LEADING LIGHTS?

LED lights are being promoted as the ultimate in eco-friendly lighting. But are they as energy-efficient as we think? By Rebecca Pool

Confusion around how LED light output is measured may be misleading consumers

PHILIPS

TO CELEBRATE the Queen's Diamond Jubilee and Olympics, London's Tower Bridge was adorned with thousands of LED lights. Described by London Mayor,Boris Johnson as "bathing Tower Bridge in eco-friendly light" the LEDs will continue to illuminate the bridge, even providing firework-like displays, for the next 25 years.

Crucially, the lighting scheme providers, GE and EDF Energy, claim the 1,800 LED lights and 2,000m of LED linear lights will reduce the energy used to light the bridge by some 40 per cent compared with the previous system. "Thanks to its state-of-the-art lighting, Tower Bridge has further reduced its carbon footprint to become a standout symbol of sustainability," enthused EDF chief executive Vincent de Rivaz.

London leaders are not alone in fitting famous landmarks with "energy-saving" LED lights. The US Empire State Building owners recently gave their tower a so-called "energy-efficiency retrofit", replacing 400 conventional lamps with 1,200 LED fixtures and claiming 75 per cent savings in annual energy costs. The Singapore Flyer, Stockholm's Globe Arena and Canada's CN Tower are but a few of many landmarks also decked out with the apparent cost-cutting light alternative.

Clearly, people at home and work are eager to ditch the unloved CFL and the not-so-efficient halogen and slot in the small, ready-to-glow semiconductor diode, be it to boost energy efficiency, cut energy consumption or even glow a brighter shade of green. But does the LED live up to its glowing reputation? Not yet.

As one disappointed user recently wrote on a LED web forum: "I bought 12 LED GU10 lamps about 18 months ago of which around half no longer work, two only lasted for 48 hours. The light output is nowhere near what is claimed either, even using 3 by 3W LEDs does not equal the equivalent 50W light bulb."

A matter of quality

The disappointed LED lamp user's comments are not unusual by any stretch of the imagination. Iain Macrae, president of the Society of Light and Lighting and global technical manager of Thorn Lighting, supplier of luminaires and lighting controls, says: "High-quality players will have great performing LEDs, tell you the truth and be able to back it up. At the lower end of the market, players have more poorly performing LEDs – quite rightly so at the price point – but they won't always tell you about it."

According to Macrae, confusion exists around how light output is measured, and this has been exploited to fool the customer. Typically, two light figures are quoted by LED and luminaire (complete light fittings) manufacturers: lumens per watt and luminaire lumens per watt.

The former, lumens per watt, refers to the ratio of light output from the actual LED to the power consumed; the higher the value, the more energy efficient >

Consumers don't always register the fact that product and chip efficiencies are two different things

< the LED (see 'Know your Lumens'). The second is the light from the LED that makes it out of the luminaire for the amount of power you put in. Depending on the actual fixture in which the LED is fitted, this figure will be lower, as it takes into account thermal, control and optical losses that vary from fitting to fitting.

"A manufacturer [of a light fitting] will want to know the raw figure before he designs the luminaire around it, but the end user wants the light output [from the fitting] onto the desk," says Macrae. "A lot of people are supplying different customers and haven't quite figured out the different languages yet."

Mike Simpson, technical and design director at Philips UK agrees. Philips Lighting is driving the LED lighting 'revolution', but as Simpson explains, the industry has suffered some confusion.

"When LED lights first came out, people were talking about efficiencies and everyone said wow, 150 lumens per watt," he says. "When they got the real lighting products they said 'but this is nothing like it'. Of course industry had been referring to the chip efficiencies and now we try to make it clear that product and chip efficiencies are two different things."

Simpson emphasises that the consumer, be it the luminaire manufacturer or an end user, must make sure they get the efficiency of the actual product they are buying. But, given the consumer understands the difference, is he or she still going to get the promised energy savings?

Earlier this year, BBC News ran a story based on a report from the Energy Savings Trust and stating: "[LEDs are] are much more energy efficient, using up to 90 per cent less energy than incandescent bulbs." However, the jury is out on exactly how much energy will be saved by switching to LED lighting.

"LEDs push light out in one direction," Simpson explains. "So if you compare an application where you want directional light, say spot lighting in your home, the LED produces more light for the power that goes in and is more effective at producing light in one direction, than a filament bulb in a reflective light fitting."

But what if the user doesn't want a directional spotlight? Indeed, in the rush to slash energy bills and make instant savings, owners of shops, hotels, office blocks, even lifts, have been whipping out the 50W tungsten filament

and plugging in a 10W LED, often with disappointing results.

