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**MARK THROWER** MANAGING EDITOR

MODULE TEN
**LIGHTING**

# Good lighting design: what to consider

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The previous CPD article on lighting provided an introduction to lighting characteristics and different lamp types and controls. This article shall follow on from that in order to provide an overview of considerations for good lighting design.

The first aspect when looking at retrofitting lighting is to meet building regulations. There are minimum standards set for both general lighting requirements and display lighting requirements. It should also be highlighted that these standards are for both new and existing buildings. In the instance of existing buildings, the deciding factor is not whether a building warrant is required.

There are exemptions for having to meet building regulations, but a building warrant is not one of them. If in doubt, speak to your planning officer before undertaking any works and review the exemptions carefully.

However most designers and building owners should be looking to do better than the minimum requirements rather than avoiding meeting them. Additionally, the building regulations are about improving the energy performance of the buildings.

For Part L requirements (England and Wales), there are three areas to consider :

• Lighting in a new and existing building should meet the recommended minimum standard for

1) Efficacy (average over the whole area of the applicable type of space in the building and control in table 1

2) The LENI in table 3. The LENI should be calculated using the procedure described in section 12.5.

• The lighting should be metered to record its energy consumption in accordance with the minimum standard table 2.

• Lighting controls in new and existing buildings should follow the guidance in BRE digest 498 Selecting Lighting control. Display lighting, where provided, should be controlled on dedicated circuits that can be switched off at times when people will not be inspecting exhibits or merchandise, or being entertained.

**Table 1: Recommended minimum lighting efficacy with controls in new and existing buildings**

| General lighting in office, industrial and storage spaces | | Initial luminaire lumens/circuit-watt 60 |
|---|---|---|
| **Controls** | **Control factor** | **Reduced luminaire lumens/circuit-watt** |
| a daylit space with photo-switching with or without override | 0.90 | 54 |
| b daylit space with photo-switching and dimming with or without override | 0.85 | 51 |
| c unoccupied space with auto on and off | 0.90 | 54 |
| d unoccupied space with manual on and auto off | 0.85 | 51 |
| e space not daylit, dimmed for constant illuminance | 0.90 | 54 |
| a + c | 0.80 | 48 |
| a + d | 0.75 | 45 |
| b + c | 0.75 | 45 |
| b + d | 0.70 | 42 |
| e + c | 0.80 | 48 |
| e + d | 0.75 | 45 |
| General lighting in other types of space | | The average initial efficacy should be not less than 60 lamp lumens per circuit-watt |
| Display lighting | | The average initial efficacy should be not less than 22 lamp lumens per circuit-watt |

## Efficacy Requirements method

Item (i) refers to a minimum efficacy in lumens per circuit wattage for the area that is being lit, and sets out the standards in a table. A designer/installer simply has to ensure that the general lighting and display lighting proposed is better than what is shown on the table. Note: lumens is the amount of light out of a fitting and the total circuit wattage is the total power from a fitting (i.e., including the ballast as well as the lamp).

## The details of table 1

• The first row shows the initial lumen per circuit watts required by a fitting;

• The following controls row shows the factor that can be included for the installation of controls or combinations of controls. For example, an unoccupied space with auto on/off can have luminaires with an efficacy of 54 lm/TCW – a PIR being installed;

• The penultimate row shows the efficacy required for other areas, like a sports hall or café – not an office/ classroom, industrial or storage area.

• The last row is the minimum efficacy for any installed display lighting.

To put this into perspective, Figure 1 (over page) shows the approximate efficacies of some lamps over the last 70 years and projected in the near future. If we drew a line across from the 60lm/ TCW, we would see that a lot of the traditional lamps would not be suitable going forward. It is also implying that linear fluorescents like T5 are likely to be the only fluorescent lamps suitable when this minimum standard is increased further, which is likely in the near future. It also highlights what is expected of LEDs and that it is likely to be the main source of light. Many other similar versions of this chart are available online.

