Low pressure sodium (LPS) lamps seem to have fallen from favor with specifiers. According to figures from the U.S. Department of Commerce, LPS lamp shipments totaled only three percent that of high-intensity discharge (HID) lamps in the U.S. in 1992. Even in the U.K., one of the largest worldwide markets for LPS, sales have fallen more than 40 percent between 1995 and 2003. Perhaps LPS can be added to the list of endangered light sources such as carbon arc lamps.

To many, this is as it should be because LPS is essentially a monochromatic (589 nm) light source making color perception impossible. Indeed, there has been a general world movement toward “white” light sources; even high pressure sodium (HPS) is becoming less prevalent in outdoor applications.

Twenty years ago the ground was orange when viewed from an airplane at night. Today in North America the same ground is a patchwork of white and orange. This transformation in outdoor lighting is interesting, because objective assessments of LPS lead one to wonder why it is going the way of the passenger pigeon.

Making the Case

**Efficiency.** LPS is a very efficacious light source. A 180-W LPS lamp, the most common available, generates light at about 180 lumens per watt (lm/W). Since the lighting requirements for almost all lighting applications are specified by IESNA in terms of lumens per unit area (i.e., illuminance), LPS is the most efficacious source for meeting specified light levels. Presently there is no other formally recognized criterion for “light” than the lumen. Although the lumen is sometimes, and sometimes correctly, depreciated as a measure of the stimulus for visual perception, the lumen is still a robust representation of “light” for visual performance, visual acuity and on-axis reaction times. Probably rightly then, the lumen remains a quite satisfactory, if not completely useful, measure of “light” emitted from all light sources. Until the definition of “light” changes, LPS will probably remain the most efficacious source for achieving specified illuminance levels.

LPS is also efficacious for off-axis vision. Recently there has been a great deal of interest in off-axis (peripheral) night-time vision and its important role in outdoor lighting. Many lighting practitioners know that the photopic lumen is based upon the combined spectral sensitivity of cones and that the scotopic lumen is based upon the spectral sensitivity of rods. The peak spectral sensitivity of rods is at a shorter wavelength (e.g., toward “bluer” and “greener” light) than the combined peak spectral sensitivity of cones. It is sometimes stated that LPS is a poor source for night time (mesopic) vision where both rods and cones contribute to human vision." This argument is based upon the fact that the peak spectral sensitivity of off-axis vision at night is shifted away from the long-wavelength (“yellow”) emission line of LPS. On an equal light level criterion, LPS does indeed perform worse for off-axis vision than lamps with greater short-wavelength (“blue” or “green”) emission. But on a luminous efficacy (lumens per watt) basis, LPS continues to outperform nearly any other commercially available sources at night-time light levels simply because LPS generates light so efficaciously. In other words, the mesopic (off-axis) luminous efficacy is still higher for LPS than most other sources. Table 1 compares relative power requirements for different light sources at equal mesopic luminances for different levels.
Different outdoor applications.

Cost. LPS is less expensive to own and operate than any common outdoor light source except HPS. Using 2001 Means Electrical Cost Data, the initial costs (equipment and labor) of LPS, HPS and metal halide (MH) lamps, luminaires and poles are all within about five percent of $1 100 (Table 2). To provide the IESNA recommended maintained illuminance and uniformity for parking lot illumination, luminaires containing 180-W LPS lamps compare favorably with systems using 400-W HPS lamps because of the lower wattage.

Extended Source. LPS is an extended source. The lumens from this light source come from a relatively large area. Although precise control of light from LPS lamps is very difficult in small fixtures, larger fixtures mounted high above the surface to be illuminated can gather the lumens from an LPS lamp to create acceptable, if not better, uniform luminous distributions than small-area sources. Large-area sources like LPS produce relatively less discomfort glare than small-area sources because of their much lower brightness. Belgium illuminates nearly all of its major motorways with LPS systems. Compared to driving at night in North America along roads illuminated by HPS cobrahead fixtures, driving in Belgium is, at least to the first author, a much more comfortable experience because of the uniform lighting distribution and low discomfort glare provided by LPS.

