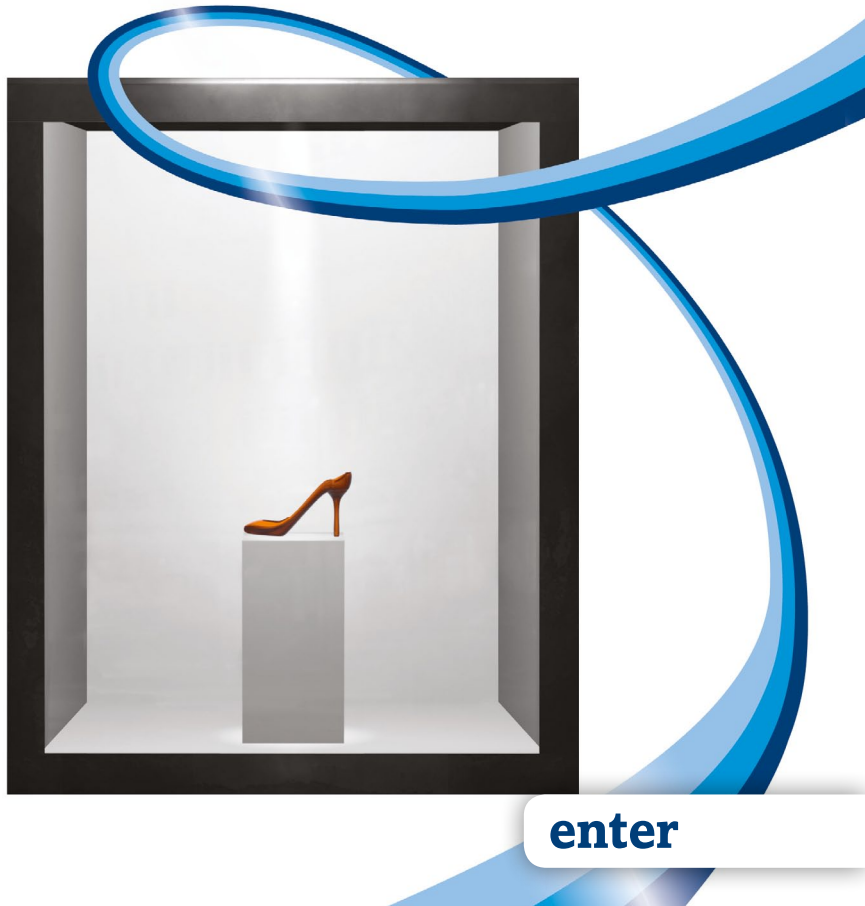
CARBON TRUST

Display lighting

Creating maximum impact with minimal energy consumption



Preface

Reducing energy makes perfect business sense; it saves money, enhances corporate reputation and helps everyone in the fight against climate change.

The Carbon Trust provides simple, effective advice to help businesses take action to reduce carbon emissions, and the simplest way to do this is to use energy more efficiently.

This technology guide introduces the main energy saving opportunities relating to display lighting and demonstrates how simple actions reduce energy costs and cut carbon emissions without losing visual impact.

Introduction

Effective display lighting ensures that merchandise, exhibits and the internal environment can be clearly seen in an aesthetically pleasing manner with the maximum visual impact. Every business or organisation has different lighting requirements. Aside from essential health and safety functions, lighting is also imperative in creating appropriate comfort conditions and ambience.

This publication focuses on the key sectors that use lighting specifically for display purposes. These include:

- The retail sector, where lighting helps to entice customers, highlight merchandise and maximise sales.
- The hospitality and leisure sectors, where lighting enhances the guest experience.
- The heritage and cultural sector, where lighting illuminates displays in museums and art galleries and aids visual comfort in libraries.
- The business environment, where lighting is used to make reception areas feel welcoming and create a professional feel for staff and visitors.

Who is this publication for?

This guide contains detailed information aimed at energy managers, facilities managers and those with a real interest in implementation. It has been designed to help users understand the key elements to be considered when designing lighting displays, selecting the best choice of equipment available for their requirements and maximising the opportunities for energy saving.

It is expected that readers will have prior knowledge and experience of energy efficiency and are familiar with the basic advice given in the Carbon Trust's Lighting technology overview (CTV049).

What are the benefits?