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### (Lighting Energy Numeric Indicator) LENI

An alternative way to ensure compliance is to use the LENI method (Item ii), which is a way to calculate the performance of lighting as the amount of energy per square metre (kWh/m2). This method takes into account the day time energy use, the night time energy use, and also the parasitic energy from any of the controls. The overlaying formula is:

Where:

- Ep is the Parasitic Energy consumption in W/sqm;
- Ed is the daytime energy use
- En is the night time energy use

The factors contained in the formulas are:

- Pi is the total power in watts for the lighting in the space.
- Fo is the occupancy factor for the area, this will be dependent on the controls installed.
- Fd is the daylight factor, when controlled by some form of daylight control.
- Fc is the constant illuminance factor, which is centred around some lighting systems controlling the output from the lamps to overcome any maintenance factor (depreciation of lighting over time).
- Td and Tn is the daytime and night time hours that they operate for.

The LENI value along with the design lighting level (Lux) can be compared with the table 2 to ensure compliance.

In addition to the lighting efficacy and consumption benchmark, metering and controls are also a requirement.

### Metering for Lighting

Lighting systems should be metered in some way. The guide offers three options to do this which are shown in the table 3:

In practice, the means by which this shall be met will depend on the cost, which systems are already in place or going to be in place, their capability, and also how the information is looking to be presented. It is likely that cost and ease of use shall be the main drivers.

### Lighting Controls

The guidance directs us to the BRE digest 498. The essence of this is that a building is divided into zones according to:

- 'ownership'/use (office/corridor/ meeting room and so on); and
- availability of natural light.

Appropriate controls are then selected for each zone. Controls to be considered are:

- movement sensing;
- light level sensing and 'daylight harvesting';
- [a] maintained illuminance;
- timing control;
- integrated building control; and
- any combination of these.

For further information on lighting control, see the Light Industry Association website: www.thelia.org.uk

### Scotland

In Scotland a building with a floor area of more than 50m$^2$ and installed with artificial lighting should have general purpose artificial lighting systems which are designed to meet the minimum standards for efficiency:

- general lighting in office, industrial and storage areas - Not less than 55 luminaire lumens per circuit-watt.
- general lighting in other types of space - not less than 55 lamp lumens per circuit-watt.

The guidance also includes control factors. When calculating the average luminaire lumens per circuit-watt, the circuit-watts for each luminaire may first be multiplied by the control factors:

- control factor of 0.9: for Luminaire in a day-lit space, light output controlled by photoelectric switching or dimming control, with or without override.
- control factor of 0.9: for Luminaire in a space likely to be unoccupied most of the time, where a sensor switches off the lighting in the absence of occupants but switching on is done manually except where this would be unsafe.
- control factor of 0.85: if both Circumstances above are combined.
- control factor of 1: if None of the above.

In addition, the guidance also states that 'the lighting design should be completed in accordance with the guidance given in the Society of Light and Lighting (CIBSE) Code for Lighting 2009'.

**Fig 1: Approximate efficacies of some lamps over the last 70 years**

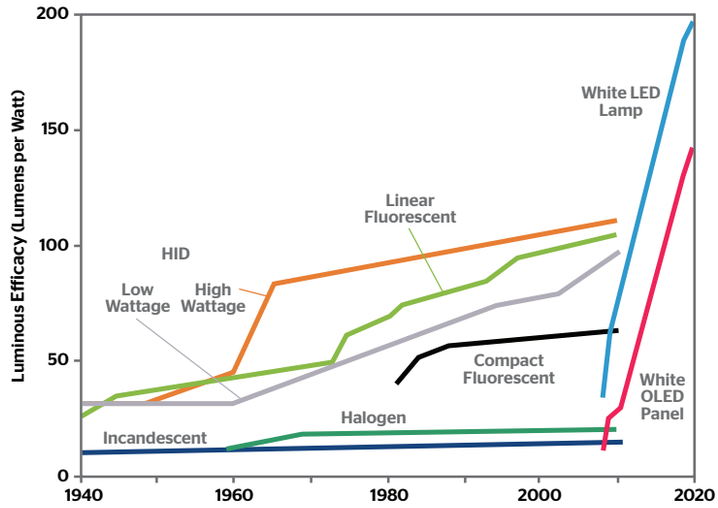



**Table 2: Recommended maximum LENI (kWh per square metre per year) in new and existing buildings**

| | Standard |
|---|---|
| Metering for general or display lighting | a. kWh meters on dedicated lighting circuits in the electrical distribution, or<br>b. local power meter coupled to or integrated in the lighting controllers of a lighting or building management system, or<br>c. a lighting management system that can calculate the consumed energy and make this information available to a building management system or in an exportable file format. (This could involve logging the hours run and the dimming level, and relating this to the installed load.) |

