Email: ed@eandpelectrics.co.uk

ENERGY EFFICIENT LIGHTING & CONTROLLERS

The advent of relatively cheap electricity in the mid 1950s together with advances in lighting technology shifted the balance in building design away from the traditional use of day lighting towards more reliance on artificial lighting. This change reflected society's newly kindled love-affair with technology and the belief that the environment within a building should be, above all, controllable and isolated from the exterior.

However, awareness of the planet's dire future and increased energy costs, have shifted the emphasis from mere comfort to energy conservation. The UK government's target is for an 80% reduction in carbon emissions by 2050 and to meet this all aspects of energy consumption must be examined and revised.

Ideally most working activities would be conducted by daylight, but of course this is not feasible, particularly in countries in northerly latitudes as the UK is. Energy efficiency in artificial lighting can be achieved by the use of better performing lamps, bulbs, luminaires/ballast and improved controls. This article will concentrate on these methods.

CONVENTIONAL LAMPS

Incandescent (GLS) lamps are still the most commonly used source of artificial light. A current is passed through a tungsten wire, heating it to about 2700K and making it glow. The system is cheap but because the filament has to be heated to such a high temperature, it has a luminous efficacy of only 15lm/W and about 95% of the energy is wasted as heat. Lifetime is only 750-2000 hours because of degradation of the filament which also causes blackening of the bulb and reduces light output through its lifetime. Reflectors can be built into the bulb to achieve a more directional light output.

Tungsten halogen lamps are similar in design but have a bromine compound added to the gas in the bulb which allows them to operate at a higher gas pressure and temperature and to avoid blackening. The luminous efficacy is increased to between 16 and 18lm/W and the average lifetime to 1000-2000 hours. Their smaller size allows for greater freedom in luminaire design, making them ideal for narrow beam spotlights.

Linear fluorescents are referred to by the letter "T" followed by a number referring to the diameter of the lamp in eighths of an inch. For example, the most common one, T8, has a 1 inch diameter. They operate by passing a current through a gas containing a mercury compound. The mercury atoms become excited and emit radiation, which is turned into visible light by a coating on the tube. As they operate at low temperatures they have a much higher luminous efficacy of between 60 and 96lm/W and a much longer lifetime of 12,000-20,000 hours. The current to the lamps is regulated by the ballast, which also pre-heats the lamp and provides the initial voltage to switch it on by establishing an arc between it electrodes. After starting, the ballast reduces the voltage and regulates the electric current – otherwise, the lamp would increase the current draw uncontrollably, overheat and burn out.
Conventional ballasts work on an electromagnetic basis and because they do not alter the frequency of the incoming current are prone to flickering. Electronic lighting ballasts, on the other hand, use solid circuitry to change the voltage and as they also alter the frequency of the current, flickering is avoided. Because of their use of solid circuits, electronic ballast are more efficient and run cooler than magnetic ones. The Lighting Industry Federation calculates that the cost of replacing magnetic ballast with a high frequency electronic one in a luminaire fitted with a T8 tube would be recovered within the first year.

ENERGY EFFICIENT LAMPS

One of the government's responses to the EU Energy Performance in Buildings Directive and its international obligations to reduce the country's carbon footprint, has been to phase out energy inefficient lamps, with the aim of totally eliminating their sale by 2012. As part of this timetable, the sale of GLS A-shaped lamps higher than 60W was discontinued from January 2009, sale of 40W lamps will be stopped by January 2010 and all GLS-A and 60W candle and golfball lamps will become unavailable from 31 December 2011.

Compact fluorescent (CFL) can be used in place of incandescent lamps. They have integrated ballasts and this accounts for their relatively high initial cost. A 20W CFL is equivalent to a 100W GLS-A and the European Lamp Companies Federation estimates that a straight replacement would achieve an £80 saving over the six year life of the lamp. Because CFLs contain small quantities of mercury, special provisions must be made for this disposal. The life of CFLs is 8000-10,000 hours.