As Macrae says: "In spotlights, where you want a focused beam, or [in] architectural lighting, where you want to pick something out, the LED is absolutely superb. But here in my office I have a couple of [fluorescent] luminaires with soft ambient light drifting out of them: LEDs many not be the answer here."

Fanciful figures?

Simon Robinson is technical director of property and development at engineering consultant group, WSP UK. His experience indicates that in some cases, LEDs are used inappropriately as the sellers of LED lighting don't always understand what they are selling. What's more, while the figures they provide for, say, efficiency and energy savings are true, they do not relate to what the general public understands.

"Why not have the manufacturers of LED products reference the lighting output of their products to something the general public understands?" he asks. "This would be what the classic GLS lightbulb is; a 100W or 60W lamp equivalent."

Failure to meet part L of the UK building regulations, which demands luminaires in commercial properties deliver at least 55 luminaire lumens per watt, is another issue his clients have faced. Often LEDs have been fitted into poorly designed luminaires, or simply retrofitted into fluorescent light fittings, giving inadequate light output.

"There is nothing illegal about selling a luminaire that doesn't meet Part L; it is the fitting of it that counts," he explains. "And, because clients see LEDs as efficient, they assume the entire light fitting will meet building requirements; not always so."

Colour temperature and colour rendering have been another bone of contention among users of LED lights. At home, most of us have grown up with a warm, yellow glow from tungsten halogen incandescents. These bulbs deliver a so-called colour temperature of around 2,700K – in contrast, a candle is 1,900K and a sunset is around 2,000K – and people genuinely feel more comfortable under these warmer colours.

Now, switch on the LED.

Almost all white lighting LEDs are based on a blue-emitting die with a yellow phosphor on top to convert some of the blue light to broadband amber, giving an overall result of white light. Generally, the more phosphor you use on a white light LED, the warmer your white light, but the greater your emission losses and the lower your efficiency.

Thankfully, this has become less of an issue over time as the basic chip efficiencies have improved, making it more cost-effective to modify that cool blue raw light to the warmer light much preferred in the home. Indeed, top-of-the-range LEDs are now available at 2,700K and 3,000K, closely replicating the more yellow glow of halogen tungsten and fluorescent light sources.

Importantly, converting light in an LED could be more cost-effective than doing the same in the widely-used fluorescent lamp, the LED light's key competitor. As Macrae highlights, in the same way that a yellow phosphor is used to modify the blue LED light, most fluorescent bulbs emit ultraviolet light and use a white phosphor to convert this high frequency blue light into white light.

"LED light sources are smaller [than fluorescent alternatives] so you have less phosphor per unit of light. This means you can afford to put a little bit more expensive phosphor in as there is so little of it," he explains.

Colour rendering

But, while a warm glow can make for a happy home, what about the workplace? This is where colour rendering becomes more of an issue.

Colour rendering relates to the way objects appear to somebody, under a given light source. It is measured via the colour rendering index (CRI), a quantitative measure of the ability of a light source to reproduce the colours of various objects faithfully in comparison with an ideal or natural light source.

A low CRI indicates that objects may appear unnatural under the light source, while a light with a high CRI rating will allow an object's colours to appear more natural. The ability of an artificial light to meaningfully show, say, blood in a hospital setting, or to light up beef on a supermarket shelf in an attractive way, is crucial.

Today's LED lights typically have a CRI on a par with that of a fluorescent light fitting – around 85 – while the CRI of a tungsten halogen is 100. However, this original colour-rendering scale was developed in the 1970s to measure phosphor-based light sources, and does not necessarily provide an accurate reflection of an LED's colour quality.

LED manufacturers could reproduce more relevant CRI figures for the interested customer but will not specify them. Instead, spectra of a product's colour characteristics are published, leaving the buyer to make his or her own evaluations and calculations. Thankfully, this will soon change.

The CRI index is currently being revised by the International Commission on Illumination (CIE) to take into account new light sources including the white LED. "We now know a lot more than we did when this scale was developed. We have new light sources, we view from different angles and different dimming levels so this rendering scale is not longer ideal," explains Macrae. "We need to change the scale so it includes more vivid colours and less of the skin tones – we'll have the solution in about a year or so." >

Colour aside, what about lifetime and costs? Right now, LED bulbs come with advertised lifetimes of 25,000 hours while the compact fluorescent bulb is meant to last 10,000 hours and the lowly incandescent halogen some 1,000 hours. However, according to Simpson, LEDs can last 50,000 to 60,000 hours, that's between 15-60 years, depending on how the product is used. As such, Philips is careful not to put life into a product where it isn't needed.

"For example, we design domestic products for 25 years," he says. "But you have to ask yourself, how long do I want this in my home? If I bought one of these products, I'm going to be leaving it in my will to my children."