**Table 3: Recommended minimum standards for metering of general and display lighting in new and existing buildings**

| Hours | | | Illuminance (lux) | | | | | | | | Display lighting | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | Day | Night | 50 | 100 | 150 | 200 | 300 | 500 | 750 | 1000 | Normal | Shop window |
| 1000 | 821 | 179 | 1.11 | 1.92 | 2.73 | 3.54 | 5.17 | 8.41 | 12.47 | 16.52 | 10.00 | |
| 1500 | 1277 | 223 | 1.66 | 2.87 | 4.07 | 5.28 | 7.70 | 12.53 | 18.57 | 24.62 | 15.00 | |
| 2000 | 1726 | 274 | 2.21 | 3.81 | 5.42 | 7.03 | 10.24 | 16.67 | 24.70 | 32.73 | 20.00 | |
| 2500 | 2164 | 336 | 2.76 | 4.76 | 6.77 | 8.78 | 12.79 | 20.82 | 30.86 | 40.89 | 25.00 | |
| 3000 | 2585 | 415 | 3.31 | 5.72 | 8.13 | 10.54 | 15.37 | 25.01 | 37.06 | 49.12 | 30.00 | |
| 3700 | 3133 | 567 | 4.09 | 7.08 | 10.06 | 13.04 | 19.01 | 30.95 | 45.87 | 60.78 | 37.00 | |
| 4400 | 3621 | 779 | 4.89 | 8.46 | 12.02 | 15.59 | 22.73 | 37.00 | 54.84 | 72.68 | 44.00 | 96.80 |
| 5400 | 4184 | 1216 | 6.05 | 10.47 | 14.90 | 19.33 | 28.18 | 45.89 | 68.03 | 90.17 | 54.00 | |
| 6400 | 4547 | 1853 | 7.24 | 12.57 | 17.89 | 23.22 | 33.87 | 55.16 | 81.79 | 108.41 | 64.00 | |
| 8760 | 4380 | 4380 | 10.26 | 17.89 | 25.53 | 33.16 | 48.43 | 78.96 | 117.12 | 155.29 | 87.60 | 192.72 |

### For Display Lighting

Display lighting installations will be considered energy efficient where:

- the installed lighting capacity comprises of lighting fittings with lamps having an average initial (100 hour) efficacy of not less than 22 lamp lumens per circuit watt; or
- at least 95 per cent of the display lighting capacity in circuit Watts (i.e. the power consumed by lamps, their associated control gear and power factor correction equipment) which is provided by lighting fittings with an efficacy not less than 22 lamp lumens per circuit watt.

### Lighting Control Compliance for Scotland

Similar to the Part L guidance on Controls, Scotland does refer to the BRE digest 498 but also refers to BRE information Paper IP6/96 'People and lighting controls', Society of Light and Lighting (CIBSE) Code for Lighting 2009 and BRE Non Domestic Lighting GBG 61 Part 3.

It also states that 'every artificial lighting system in a building that has a floor area of more than 50m2 should have controls which encourage the maximum use of daylight and minimise the use of artificial lighting during the times when rooms or spaces are unoccupied.' It provides Table 4 as guidance:

For display lighting it is expected that the lamps are time controlled in some way: 'can be switched off at times when people will not be inspecting exhibits or merchandise or occupying the spaces used for public entertainment.'

The Scottish Building Regulations also make the statement that for existing buildings: 'improvement....should be made....when upgrading of lighting controls and luminaires to current levels of efficiency/efficacy'. This is simply to cement the spirit of building regulations

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in order to improve the energy performance of existing buildings.

