



LED General Lighting – Are we there yet?

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LED lighting has become a major source of discussion in the lighting and architectural communities. Manufacturers and proponents of LED lighting for general illumination point to its energy saving attributes as a major reason for utilizing the technology today. At the same time, designers and specifiers are approaching the technology with some caution, unsure if the energy claims outweigh the potential downsides.

To date at Illumination Arts, we have utilized LED luminaires for aesthetic and decorative purposes, but have avoided utilizing LED general lighting out of concern that the technology and the standards around it have not yet matured enough to serve as the primary light source in an architectural environment.

Recently, as part of our internal best practices, Illumination Arts undertook a series of meetings and working sessions with manufacturers of LED components, luminaires and controls to assure that the opinions and guidance we provide to our clients are based on the most current information available on the state of development in the LED marketplace.

Based on this research we have prepared the following outline of the positive, negative and neutral implications related to the use of LED luminaires in general lighting situations.

Positive Implications:

Energy:

The most compelling argument for the use of LED downlights today is energy efficiency. Comparing a single lamp compact fluorescent luminaire that delivers approximately 1430 lumens to a LED downlight that delivers 1500 lumens, the LED luminaire saves nine (9) watts per luminaire, a reduction of 25%.

Given the ever decreasing wattage allowances in energy codes, that wattage reduction appears quite compelling.



Long Life:

With rated usable lifetimes that can reach up to 60,000 hours, the long life of LED luminaires is another compelling characteristic, particularly in areas where the luminaires may be difficult to access for maintenance.

However, usable life of LED luminaires is a double edged sword, as noted below.

Negative Implications:

First Cost:

In today's lighting market, LED luminaires are sold and priced at a premium. Using the same comparison of a compact fluorescent luminaire delivering 1430 lumens and an LED delivering 1500 lumens, the compact fluorescent luminaire costs \$100 (distributor cost), while the LED costs \$250 (distributor cost), a 150% increase.

Dimming:

Because of the lack of standardization in the LED market at the moment, there are a number of complications around the ability to dim LED products. These issues revolve around the fact that any given LED luminaire can require a set of electrical and electronic characteristics (current [AC or DC], voltage, amperage, and control signals) that are different from any other LED luminaire. In fact, these characteristics not only vary by manufacturer, but also by product within some manufacturers' product lines.

This in turn leads to scenarios where a particular LED luminaire may seem appropriate for an application, but a variety of dimming complications can arise.

These can include the following:

- The luminaire cannot be dimmed effectively at all.
- The luminaire can be dimmed effectively only to a level of 10-20% (which is not low enough in most cases) or, at some point in the dimming range, the luminaire behaves erratically (flickering, flashing)
- The luminaire has a noticeable color shift when dimmed.
- The luminaire can be dimmed effectively, but only by a wall box dimmer.



- One LED luminaire can be dimmed by a particular dimming product, but others on the job cannot, or require a different dimming product. (This defeats the ability to have simple, central dimming control and requires a special system for a particular luminaire.
- The luminaire manufacturer may claim that the luminaire can be dimmed, but the controls manufacturer does not support the use of their controls system with the luminaire. Under such circumstances, the controls manufacturer will not stand behind the project if there is a problem in the field.

Long Life/End of Life:

While the long life of LED luminaires has some obvious advantages, as noted above, this also leads to some new issues that must be considered by a design team and an owner.

Availability of replacement LED modules:

The LED industry is an outgrowth of the semi-conductor industry, not the lighting industry. The lighting industry has traditionally had a relatively slow product development and life cycle to obsolescence whereby an owner today can still acquire replacement lamps and ballasts for luminaires that were designed, manufactured and installed decades ago.

By comparison, the semi-conductor industry has a product development cycle that is measured in months rather than years. (Consider how quickly a new computer or cell phone becomes obsolete and how difficult it is to find replacement parts for a four year old computer.)

The LED marketplace is an intersection of these two very different models of product life cycles and consumer expectations. This plays out in the LED luminaire market with LED modules changing on a semi-conductor time scale (months), while the products are being installed in facilities intended to last for years or decades with their current designs. Luminaire manufacturers have indicated that the availability of replacement LED modules and components will be limited over time. Manufacturers will not be maintaining back stock of components over long periods of time. This will inevitably lead to installations that require replacement components



that will not be available, necessitating the complete replacement of luminaires and in some instances complete systems.

During discussions with manufacturers, several suggested that it would be wise to purchase “shelf stock” of replacement components during construction to assure a long term supply of parts. This will increase the project’s first costs.