Dark Sky Preservation. LPS also improves astronomical observations at night. In urban areas near astronomical observatories, LPS is often used. Since LPS is essentially monochromatic, it is possible to almost completely eliminate sky glow from these sources using light pollution suppression (conveniently also called LPS) filters, thus providing astronomers with a largely unfettered view of the stars. For those who want to enjoy the night sky, and who have access to these filters, LPS is the preferred source, hands down.

Mercury Free. LPS contains no mercury. Recent concerns over products containing mercury may be somewhat short-sighted because lamps containing mercury are usually more efficacious (lm/W) than those that are not. Since fossil fuels containing mercury dominate electrical generation in North America, less mercury is

<table>
<thead>
<tr>
<th>Source</th>
<th>Illuminance (lx)</th>
<th>Relative Power (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 W HPS</td>
<td>26.9</td>
<td>100</td>
</tr>
<tr>
<td>180 W LPS</td>
<td>28.8</td>
<td>74</td>
</tr>
<tr>
<td>400 W MH</td>
<td>23.5</td>
<td>104</td>
</tr>
<tr>
<td>32 W T8 FL 5000K</td>
<td>22.3</td>
<td>108</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>Illuminance (lx)</th>
<th>Relative Power (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 W HPS</td>
<td>13.5</td>
<td>100</td>
</tr>
<tr>
<td>180 W LPS</td>
<td>15.8</td>
<td>82</td>
</tr>
<tr>
<td>400 W MH</td>
<td>10.1</td>
<td>89</td>
</tr>
<tr>
<td>32 W T8 FL 5000K</td>
<td>9.0</td>
<td>87</td>
</tr>
</tbody>
</table>

Comparison of illuminances and relative power required to illuminate two types of roadways (collector roads at 0.6 cd/m² and local roads at 0.3 cd/m²) using various light sources.

<table>
<thead>
<tr>
<th>Source + Pole</th>
<th>Number of Poles</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPS (180 W)</td>
<td>6</td>
</tr>
<tr>
<td>HPS (400 W)</td>
<td>6</td>
</tr>
<tr>
<td>HPS (250 W)</td>
<td>8</td>
</tr>
<tr>
<td>MH (400 W)</td>
<td>9</td>
</tr>
<tr>
<td>MH (250 W)</td>
<td>12</td>
</tr>
</tbody>
</table>

Initial cost comparison (per pole) for LPS, HPS and MH area luminaires. Total cost is estimated by doubling the equipment cost to account for installation and wiring costs.
Moreover, epidemiological studies have pointed to light at night as a potential risk factor in night-shift nurses because light suppresses melatonin. We know that the spectral sensitivity of the circadian system peaks between 440 nm and 500 nm, with little sensitivity to light at 589 nm. Here again, if we are to believe that light at night is, in fact, a risk factor for cancer (not a proven link, by any means, however), then LPS is an ideal light source for night time applications.

**Closing Arguments**

Yes, LPS is a monochromatic source and does not support color vision. And sure, no one wants to choose tomatoes or apples under a monochromatic source. But do we really care about the color of the bicycle we want to avoid when driving at night? And are we to conclude that color deficiency is the most important criterion for rejecting a light source from consideration? From a design perspective aren’t (a) low life cycle costs, (b) no lumen depreciation, (c) lower discomfort glare, (d) better acuity, (e) good visual performance (both on-axis and off-axis), (f) better astronomical observations, (g) mercury-free lighting, and, theoretically at least, (h) lower health risk for night-shift workers also worth considering?