So far we have looked at the compliance of the lighting requirements for building regulations. In addition to this there are several other considerations that need to be considered (excluding emergency lighting which is another consideration for lighting design):

- visual function;
- visual amenity;
- maintenance;
- architectural integration;
- energy efficiency and sustainability; and
- capital and operating costs.

Two other areas in lighting design to be considered but that are not covered in this article are (see Society for Light and Lighting 2009 for these items):

- photopic or mesopic vision; and
- light trespass and sky glow.

Visual Function is the lighting required for undertaking a task without causing discomfort. It can be summed up in four situations :

- visual task difficulty – lighting that makes it difficult to extract information;
- under or over stimulation – visual environment has too little or too much information.
- distraction – observer's attention is drawn to objects that do not contain information.
- perceptual confusion – pattern of illumination is confused with pattern of reflectance.

This means in designing we also need to consider:

- sufficient light to perform the task;
- an appropriate lighting level (not too little or too much).
- Illuminance uniformity:

Utilising a regular array of luminaires while avoiding too high and low levels under and between luminaires (maximum/minimum, and/or minimum/average lighting levels in a space).

- Glare:

The presence of too much light above the average in the field of vision will produce discomfort.

- Reflections:

Reflections from surfaces that change the contrast of the visual task, this is dependent on the surface reflection and also the angle between the eye/surface/light.

- Shadows:

Cast when light is blocked in some way by an object reducing the lighting levels in an area.

- Flicker:

When the AC supply produces fluctuations in the amount of light output, this is called flicker.

## Visual Amenity

This is using lighting to add amenity to a space and it is categorised as visual lightness and visual interest. Visual lightness is the overall lightness in a space (brightness) and is related to the lighting levels of a vertical surface. The desire for visual amenity shall depend on the task, i.e., this would be different in a warehouse from a classroom. Visual interest refers to the non-uniformity of the pattern of light (dark and light areas). To illustrate this, it may be considered a poor design if the light variation for no beneficial reason provides random dark patches in a room. Colour temperature and colour rendering will also have an effect on the visual amenity.

## Maintenance

Lighting and the light output will depreciate over time and during the design stage this needs to be taken into consideration. The factors that need to be taken into consideration are:

- lamp replacement;
- cleaning of luminaires;
- cleaning of room surfaces;
- maintained lighting level required near end of life; and
- disposal of lamps may also be a consideration.

At the design stage a maintenance factor is included to cover these aspects. With LED fittings having a lower maintenance factor there is an additional benefit to them. However, it should still be included in the design and not overlooked like it commonly does in some LED evaluations.

## Architectural integration

Generally all lighting will impact on the architecture of the interior of a building, and consequently when designing lighting it is important to understand the space. The aspects that need to be considered are the dimensions, the finishes, the textures and the colours of material of the finishes, as these all add to the atmosphere in a space. It can also mean consideration of daylight in a building and not just the artificial lighting. A simple look of a fitting can often be contentious as can the mounting of it, i.e. a previously recessed fitting changing to a suspended fitting.

## Energy efficiency and sustainability

It is the responsibility of designers and owners to ensure that lighting is achieved as efficiently as possible whilst providing an effective environment (effective being the appropriate design for the task and space). It also means taking consideration for the use of lighting energy consumption, the materials to be disposed of safely at the end of their useful life, and the materials that need replacing over time – lamps and ballast.

**Table 4: Controls for general and display lighting**

| Space Classification | Control Type |
|---|---|
| Owned<br><br>(small room for one or two people who control the lighting) | Manual, by door |
| Shared<br><br>(multi-occupied area, e.g. an open-plan office or factory production area) | Flexible manual switching, e.g. pull cords or wireless transmitter |
| Temporarily owned<br><br>(where people are expected to operate the lighting controls while they are there, e.g. a hotel room or meeting room) | All types and ratings |
| Occasionally visited<br><br>(used for short period of time, e.g. store room or toilet) | Presence or absence detection (avoid use where this may cause a hazard or inconvenience, e.g. in an accessible toilet), manual control |
| Unowned<br><br>(where individual users require lighting but are not expected to operate controls, e.g. a corridor or atrium) | a. time switching<br><br>b. presence or absence detection or<br><br>c. photoelectric switching or dimming (if daylit space) |
| Managed<br><br>(where lighting is under the control of a responsible person, e.g. a hotel lounge, restaurant or shop) | a. time switching<br><br>b. centralised manual switching or<br><br>c. photoelectric switching or dimming (if daylit space) |