Lack of End of Life Signaling:

As standards begin to emerge for LED luminaires, it is generally agreed that their useful life is reached when the LED module produces 70% of its initial light output. This is the number that manufacturers are referring to when they indicate the life of an LED luminaire (60,000 hours as an example).

Unfortunately, at the point in time when 70% is reached, the luminaire will remain lit, with no way for maintenance personnel to know that the luminaire needs replacement. This leads to two problems:

- 1) The light level in the space has now slowly degraded over time to be 30% less than it was originally designed for. While this slow degradation over time is not noticeable while it is in process, the end result is a darker space than originally intended, without the benefit of a lamp going out and being replaced to bring the light level back to design levels. This will have impacts on the useability of the space.
- 2) At the point where the luminaire is running at 70% light output, the luminaire is still drawing the same amount of energy as it was at 100% output, thereby decreasing the lumen/watt ratio and decreasing its energy efficiency.

Life of System Components:

One of the overlooked issues when evaluating the life of an LED luminaires is the fact that the LED module is only one part of the luminaire system. In order to evaluate the expected life of an LED luminaire, the life of the other components such as the electronic driver must also be reviewed. Often the anticipated life of the LED module will be



substantially longer than the anticipated life of the driver. However, when the driver fails, the luminaire ceases to function until the driver is replaced.

Lack of Cleaning:

When calculating light levels with LED luminaires, a lower Dirt Depreciation Ratio should be employed to account for a greater accumulation of dirt over the life of the luminaire.

Although it may seem counterintuitive, when a luminaire is relamped it provides an opportunity for the luminaire to be wiped down and dust and dirt removed from its optical components. With the 60,000 hour life of an LED luminaire, this cleaning opportunity may be lost, decreasing the luminaire's efficiency and light output over time due to dust and dirt.

Neutral Implications:

Cost of Ownership:

When calculating a one-for-one comparison over time, and accounting for energy use, first costs and replacement module costs (LED luminaire) or lamp costs (CFL luminaire), the final cost of ownership of the LED luminaire will be more than the equivalent CFL luminaire.

Depending on the priorities of the project, this may or may not be a deciding factor. For example, if the project goals include aggressive wattage targets, then the LED's energy saving characteristics may outweigh the monetary side of the equation, while an owner that is more budget sensitive may decide that the LED luminaires are not a cost effective option.

In-Rush Current:

In-rush current is the term used to describe the initial spike in amperage created when a luminaire that utilizes a line voltage driver is first turned on. At that moment, there is a large spike in current as the capacitors (devices that smooth out the power curve provided to the driver) are charged. This spike can be over ten times the amount of amperage the luminaire draws during normal operation.

This has become an issue with LED luminaires because their low wattage would suggest that more LED luminaires can be loaded on a circuit than an equivalent



CFL or incandescent source. Unfortunately, the high in-rush current on the LED luminaire can trip the circuit breakers on start-up if the circuit is loaded in that manner and the in-rush has not been taken into account during the electrical design.

We have been advised by a prominent controls manufacturer to do the following to avoid this scenario.

“There is clearly a recurring inrush issue on every half cycle with the current LED power supplies. Its greatest impact can be on the semiconductors used for phase or reverse control dimming but it could likely have an impact on relay or contactor contacts as well. Our rule of thumb of sizing the control devices is fairly straightforward - use the size of the incandescent load that you are replacing to determine the size of your control. So if you were going to use a 75W halogen lamp and are now using a 15W LED lamp, size the control as if it was a 75W load.”

This means the project will not see any first cost savings in terms of a reduction in circuits, panels, wire and conduit through the use of LED luminaires.

In-Rush is an issue that the project Electrical Engineer should be cognizant of when designing the electrical system.

Conclusions:

Based on these discussions and the issues that have been brought to light through them, we have concluded that at this time the use of LED luminaires for general lighting applications has not yet reached the point of being the simple, completely positive choice promised by manufacturer’s marketing materials and that we as designers would like them to be.

The decision as to whether LED luminaires are appropriate must be made on a project by project basis and will depend on a number of factors, including:

- The project’s energy efficiency goals.
- The project’s dimming requirements.
- The project’s budget restrictions, both first cost and life cycle cost.
- The owner’s willingness to accommodate the specific maintenance needs of the LED luminaires.



Depending on the answers to these questions, the LED luminaire may or may not be an appropriate choice for general lighting applications.

All this being said, LED luminaires will certainly be a major part of the lighting designer's toolbox in the future. It is where the most research and development funding is being spent, the technology has the firm backing of the U.S. Department of Energy, and manufacturers are actively seeking solutions to some of the issues we outlined above.

In the not too distant future, the choice of LED luminaires may be a simple and straightforward one. However, today we continue to urge caution and due diligence when they are being considered.