T5 fluorescent lamps are thinner than T8 lamps and also more efficient, offering a higher intensity of light output. Maximum output is achieved at 35°C rather than 25°C as in T8 lamps. This permits their use in more compact locations where overheating would present problems, but also means they may need to be kept warm in colder locations, for example unheated warehouses. Until relatively recently it was not possible to fit T5 lamps into luminaires designed for T8 lamps, not only because of their size but also the need for different ballasts. However, an adapter has been developed that permits the use of T5 lamps in T8 luminaires. This both reduces energy consumption and extends the lamp's life. Typical life for a T5 lamp is 20,000 hours.

Light emitting diodes (LEDs) are electronic light sources. Diodes are electronic components, generally semiconductors such as silicon, germanium or selenium, that conduct electric current in one direction only. When current circulates through an LED, energy is released in the form of light, a phenomenon called electroluminescence.
At first their use was limited to pilot lights, electronic circuitry, etc, but high energy LEDs sources, producing 40-80lm/W, have been developed and these can be used for all forms of illumination. They have lower energy consumption than conventional lamps, extremely long lifetimes, are robust and very compact and have very fast ignition time. Different colours can be obtained according to the composition of the semiconductor used. LEDs do not burn out like GLS lamps, their light output declines slowly with time. In fact, the lifetime of LEDs is so long that it would not be practical to assess it by conventional testing to destruction as is done with other forms of lamps. Instead, the concept of estimated useful life, ie, the point at which lighting output has been reduced to 70% of the original, has been developed. For LEDs L70 is 35,000-50,000 hours.

ENERGY EFFICIENT CONTROLS

Case studies have shown that well applied lighting control systems can reduce the use of artificial lighting by 30-40%, with corresponding reductions in energy consumption. Control strategies can be broken down into:

- Manual. Occupants will initially turn on lighting according to daylight levels, but will often turn on all the lighting and not turn off again until everyone has left. This is often the best strategy for small rooms with only one or two occupants but for larger, more occupied spaces, energy can be wasted as occupants tend to turn on all the lights in the morning when daylight levels are low and leave them on all day irrespective of improved natural lighting. However, even a basic type of control can be used to create flexible and energy saving lighting options: for example, half of the lamps in each fixture could be switched together, every other fixture could be switched together to uniformly reduce the light levels, or lighting near the windows could be turned off.

- Timed systems. Lights can be turned off automatically at set times. Occupants can then switch them on again, but if natural lighting levels have improved they rarely do so. Clock switches can be used in conjunction with light-level sensors.

- Photoelectric switching. In its simplest form, lights are switched on or off according to daylight levels at a control point. This may result in continual switching if natural lighting levels are oscillating around the cut-off value, due to partly cloudy conditions for example. Therefore, these systems are better suited for well-lit perimeter areas where the lights are normally off during the day.

- Photoelectric dimming. These system also monitor natural lighting conditions, but use this information to alter artificial lighting levels to provide constant illuminance.

- Occupancy sensors serve three basic functions: to turn lights on automatically when a room becomes occupied; to keep the lights on without interruption while the controlled space is occupied; and to turn the lights off within a preset time after the space has been vacated.
  There are basically three types of occupancy sensors: passive infrared (PIR), which are triggered by the movement of a heat-emitting body through their field of view; ultrasonic sensors which emit an inaudible sound pattern and reread the reflection; and dual-technology occupancy sensors which use both passive infrared and ultrasonic technologies.
  PIR occupancy sensors are best suited to small, enclosed spaces such as private offices and corridors etc, where the sensor replaces the light switch on the wall and no extra wiring is required. PIR sensors cannot "see" through opaque walls or partitions, so occupants must be in direct line-of-sight view of the sensor. This is not a problem with ultrasonic sensors, which detect very minor motion better than most infrared ones and are often better suited to use in corridors, small rooms and toilets with cubicles (where line-of-sight view of the occupant is not always available) since the hard surfaces will reflect the sound pattern effectively.