With many clients and customers now demanding that organisations demonstrate their environmental credentials, being energy efficient can significantly enhance day-to-day business on many levels. There are important social and environmental advantages to reducing energy consumption, reducing carbon emissions and minimising climate change.

Improving the efficiency of display lighting will lead to cost and energy savings. It will also reduce maintenance costs, improve lighting distribution and control, increase staff and customer satisfaction, reduce heat gain (leading to a reduction in cooling demand) and help organisations comply with legislation.

This guide will help to:

- Assess the potential for energy savings in current display lighting schemes and indicate areas for improvement.
- Brief design consultants to produce attractive, energy efficient lighting designs.
- Select the most appropriate lighting.
- Appraise the economics of energy efficient lighting schemes.
- Raise awareness of energy conservation among staff and motivate them to reduce energy waste.

Display lighting requirements for Part L of the building regulations

Approved Document ADL2 Conservation of fuel and power in non-dwellings provides guidance applicable to all new buildings and refurbishments with over 100m^2 of floor area. Under the regulations, the definition of display lighting refers to lighting intended to highlight exhibits or merchandise and lighting used in spaces for public entertainment. The exception is special process lighting such as that used in theatre spotlights, photographic studio lighting, illuminated signs and portable lighting. Other decorative elements such as illuminated fountains, chandeliers and all forms of emergency escape lighting are also exempt.

The regulations state that *reasonable provision* would be to demonstrate that the installed capacity of display lighting averaged over the building, has an initial (100-hour) efficacy (see page 7) of at least 15 lumens per circuit-watt (this figure includes power consumed by ballasts or transformers). The types of light source that are likely to meet the guidance criteria for display lighting are shown in the table below.

Spaces where display lighting is present would normally be expected to also have general lighting for circulation and for the purposes of cleaning and restocking outside public access hours. This does not have to be included in the calculation for building regulations.

For further information on building regulations see www.planningportal.gov.uk

Table 1 Light sources meeting the criteria for display lighting

Light source	Types and ratings
High pressure sodium	All types and ratings
Metal halide	All types and ratings
Compact and tubular fluorescent*	All types and ratings
Tungsten halogen	All types and ratings
Other lamps	Any type and rating with an efficacy greater than 15 lumens per circuit Watt

*From an energy efficiency and lighting standpoint, triphosphor or multiphosphor lamps should always be the first choice for all fluorescent interior applications.

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Energy consumption

In the UK, lighting consumes around 20% of all electricity generated and can account for a significant proportion of an organisation's electricity bill and carbon emissions.

There are three key factors that impact on energy consumption in lighting:

1. **The quantity of light** – It is important to design for adequate but not excessive lighting. Good contrast between display and general lighting can be as effective a marketing tool as using more lighting overall, so do not use any more than necessary.
2. **How it is used** – Check what lights are on and for how long. Learn how to set and regulate controls to maximise efficiency opportunities.
3. **The associated equipment** – The most efficient lamps and fittings must be used for the required task along with the appropriate controls. These should all be regularly checked as part of a maintenance programme.

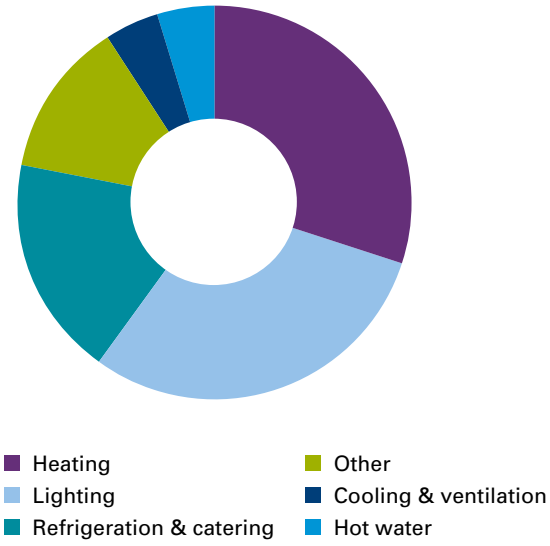
It is not just the light itself which consumes energy. Some lamps have a high heat output which can make an area uncomfortably warm, therefore increasing ventilation and cooling requirements.

Making savings

Installing efficient lighting need not be expensive and can save money, improve customer and staff satisfaction and enhance the aesthetics of the display lighting setup. The following steps can cut energy use and costs.