Longevity of LEDs

Temperature is a real killer for an LED's lifetime, although clever cooling techniques counter this. Recent LED lightbulbs, packed full of LEDs, come with some sophisticated passive cooling fins to divert heat away from the bulbs. Meanwhile, other fittings are equipped with the same fans or syn-jets used in laptops, which are rated to nearly 100,000 hours and could possibly outlive the LEDs.

And then there's the thorny issue of cost. With prices up to £25 per bulb, the received wisdom that LED lighting is expensive seems well deserved. However, rising electricity prices and falling LED costs could see the technology finally making financial sense. Factor in the long lifetimes and the fact that a typical 35W halogen replacement LED could use as little as 4W, much less than the 10W compact fluorescent equivalent; then the cost case for the LED becomes much stronger.

But despite these gains, for the present the LED still might make less sense in large-scale commercial applications. "The LED hasn't broken the cost of efficiency barrier yet," asserts Macrae. "A fluorescent fitting is cheaper and not particularly inefficient, you don't want to recycle your building stock all the time."

And, although Simpson asserts the £15 LED lamp will pay for itself in two years, he admits industry is still waiting for prices to come down while watching the performance go up. "Like all semiconductor technologies, the price is going to continually come down and performance will rise. At a chip level we are currently at 150 lumens per watt, but by end of this decade, that figure will have gone up to 250L/W."

In fact, time seems to be the answer for just about every LED light issue. Despite the clear discrepancies on energy efficiency and savings, colour quality and rendering as well as cost issues, most in the industry agree that the LED is the light of the future.

An LED revolution

Philips Lighting's Simpson is incredibly positive: "In 2003, 6 per cent of our sales were in LED technology and by 2020 we see 75 per cent. You start off saying you wouldn't ever see LEDs in this application and then six months later you say yes, yes, yes. LEDs are going to encompass almost every lighting application you can probably think of."

Not as upbeat, but still positive, Robinson also points to the ongoing increases in luminance lumen per watt. "I am certain this will match that of the latest fluorescent in another four to five years so if you intend to have lighting installed for 20 years, wait five years and you might find the fifteen years you've got left of your savings is more than jumping in now," he says.

But, perhaps surprisingly, Macrae expresses some reservations. While he fully expects the industry to move towards LEDs, he believes demand for other light sources is not going to disappear.

"I know of fluorescent lamps that offer a similar sort of lifetime to LEDs and are more efficient than LEDs," he points out. "And importantly, if I'm not cash rich, can I really afford to replace fluorescent lighting that might still have another 20 years' worth of life?"

COLOUR RENDERING INDEX

22	high pressure sodium lighting	street lighting
62	common 4ft flourescent tube	office
80-85	compact flourescent lighting (warm white)	residential
85	premium 4ft flourescent tube	retail
80-90	solid state LED lighting	residential
95	incandescent lightbulb	residential

Lights with CRIs of 80 or higher are generally considered to have a high CRI. CRI values should only be compared when the light sources being compared have similar colour temperature ratings.

ORGANIC LIGHTING

BRIGHTER FUTURES?

Iain Macrae, president of the Society of Light and Lighting, asserts the organic LED is where the real action is. As he says: "LEDs will change the market but organic LEDs will change the way we light spaces completely."

The OLED is made by placing a series of organic thin films between two conductors. When electrical current is applied, a bright light is emitted. OLEDs can be printed on to any suitable substrate, including plastic, giving way to flexible organic light-emitting diodes and other applications such as roll-up displays and lights embedded in fabrics, clothing, even wallpaper.

The technology is already used in the displays of Motorola and Samsung colour mobile phones, as well as a host of other mobile devices. What's more, Philips Lighting, Germany-based Novaled and US-based Universal Display Corporation have developed OLED lamps. Indeed, as Macrae points out, OLEDs suit soft lighting and says: "If in my office I didn't want to put luminaires in the ceiling, I could instead put wallpaper or light panels on the wall."

However, the cost of OLED lights must first come down if the technology is to light up the mainstream; will this happen? Macrae believes so: "Efficiency and quality must also go up, and this [development] will cost millions. But it will happen in about five years' time."

LIGHT MEASUREMENTS

KNOW YOUR LUMENS

Lightbulb efficiency is measured in lumens per watt; the amount of light produced for each watt of electricity consumed. Put simply, more lumens per watt means more light for your money.

The most common energy-efficient lightbulbs include energy-saving or halogen incandescents, compact fluorescent lamps (CFLs), curly versions of the long tube fluorescent lights, and LEDs. Today's white light LED bulb produces around 150 lumens per watt; this figure is predicted to increase to 250 lumens per watt in the next decade. In comparison, the CFL produces 60 to 80 lumens per watt while the halogen incandescent produces around 16 lumens per watt.