

Is Your Lighting *Application*-Efficient?

Overemphasizing *luminaire* efficiency, at the expense of *application*-efficiency, can result in offensive glare or gloomy spaces, even while conserving energy.

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The “greening” of commercial construction and renovation is not a fad. More than 30 states, 135 cities and 10 Federal agencies now require or encourage new public buildings to register with the LEED green-building rating system. As public construction continues to benefit throughout 2010 and 2011 from the 2009 American Recovery and Reinvestment Act funds, green-building practices are more important now than ever before. By 2013 McGraw-Hill Construction predicts that the green-building market will grow to 25 percent of the value of all new construction starts, or about \$140 billion.

In the professional discipline of lighting, this is creating extraordinary opportunities to design lighting solutions that provide effective lighting output with optimal visual comfort, attract interest, and reveal form and architecture indoor and outdoor. It is also creating extraordinary risks, as designers are pressured to emphasize LEED points over the quality of lighting performance and efficiency metrics over people’s needs. This is not to say that lighting should not be efficient: Lighting should be very efficient. But the metrics of efficiency tell only part of the story of what lighting does. Overemphasizing these metrics can still result in unintended offensive glare or gloomy spaces.

Good lighting design does not start with product, it begins with need: What emotional response does a professional lighting designer or architect want to stimulate in users of a space? What surfaces and objects should be lighted, at what intensity, to draw attention and shape spatial perception? How much light do users need on task surfaces to enable them to perform those tasks without headache, eye strain, glare or veiling reflections? Once these design decisions are made, the light source and luminaires can be more accurately selected. The right luminaire for the job is often not the one that is most efficient in lumen output but, rather, in lumens onto worksurfaces or lumens on the ground or floor.

Luminaire efficiency may be judged based on input watts, luminous efficiency, efficacy rating (lumens per watt) and a coefficient of lamp utilization. As luminous efficiency is published in most photometric reports and catalog sheets, designers often focus on this one metric. It is an important metric, telling us the percentage of light produced by the lamps in a luminaire that is, in turn, emitted by the luminaire.

But it only tells part of the story of luminaire performance. Overemphasizing it can lead to ultimately weaker or improper lighting choices for applications at hand. After all, a bare lamp offers 100 percent efficiency but would not be a good choice in, say, a classroom. The most efficient luminaires—particularly unshielded luminaires with direct light distribution—can easily be “glare bombs” when installed with clear or no lensing, in applications with lower mounting heights or by simply installing too many fixtures.

Attention to lighting choices and their design can result in luminaires that are not only energy-efficient and energy-saving, but provide more effective lighting solutions for offices, classrooms, stores, public spaces and grounds.

Application-efficient lighting, as contrasted with output efficiency-only criteria, is judged by entirely different goals:

- It provides adequate and proper light levels for good task visibility and performance in specific applications;
- It distributes uniform illumination where needed and shadow and contrast for interest;
- It maximizes visual comfort by minimizing glare, including irritating reflections on computer screens; and
- It renders colors and skin tones naturally.



Application-efficient lighting employs a different, superior set of metrics:

1. Average maintained footcandles, which approximate Illuminating Engineering Society (IES) recommendations, adjusted if needed based on designer judgment;
2. Spacing criteria for luminaires, which should ensure a.) they are not spaced too far apart from each other, resulting visually fatiguing patchwork of light and dark spaces, and b.) they are not spaced too far from walls, resulting in dark walls and a gloomy atmosphere;
3. Luminous intensity measured in candelas, which avoids direct and reflected glare by a.) not being above 300 candelas at a viewing angle from a luminaire of 55 degrees in open offices, according to IES Recommended Practice for office lighting, b.) not being above 1,000 candelas at 65 degrees for luminaires in high-ceiling spaces such as warehouses, and c.) not being above 600 candelas at 65 degrees in other applications;
4. Color rendition index (CRI) should be >80 CRI for most indoor commercial applications where skin tones and human interaction are important, and >90 for applications where color matching is critical.

Saving energy is easy today with the new lower wattage linear fluorescent and some LED luminaires. Providing good and proper energy-saving lighting however, can be challenging to get right.

The most appropriate metric for efficiency is lighting power density (LPD), a measure of efficiency for a lighting application, not an individual luminaire. LPD establishes the basis of energy codes by providing a budget for lighting load based on maximum allowable watts per square foot. An energy-effective lighting design, therefore, is one that achieves specific design goals, for the lowest LPD. In offices, for example, LPDs as low as 0.7 Watts/sq.ft., or 30 percent less than ASHRAE 90.1-2004 using the Building Area Method, are entirely achievable with high lighting quality, using luminaires nominally less efficient than others that trade-off efficacy for glare.

Consider the T5HO lamp: depending upon the ballast used the T5HO lamp can often be slightly less efficacious than the T8 lamp, but 2.5 times more luminous and about 40 percent smaller. Thereby improving photo-optic control of luminaire output and efficiency, enabling more compact luminaires, contributing to sustainability by using less mercury and generating less waste. It is a bright source and bare lamps should not be viewed directly at lower mounting heights, but T5HOs can be used virtually anywhere T8 lighting can. Brightness can be maintained but controlled, using quality optics that diffuse the source by spreading, scattering, reflecting or concealing the source.

Suppose we are responsible for lighting a 24 x 32 ft. (768 sq.ft.) office featuring computer work as a primary task, with an IES target of maintained light level at 30 footcandles. In our evaluation, we compare the performance of 22-inch-aperture, three-lamp, T8 deep-cell parabolic luminaires versus 3-inch-aperture, single-lamp, T5HO parabolic luminaires. The same number of luminaires are used, although the T8 solution uses three times the number of lamps. The results are shown in Table 1.