- **Reduce the need** – The design and specification of lighting systems have a big impact on energy use and hence, energy costs. Understanding the requirements of display lighting can help to specify more efficient systems – see page 21 to find out more.
- **Maintain existing systems** – Regular maintenance is vital for maximising energy savings and maintaining the desired aesthetic of display lighting as explained on page 22.
- **Understand and use controls** – Learning how to set up and regulate lighting controls can provide substantial savings and enhance displays. See page 24 for more information.
- **Refurbish** – There are significant opportunities for energy saving during upgrades, new build or refurbishment. Page 26 shows how new, efficient equipment can quickly pay back its costs.

Figure 1 Total carbon emissions from energy use in public and commercial buildings 2002



Technology overview

There is a broad range of lamps, fittings and controls available. By considering all the options, you can make the most informed choice to meet your display lighting needs with the most energy-efficient setup.

Display lighting systems, like other lighting systems are made up of three key components:

- **The lamp** – the source of the light, for example, the bulb or tube
- **The luminaire** – a light fitting that incorporates the lamp
- **The controls** – manual or automatic switching equipment, which operates the lighting system.

The primary objective of any display lighting scheme should be to maximise the effectiveness of light. This is not just about the energy used but also the aesthetics, the mood, and the look and feel that display lighting creates. The key factors are described below.

Illuminance

Luminous efficacy

Efficacy is measured in lumens/Watt and describes the efficiency at which a lamp converts electricity into light. It relates the total light output of a lamp to the total amount of electricity consumed by the circuit. It is important to include all the elements of the system that consume energy and affect light output.

The table on page 7 shows the typical efficacy range for most lamp types. A range of values is shown for all lamps because efficacy is not a constant for a particular lamp type but depends also on its size, power rating (Watts), light output (lumens) and also its shape and material composition.

For instance, tubular fluorescent lamps are available in three common diameters – 38mm (T12, now obsolete), 26mm (T8) and 16mm (T5) and three common phosphor types – halophosphate (low colour rendering; not recommended), triphosphor (good colour rendering; most efficient) and multiphosphor (excellent colour rendering; for use when colour rendition is critical).

Consult the lamp manufacturer for more accurate data. Lamp manufacturers' catalogues will also provide details of all aspects of lamp performance.

Did you know?

It is possible to cut your lighting bills by up to 30% by implementing simple efficiency measures.

Table 2 *Typical lamp efficacies*

Lamp type	Efficacy lumens/Watt
Incandescent – tungsten filament	6-14
Incandescent – tungsten halogen	13-26
Compact fluorescent	45-70
Tubular fluorescent	38-106
Low pressure sodium	100-168
High pressure sodium	70-150
High pressure metal halide	70-113
Light emitting diodes (LEDs)	25-100 Variable depending on colour and increasing as technology develops

Illuminance or 'the right amount of light'

Illuminance is measured in lumens/m^2 or lux and is the term used to describe the amount of light falling on a surface, such as on a table, wall or a display area. The amount of light required will depend on what activity is taking place in the area or what is being displayed. Recommended illuminance figures for all indoor workplaces, including retail and other display lighting are given in a European Standard BS EN 12464-1[1].

For specific display items that require high light levels, it is often better to provide task lighting or spot lighting rather than lighting the whole area. This will allow other areas in the space to be lit to a lower level, which can reduce costs and create a feeling of drama or mood. The beam angle of spotlighting should be considered to provide high impact lighting only to the specific area where it is required. Focal points of display lighting can draw customers through a shop, exhibition or gallery.

Did you know?

As lamps age, they emit less light for the same amount of energy. 'Maintained illuminance' is the minimum light level required for the task and is a useful way of gauging whether a lamp should be imminently replaced.

[1] BS EN 12464-1 Light and lighting. Lighting of work places. Indoor work places.

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Colour

Colour performance and colour rendering

The colour performance of a lamp is described by its general colour rendering index (Ra) which defines its ability to show colours accurately. It is described by a number: 90-100 is considered to be excellent, whilst a value of 80 and above is good and appropriate for most situations where display lighting is required. Where accurate colour identification is important, a value of 90 or above should be used. The Society of Lighting and Light recommends that most general building areas should now use a minimum colour rendering of Ra 80+.