In a recent presentation, Dr. Paul Schoemaker made the point that our beliefs are often based upon what we hear rather than what is true. He asked the audience to choose which killed more people in the United States:

- Stroke, or all forms of accidents
- Lung cancer, or motor vehicle accidents
- Emphysema, or homicide

The response from the audience (a show of hands) was consistent with the results presented in Table 4 that were obtained earlier by Dr. Shoemaker. Table 4 drives home his point that our estimates of the relative numbers of causes of deaths more closely follow what we hear and see in the press than what actually occurs. In a similar exercise, we asked subscribers of the National Lighting Product Information Program to compare MH, HPS and LPS in terms of their effectiveness for night time applications, considering factors such as:

- Initial costs and operating costs (including energy usage)
- Visibility
- Color vision
- Glare
- Environmental impact
- Health effects
- Aesthetic appeal

We also reviewed lighting-trade magazines in the U.S., U.K. and Canada over the past five years by simply counting the frequency of articles related to outdoor or roadway lighting that discussed MH, HPS or LPS. Figure 1 provides a comparison of responses (more than 600 individuals responded) to our questionnaire and of our review of the number of articles dealing with these three light sources in American, British and Canadian lighting trade magazines. Figure 1 further illustrates the point that our beliefs mirror what is popular. In fact

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**Table 3**

Comparison of annualized costs (initial, energy and maintenance costs equated to an annual payment) of the installations in Table 2.

<table>
<thead>
<tr>
<th>Type of lamp</th>
<th>Total annualized cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPS (180 W)</td>
<td>$1809</td>
</tr>
<tr>
<td>HPS (400 W)</td>
<td>$1811</td>
</tr>
<tr>
<td>HPS (250 W)</td>
<td>$2239</td>
</tr>
<tr>
<td>MH (400 W)</td>
<td>$2623</td>
</tr>
<tr>
<td>MH (250 W)</td>
<td>$3447</td>
</tr>
</tbody>
</table>

---
there is a nearly perfect
correlation between the
likelihood of a particular
light source being select-
ed as better and the num-
ber of times it was men-
tioned in the lighting
trade press!

We are all very busy,
balancing our profession-
al obligations and person-
al pleasures. It is undoubt-
edly easier for us to form
our beliefs from what we
hear than it is to form our
opinions after digging for
the facts. Few of us even
have time to think of the
right questions, let alone
find the answers to those
questions. Rational argu-
ments in favor of LPS may
make little difference to
the future of LPS if they
are never considered in
the first place. And, as
shown in Figure 1, LPS is
widely ignored by the
lighting trade. LPS is an
old technology of little
interest to manufacturers
interested in producing
higher margin products
and to specifiers interest-
ed in creating pretty
places. Unless the eco-
nomic, environmental
and social values of all
forms of lighting are more
widely and openly dis-
cussed, LPS sales will con-
tinue to decline despite
the many rational argu-
ments in its favor.

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<table>
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<tr>
<th>Causes of Death</th>
<th>Annual U.S. Total (In 1000’s)</th>
<th>People’s Estimate (In 1000’s)</th>
<th>Newspaper Reports Per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke</td>
<td>209</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Accidents(All)</td>
<td>112</td>
<td>89</td>
<td>276</td>
</tr>
<tr>
<td>Lung Cancer</td>
<td>76</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Motor Vehicle Accident</td>
<td>55</td>
<td>41</td>
<td>136</td>
</tr>
<tr>
<td>Emphysema</td>
<td>22</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Homicide</td>
<td>19</td>
<td>6</td>
<td>264</td>
</tr>
</tbody>
</table>

Comparison between the actual number of deaths in the U.S. by various causes and the public perception of the number of deaths, and the number of newspaper reports of each cause of death.

About the Authors: Mark S. Rea, Ph.D., Fellow IESNA (Member 1980), FSLL, LC, is the director of the Lighting Research Center at Rensselaer Polytechnic Institute. He has authored more than 100 scientific and technical articles and was editor-in-chief of the 8th and 9th editions of the IESNA Lighting Handbook. His current research areas include new metrics for energy-efficient lighting systems, the effects of daylight on worker productivity in offices, and the effects of light and circadian disruption on breast cancer.

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