Evaluating the Efficiency of Light Fixtures

by Craig DiLouie

Craig DiLouie, principal of ZING Communications, Inc. (www.zinginc.com), is a consultant, analyst and reporter specializing in the lighting and electrical industries, and a regular contributor to LM&M.

Lighting management companies are often called upon to provide lighting upgrade services that involve lamp and ballast replacement, but in some cases, entire light fixtures must be replaced, and there is an opportunity to relight, rather than simply retrofit, the project. In this case, the lighting management consultant is placed in a position to evaluate and select light fixtures based on how they distribute light and how efficiently they can do so. This article provides several metrics for how light fixture efficiency is measured to aid these evaluations.

Light fixtures can be evaluated based on center beam candlepower (cd), total input watts (W), efficiency (fraction of lamp lumens that exit the fixture), efficacy rating (lumens/W), coefficient of utilization (CU) and comparative yearly energy cost of light ($/1000 lumens).

While these metrics provide valuable tools for comparing the efficiency of light fixtures, it is important to remember that efficiency is only part of the story of a lighting product and should be considered along with how the fixture distributes the light and at what intensity. This will result in selection of lighting that is both efficient and likely to achieve good visual comfort.

Light Fixture Efficiency

Light fixture efficiency is the ratio of light output emitted by the fixture to the light output emitted by its lamps. Another way of looking at it: Fixture efficiency is the percentage of light output produced by the lamps that are in turn emitted by the fixture.

Not all light produced by lamps exit the fixture; some of course remains trapped inside and dissipates as heat. The fixture's physical characteristics will affect how much light exits and how much is directed at the workplane.

Light fixture efficiency is important because while you can have a very efficient lamp-ballast system, if the fixture itself is not efficient at delivering lumens, then the lighting system overall is not either. Factors that affect the efficiency of the light fixture include its shape, the reflectance of its materials, how many lamps are inside the housing (and how close they are to each other), and whether shielding material such as a lens or louver is used to soften or scatter the light.

While a high level of light fixture efficiency should be valued, overemphasizing it, of course, can lead to poor lighting quality and angry users. After all, a bare lamp offers 100 percent efficiency, but is hardly a good choice. In reality, the most "efficient" light fixtures are often candidates for direct glare, particularly unshielded light fixtures with direct distribution at lower mounting heights typically found in offices, classrooms and similar applications. In such cases, light may exit the fixture very efficiently, but the fixture itself is a "glare bomb," and users may resort to wearing baseball caps.

Light Fixture Efficacy

Light fixture efficacy describes the efficacy of the entire light fixture, including the light source, ballast and light fixture losses. The Luminaire Efficacy Rating (LER) provides a metric for comparing the relative energy efficiency of fluorescent light fixtures. Initiated in response to the Energy Policy Act of 1992, LER offers a voluntary rating standard for several categories of commercial and industrial fluorescent fixtures such as 2x4 recessed lensed and louvered fixtures, plastic wraparounds and striplights (see NEMA LE 5-2001 for more information).

LER is expressed:

$$\text{LER} = \frac{[\text{Light Fixture Efficiency (EFF) x Total Rated Lamp Lumens (TTL) x Ballast Factor (BF)}]}{[\text{Light Fixture Watts Input}]}$$

Some manufacturers publish LER in their products' photometric reports and specification sheets. Even without it, lighting management consultants can easily calculate LER themselves as the information required by the above formula should be generally available for the product.

Coefficient of Utilization

The coefficient of utilization (CU) metric allows us to look at light fixture efficiency in the context of the actual application. Since all room surfaces are potential reflectors of light, the room itself acts an extension of the lighting system. A given light fixture may emit some of its light directly at the workplane and some at a nearby wall. The wall absorbs some of the light and reflects the rest, some of which in turn reaches the workplane.

CU therefore allows us to compare light fixture efficiencies in a given environment. It shows the percentage of light output produced by the lamps that reaches the workplane after light is lost due to the fixture's efficiency at transmitting light, the room proportions, and the ability of room surfaces to reflect light.

Light fixture manufacturers provide CU tables for their products in the photometry report and associated IES files downloadable for design calculations and analysis using software. As Average Maintained Light Levels (fc) = (Lumens x CU x Light Loss factors) ÷ Area (sq.ft.), CU can have a big impact on the capacity needs for a given lighting project and hence both its capital and operating costs. CU shows how changing room finishes, for example, can affect light levels.

Comparative Yearly Energy Cost of Light

The Comparative Yearly Energy Cost of Light is another light fixture comparison metric created in NEMA LE 5-2001 in response to the Energy Policy Act of 1992. It is expressed as a $/1000 lumens value based on the below formula:

Energy Cost = (K/LER) x 1000 Lumens

Where K = $0.24/W [(3,000 average operating hours per year x $ 0.08/kWh average energy cost) ÷ 1000]

Specifiers should be prepared to make adjustments as needed to tailor the formula to their project. The operating time averages to about 8 hours per day and be adapted easily. The $0.08 per kWh cost is outdated as a national average and can also be adapted. As of December 2009, according to the Department of Energy, the national average cost per kWh of electric energy was $0.0973 for commercial buildings, increasing K to $0.29/W, and $0.0652 for industrial buildings, reducing K to $0.20/W. For the latest national averages and specific regional and even more specific state averages, visit http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_a.html.

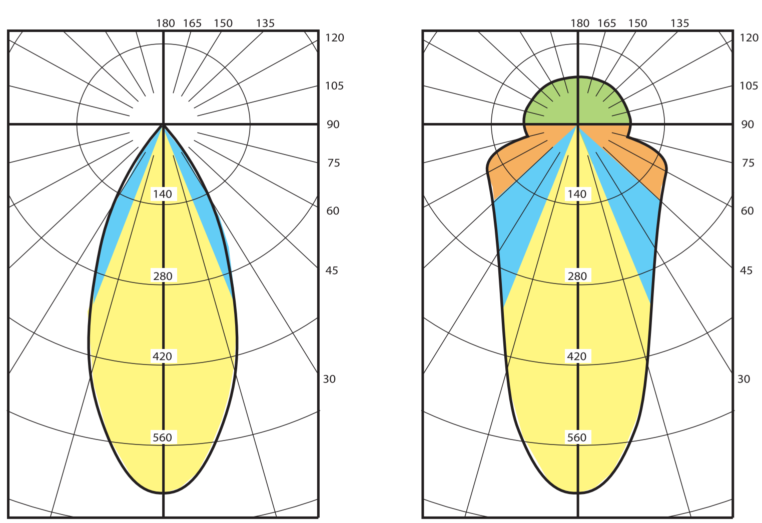

Figure 1. Efficacy is not the entire story of a light fixture. In the drawing, the left light fixture operates at an efficacy of 28 lumens/W, while the right light fixture generates about 50 percent more light output for about 33 percent more wattage, resulting in a 14 percent higher efficacy. The right fixture accomplishes this gain, however, through a lack of control of glare. Drawing courtesy of Kevin Willmorth.