When providing display lighting for museum or art collections, high levels of lighting should be avoided, particularly lamps with a high ultraviolet content which may cause material degradation or colour fading. Where tungsten halogen lighting is used, the addition of an ultraviolet filter may be required. A ceramic metal halide lamp with reduced UV content may be a better choice.

Colour appearance

The colour appearance of light from a lamp is described by its correlated colour temperature and is defined in terms of 'warmth' or 'coolness'. For example, a warm-appearance lamp, such as an incandescent lamp, will have a value of 2,700-3,000 Kelvin whilst a lamp which mixes reasonably well with daylight will have a value of 4,000-6,000 Kelvin. For more information, see Appendix A.

Visual appearance

Light distribution

The distribution pattern of lighting is crucial to the effectiveness of a system's design. Occupants walking into an illuminated space will mainly view vertical surfaces; the floor and ceiling will be in their peripheral vision. Therefore in order to make the area look bright, it is most important to illuminate the vertical surfaces. For instance, a supermarket aisle that is illuminated directly downwards with no light reflected on to shelving would appear dark, even though lighting levels may reach the required standards. Most general use areas require well-balanced light distribution to create a safe and productive environment.

Designing for daylight

The provision of daylight in a building can have positive benefits on its occupants as well as saving energy. Careful design or assessment of how windows are placed is essential to maximise natural light, using electric lighting to supplement only where necessary. The design of lighting controls is also crucial here in order to create a system that is both energy efficient and user friendly.

Luminaires

Efficient luminaire design

The light fitting or 'luminaire' physically supports the lamp, directing the light and providing a safe connection to the electricity supply. An efficient lamp in a poorly designed and inefficient light fitting can still waste energy, so look for luminaires that use efficient optics (reflectors and refractors) together with efficient lamp control gear to provide the required lighting effect.

Further information

For more information, see the Lighting technology overview (CTV049) available from the Carbon Trust.

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Light output ratio

A simple measure of a luminaire's efficiency is its light output ratio (LOR). This is the ratio of the luminaire's light output to the light output of the bare lamp(s) and is usually expressed as a ratio or percentage. For most situations, a luminaire with an LOR of 50% or greater should be used, but this will depend on the light output distribution required.

However, LOR is not normally used as a measure of the efficiency of spotlighting. For this kind of lighting, choose the beam angle (spread) required for the particular display application and the fitting that gives the required illumination level (in lux from BS EN 12464-1, see footer on page 7) using the lowest lamp wattage.

Aesthetics of luminaires

The shape and colour of a luminaire should be considered to ensure it is not detrimental to the amount of light being emitted. The luminaire also provides directional control so that the light is directed where it is needed and glare is reduced. Glare is caused by excessively bright, unshielded light sources and can cause discomfort to building occupants, so should be avoided.

Quality and regulatory compliance

Only luminaires with the appropriate quality assurance (CE Mark) should be used and lamps with a high rated 'lamp life' should be specified. Additional system components should be certified with the appropriate EN number (this can be found on products complying with specified Euro Norm (EN) safety standards).

High street banking

In banks, building societies and high street agencies which sell services rather than goods, effective and business-like lighting is needed for marketing purposes. Although there is no merchandise to display, there is a still a need for an attractive interior to draw in potential customers. Display lighting may include spotlighting to highlight posters and display boards advertising job vacancies, for example.

Retail

The use of lighting with good colour rendering is essential in helping to generate sales, particularly in fashion retail, where the customer must be able to see the actual colour of the goods. Good colour rendering is also critical in food retailing, where the goods must look appealing. The lighting designer should take care in selecting lamps to give the most appropriate colour rendering for the application.

- Lighting of a cooler appearance installed over chilled displays can enhance the fresh appearance of the goods.
- Special lamps can be used over red meat displays to bring out the fresh appearance of the meat.
- 'White goods' are best displayed under bright, clear, cool lighting.
- 'Brown goods' are better displayed under subdued lighting.
- Gold is best displayed under warm lighting, since under cool lighting its differentiation from silver is less pronounced.

Choosing the right lamp for the task

There are many different types of lamps available, and choosing the right one is vital to maximise savings.

While there are many types of lamps, as described below, for most display lighting purposes a combination of T5 fluorescent tubes, CFL 'display luminaires' and compact metal halide spotlights should provide an appropriate visual effect.

