting community is on to something with this trend toward white light. No, it's not a panacea, and yes, we have a lot of work to do before we will understand enough to know exactly when and where to use it. But there already is mounting evidence that white light sources in some outdoor applications, such as residential streets, could yield tangible benefits. If this evidence isn't incorporated in some way into lighting practice, won't that be a lost opportunity for our profession?

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