## Capital and operating costs

Costs are always an importance for any service, design and not just lighting. Both the capital costs and operating costs need to be considered during the design stage. The best way to do this (to also allow for a fair comparison of different lighting schemes) is to carry out a life cycle analysis incorporating the capital cost, the operating cost, and the maintenance costs. With the move towards LED schemes, it is often important to include the reduced maintenance cost for the scheme to show the full value of it. If a simple payback is carried out on the energy savings and capital cost, the significant maintenance benefits may be overlooked.

## Relux and Dialux

Free software is available to us that can provide designs for lighting schemes – Relux and Dialux. Most manufacturers provide a lighting file for their lighting, which can then be imported into these programmes. The programmes allow for a drawing of the room or building to be imported too, allowing for a design and several different iterations of design to be carried out. It is recommended that if you are involved in reviewing lighting schemes that you utilise these programmes as they provide information on many of the items that are associated with good design.

## Further reading/sources of information:

- *CIBSE - See www.cibse.org.*
- *The Society of Light and Lighting (CIBSE) - See www.cibse.org.*
- *Lighting Industry Federation – See www.lif.co.uk.*
- *A UK Electrical Installation Products and Contractor website - See www.voltimum.co.uk.*
- *Lighting Manufacturers websites – many have teaching materials available to learn more comprehensively about lighting.*
- *BRE digest 498 Selecting Lighting Controls.*
- *Part L2A and Part L2B.*
- *Scottish Building Regulations.*
- *Non-Domestic Building Services Compliance Guide.*
- *BRE Non Domestic Lighting GBG 61 Part 3.*
- *BRE information Paper IP6/96 'People and lighting controls'.*
- *Dialux online.*
- *Relux online.*

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Please mark your answers on the sheet below by placing a cross in the box next to the correct answer. Only mark one box for each question. You may find it helpful to mark the answers in pencil first before filling in the final answers in ink. Once you have completed the answer sheet in ink, return it to the address below. Photocopies are acceptable.

### QUESTIONS

**1. Efficacy is a measure of**
- ☐ Lumens per square metre
- ☐ Lumen per circuit watt
- ☐ Lux levels per square metre
- ☐ Lux levels per circuit watt

**2. For controls of lighting, Part L refers to the BRE digest**
- ☐ 498
- ☐ 489
- ☐ 398
- ☐ 389

**3. What is the general lighting lumen per circuit watt for Scotland?**
- ☐ 55
- ☐ 60
- ☐ 65
- ☐ 70

**4. In Part L, what is the control factor that can be used for installing a PIR auto on/off?**
- ☐ 0.8
- ☐ 0.85
- ☐ 0.9
- ☐ 0.95

**5. What does LENI stand for?**
- ☐ Lighting Efficiency Numeric Indicator
- ☐ Lighting Efficacy Numeric Indicator
- ☐ Lighting Energy Numeric Indicator
- ☐ Lighting Effectiveness Numeric Indicator

**6. What is the efficacy (lm/TCW) standard for display lighting**
- ☐ 20
- ☐ 22
- ☐ 24
- ☐ 26

**7. What category would the consideration of glare come under?**
- ☐ Visual Function
- ☐ Visual Amenity
- ☐ Architectural Integration
- ☐ Task Lighting Level

**8. How many different options are there to comply with the minimum standard for metering?**
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

**9. What is the LENI for a room requiring 300lux and 4,400 hour per year?**
- ☐ 15.59
- ☐ 19.01
- ☐ 22.73
- ☐ 37.00

**10. As well as visual lightness and visual interest what other aspect do you need to consider for Visual Amenity?**
- ☐ Colour Temperature
- ☐ Shadow
- ☐ Flicker
- ☐ Reflections

Please complete your details below in block capitals

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