Tungsten filament lamps (not halogen)

The most common types are known as general lighting service (GLS) lamps and decorative, for example, candle lamps. They have an efficacy of only about 6-14 lumens/Watt. Incandescence literally means light produced from heating, achieved by passing an electrical current through a strand of tungsten filament. The filament is delicate and eventually burns out after about 1,000 hours. Although some lamps are made to last longer and sold as double life lamps, this is at the cost of light output. Another type is the reflector (R-type) lamp. These can be used for spotlighting but they are very inefficient.

Advantages:

- Low purchase price
- Excellent colour rendering
- No ballast required
- Immediate full light when switched on
- Ease of dimming
- Sparkle lighting effects can be created
- Operates in any plane (universal operating position).

Disadvantages:

- Very poor efficacy – as low as 6-14 lumens/Watt
- Very low life, usually 1,000 hours
- Very high running cost.

Energy Technology List

The Energy Technology List (ETL) is a list of products which may qualify for Enhanced Capital Allowances (ECAs). The ETL includes high efficiency units for display lighting. Qualifying products include efficient fluorescent, compact fluorescent, metal halide and high-pressure sodium units. Manufacturers of lighting equipment should be able to advise which of their products comply with ETL criteria. More details can be found at www.carbontrust.co.uk/eca

Tungsten halogen (quartz halogen) lamps

These are versions of the tungsten filament lamp. Many tungsten halogen lamps operate at 12 volts (extra low voltage – ELV) and require a transformer. This light source is compact and can be focused and directed. They are therefore particularly appropriate for spotlighting and many come with integral reflectors. The reflector may be metal, reflecting both light and heat forward, or dichroic, reflecting light forward but allowing heat to pass through to the back of the luminaire. Dichroic lamps are therefore well suited to display lighting where heat could damage the item on display, but they require suitable lampholders and luminaires.

Although they should not be regarded as having high efficacy, tungsten halogen lamps produce 16-19 lumens per watt for standard lamps and last longer than standard tungsten filament lamps. 'Energy saving' infrared halogen lamps are slightly more efficient with efficacies of up to 25 lumens/Watt and can last up to 5,000 hours. Mains voltage tungsten halogen lamps can be dimmed with a simple domestic dimmer of the right capacity, but some ELV lamps may require a special dimmer depending upon the type of transformer used.

Running tungsten lamps at lower than the rated voltage, for example when dimming the light, will lower the filament operating temperature, preventing the halogen cycle from taking place, and causing the lamp to blacken. In a halogen cycle, when the lamp heats up, the filament gives off tungsten which combines with the halogen gas. This tungsten is re-deposited on the filament on cooling down (when the lamp is switched off).

The blackening can be removed by occasionally running the lamp at full light output. The quartz lamp envelope should not be handled with bare hands and manufacturers' instructions regarding the operating position of the lamp should be observed.

A number of new designs of tungsten halogen lamps have been developed which are designed to replace tungsten filament lamps. These lamps are 25%-50% more efficient than tungsten filament lamps and can be used when 'sparkle' is required – e.g. in glass or crystal fittings.

Case study

CDM lamps

One major supermarket used to use 100W tungsten halogen lamps but has since changed to 35W ceramic discharge envelope (CDM) tubes, reducing the energy used by over 50%.

A 20W CDM lamp is now available which can replace 50W tungsten halogen lamps, halving energy consumption yet providing increased light output. A recent test installation in two travel agents using the new type 20W CDM lamps together with 32W compact fluorescent lamps halved the installed power density from 50W/m² to 25W/m², even though the previous lighting was predominantly compact fluorescent.

Image supplied courtesy of Philips Electronics UK Limited

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Advantages:

- Brighter, whiter light
- Excellent colour rendering
- No ballast required
- Immediate full light output when switched on
- Can be dimmed
- Bulb blackening eliminated when run at full light output
- Higher efficacy than conventional tungsten filament lamps, but still very poor.

Disadvantages:

- High running cost
- Low life of 2,000 to 5,000 hours depending on type
- Transformer required for extra low voltage lamps
- Requires careful handling
- Operating positions of double ended types is limited to horizontal.