	Highest-Performance T8 Deep Cell	High-Performance T5HO Linear Parabolic
Ceiling Aperture	22"	3"
Luminaire – with lowest wattage energy-savings lamps	4-ft. (3) Lamp T8 F32T8-ES (25w)	4-ft. (1) Lamp T5HO F54T5HO-ES (49w)
Philips Advance Ballast	ICN3P32LWSC120	ICN-2S54-120v
Input Watts	59	58
System Lumens	2500x3x.78 = 5850	5000x1x1.02 = 5100
Nominal Lamp Efficacy (Lamp rated Lumens/Watt)	2500/25 = 100	5000/49 = 102
Luminaire Efficiency	85%	55.5%
Average light level on task plane (foot-candles): 30 fc recommended (IES)	42	33
Peak Candela at 55 Degrees	603	296
Meets IES-RP-1-2004?	No	Yes
Number of Luminaires	12	12
Number of Lamps	36	12
Total Wattage	12 fixtures x 59w = 708	12 fixtures x 58w = 696
Lighting Power Density	708 ÷ 768 = 0.922W/sq.ft	696 ÷ 768 = 0.906W/sq.ft

Table 1.

Comparison of T8 and T5HO solutions in a 768 sq.ft. office space using energy savings lamps.

A typical high-performance 3-lamp T8 parabolic troffer using low-watt ballast and energy savings 25w lamps VS. a linear parabolic T5HO luminaire using the new 49watt T5HO lamp. Luminaire efficiency is much lower but the T5HO light level is far more appropriate for the office environment, meeting IES-RP1-04 while lowering LPD below recommended levels and reducing lamp quantities by 2/3rds.

The T8 solution produces higher average maintained light levels, basically overlighting the space. The higher levels are a trade-off for glare on computer screens, as the T8 solution produces 603 candela at 55 degrees, twice the IES intensity recommended at this viewing angle. As a result, the T8 solution does not meet IES Recommended Practice for lighting this office space. The T5HO solution does. It produces desired light levels and optimal luminous conditions for visual comfort, uses one lamp instead of three employed in architecturally minimalist luminaires, with an LPD of 0.906 Watts/sq.ft., almost ten percent lower than ASHRAE 90.1-2004 and two percent lower than the highest energy savings T8 solution.

Based on this example, we see a T5HO luminaire that is modestly less efficient, using a lamp only slightly more efficacious, but producing desired light levels with greater uniformity, less glare on computer screens, higher visual comfort, fewer lamps, less environmental impact, less intrusion into spatial architecture, less wasted energy, smaller wattage and lower LPD. The added bonus of fewer lamps allows for a drastic reduction in fixture volume as well, 72% in this case, equating to less shipping, storage and packaging requirements for the fixture itself, not to mention lamp quantities and storage requirements for maintenance.

To illustrate further such low LPD achievability, Photo 1 is an excellent example of the use of a T5HO luminaire in an office application. Placed on an 8ft x 10ft spacing, each single-lamp fixture produces an LPW of just 0.7625 watts/sq.ft. using a standard T5HO lamp and a mere 0.725 watts/sq.ft. with the new 49w energy-savings T5HO lamp, nearly 30% below ASHRAE 90.1-2004 recommendations. Had the designer focused on luminaire efficiency, it would have narrowed the options for a room such as this, quite possibly resulting in overlighting or much higher LPD. This oft-inclination of relying primarily on luminaire efficiency has led us to develop a new, comprehensive metric: The Coefficient of Illuminance Quality or CIQ, encompassing three vital aspects of lighting design...

1. **Watts per Square Foot** - Strive to achieve < 0.7 watts per square foot.
2. **Biological and Task Requirements** - Recognize the need for safety, pleasant perception, an interesting environment and comfortable task engagement.
3. **Prescribed Illuminance** - Strive to maintain close, but not necessarily rigid, adherence to IES/ANSI recommendations.

By addressing each element relative to the others, you may achieve a well-lit environment and the lighting plan then evolves into a contributor to:

- the natural environment via reduced energy, lamps, mercury & materials;
- people's perception and appreciation of the architectural environment;
- and workers' capability to complete their tasks comfortably.

By using CIQ metrics — basing luminaire selection on efficiently satisfying an application's lighting goals, rather than simply converting more watts and lamp lumens into luminaire output—designers can develop projects with lighting that both satisfies actual and desirable human needs, while minimizing consumption of energy and materials.



Photography: Eagle Eye Images, Long Beach, CA

Photo 1.
Intuit Regional Headquarters - San Diego

CIQ metric #1: Strive to achieve <0.70 watts per square foot.

This conference room at Intuit's San Diego Regional Headquarters does just that, employing 4 parabolic luminaires, each 4ft long and only 3" wide. With merely 1 T5HO lamp per fixture this conference room is fully and comfortably lit using only 4 lamps. Placed on an 8ft x 10ft spacing, each fixture produces an LPW of just 0.7625 watts/sq.ft. using a standard T5HO lamp (8x10/61w). If the new 49w energy-savings T5HO lamp had been utilized, the LPW would be 0.725 watts/sq.ft. Saving energy couldn't be more pleasant.

For more information on how we can assist you in achieving a CIQ rated environment, please call George Pizzo at 908-581-1466 or email gpizzo@alights.com. Visit our gallery at www.alights.com/gallery.html to browse ideas for your next project.