- Programmable logic controllers (PLCs) are centralised lighting management systems that can reduce energy use significantly in buildings where the lights are often left on all night even when they are not needed. Sensors are installed to monitor daylight level, occupancy status, or both. The information is processed by a central controller that turns on, turns off, or dims lights in a building according to a preset programme. For example, turning on the lights before employees arrive, dimming them during periods of high powered demand or turning lights off at the end of the working day, perhaps turning them back on for a set period for cleaning purposes. PLCs can also be used for lumen maintenance. Lighting levels are always over-specified to account for light loss factors over the life of the lamps. Lumen maintenance allows luminaires to be dimmed when they are new, which minimizes the wasteful effects of over-design. The power supplied to them is gradually increased as they age to compensate for light loss over time. Additionally, PLCs are useful tools for conducting energy audits.

STATUTORY CONTROLS

Part L of the Building Regulations 2006 deals with the conservation of energy in buildings, including the provision of lighting. There are four Approved Documents dealing with new and existing, residential and non-residential buildings, as follows:

- New residential buildings (Document L1A). Installations having an efficacy of at least 40lm/circuit Watt are deemed to comply with the regulations. Additionally, energy efficient luminaires should be installed at least every 25m² (or one per four fittings installed). Storage areas and cupboards are not included. External lighting is limited to 150W per light fitting, with automatic switching by photocell and PIR. Alternatively, fittings with efficacy greater than 40lm/W are acceptable.

- Existing residential buildings (L1B). As above, applicable to extensions, refurbishments and material changes of use.

- New non-residential buildings (L2A). For offices, industrial and storage areas in all building types, the requirement is for efficacy greater than 45 luminaire-lumens/circuit Watt, increasing to 50lm/W initial efficacy (100 hours after installation) for all other building types. Additionally, there is a requirement for the provision of controls to avoid unnecessary lighting according to daylighting and occupancy and local switching at a distance no greater that 6m or twice the height of the luminaire above finished floor level. Display lighting should have an initial (100 hour) average efficacy greater than 15lm/W.

- Existing non-residential buildings (L2B): When installations covering more than 100m² are replaced, the criteria are the same as L2A. However, a control factor can be applied when automatic controls are in use to reduce energy consumption by reducing the required efficacy: 0.9 for photocells; 0.9 for occupancy and 0.85 for both combined.
  Since October 2008, most buildings (residential and commercial) require an energy performance certificate (EPC) when they are built, sold or let. The EPC is based on the performance potential of the buildings fabric and its services (heating, ventilation, lighting). Only buildings that use energy to condition the indoor climate are covered, so buildings with electric lighting but no heating, ventilation or air-conditioning are excluded. For example, a car park with natural ventilation and electric lighting would not require an EPC. Places of worship, temporary buildings (less than two years planned life) non-residential buildings less than 50m² and industrial sites, workshops and agricultural buildings with low energy demand are also excluded. EPCs have a three year validity for dwellings, 10 for commercial buildings.
  Additionally, public authorities and institutions with premises larger than 1000m² where public services are provided to a large number of persons require a display energy certificate (DEC). The DEC reflects the actual energy usage of the premises, as opposed to the EPC which is related to their potential performance. If the premises are sold or let, an EPC is also required.

ENHANCED CAPITAL ALLOWANCE (ECA) SCHEME

An important incentive for companies to update their installations to achieve higher efficiency is the enhanced capital allowance (ECA) scheme. This is a government initiative that allows businesses to claim 100% first-year capital allowances for energy savings investments.
The installation of high efficiency lighting units (HELUs) is included in the scheme HELUs are a combination of the luminaire, lamp/s and control gear into a single packaged unit, but none of the components qualifies individually. Six categories of HELUs are included, each with specific eligibility criteria.

COMMENTARY

Lighting consumes 19% of global electricity generation, more than the combined output of hydroelectric and nuclear power stations.
It has a profound effect on climate change and air pollution: for example, the carbon dioxide produced when generating that power is the equivalent of 70% of global emissions for passenger vehicles.

It has been estimated that 66% of all lamps installed in the EU at present are energy inefficient. The percentage for domestic use is even greater at 85%.
Friends of the Earth has estimated that if the whole of Europe switched to CFLs, there would be a saving of 28 mega tonnes of CO^2, the equivalent to that produced by 12 power stations.