Compact fluorescent lamps

Compact fluorescent lamps (CFLs) have been developed to replace tungsten filament lamp applications in display lighting, particularly in downlights, sometimes referred to as 'cans'. More compact downlights which resemble halogen sources are now available. New developments in compact fluorescent lighting are reducing source size; one example is a spiral tube in a GU10 reflector which can replace standard halogen spotlights.

Displays may also include domestic type lighting fittings with GLS tungsten lamps, which could also be replaced by compact fluorescents. These lamps give a light similar to tungsten lamps and present a good opportunity to save up to 80% of the energy required by tungsten filament lamps. Virtually all tungsten lamps can be replaced with compact fluorescents as and when the opportunity arises, except in some luminaires which use crystal glass to create sparkle.

An ever growing range of compact lamps is available in various wattages, shapes and sizes. In the majority of commercial applications, the lamp ballast is built into the luminaire so that only the tube need be replaced on failure.

Advantages:

- Low running cost
- Good colour rendering
- Small reduction of light output through life
- Prompt start and restart
- Quick run-up to full light output
- Universal operating position
- Medium efficacy.

Disadvantages:

- Excessive switching shortens life (not a problem for static retail display lighting)
- Low to moderate life (8,000-15,000 hours) in normal use
- Ballast required
- Can be dimmed but requires special ballast and dimmer.

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Tubular fluorescent lamps

Fluorescent lamps have four to 10 times the efficacy of incandescent tungsten lamps and can last up to 20 times longer, depending on the type of lamp and its ballast. All fluorescent lamps require a ballast to operate.

Fluorescent lamps work in entirely different ways to tungsten filament lamps. The fluorescent tube contains an inert gas, usually argon or krypton at low pressure, and a small amount of mercury. When an arc is struck between the lamp's electrodes, ultraviolet radiation is produced, which excites a phosphor coating on the inside of the tube to produce light at visible wavelengths.

The quality of light produced depends on the precise mix of phosphors in the coating. Older halophosphate phosphors decayed noticeably over the life of the lamp. The latest triphosphor lamps maintain most of their initial light output throughout their life and are the most energy efficient. Multiphosphor lamps are recommended only for applications for which colour rendering accuracy is critical.

Older tubular lamps 600mm long and over, were usually 38mm diameter and known as T12; newer lamps are 26mm diameter and known as T8, or 16mm known as T5. T12 tubes with switchstart fittings can be replaced directly with T8 lamps and will save up to 10% of the energy previously used (switchstart fittings often flicker briefly when switched on). T5 tubes cannot directly replace T12 tubes because of their different sizing, but manufacturers are developing retrofit systems to deal with this[2]. The higher efficiencies of T5 tubes can make the replacement of luminaires a worthwhile investment.

Using high-frequency (electronic) control gear rather than switchstart will save over 10% more energy. High frequency electronic ballasts are also lighter in weight than their electromagnetic equivalents, are silent in operation and automatically switch the lamp off at the end of its life, eliminating flashing. The high frequency operation also eliminates flicker.

In enclosed fittings, T5 lamps may offer additional energy savings. The narrow tube means that luminaire optics can be more efficient and the T5 lamp is at its optimum performance at a higher temperature, as is commonly found inside an enclosed fitting. These savings may not be realised in a retail application.

Retail luminaires are generally more open with less tight optical control, negating the benefit of the T5 lamp. However, T5 lamps offer additional benefits: as well as the compact, neat appearance of the lamp, they are more efficient in shorter lengths, which makes them a good choice for standard metric ceiling modules (e.g. 600mm[2]).

Did you know?

A 15W fluorescent lamp run on high-frequency control gear will consume 16W (A2 class ballast) or 18W (A3) but can consume up to 23W with a class B2 switchstart ballast, i.e. up to 44% more energy.

[2] It is important to note that any light fitting changed as part of a retrofit needs to be re-tested to ensure that it conforms to performance and safety standards.

Advantages:

- Low running cost
- Good to excellent efficacy (triphosphor); moderate efficiency (halophosphate)
- Very good (triphosphor) to excellent (multiphosphor) colour rendering
- Long life in normal use
- Minimal reduction of light output through life (triphosphor)
- Prompt start and restart
- Quick run-up to full light output
- Up to 10% energy saving when replacing equivalent T12 tubes with T8
- A further 10% (plus) saving from using electronic control gear (ballast)
- Universal operating position.

Disadvantages:

- Excessive switching shortens life (not a problem for static retail display lighting)
- Ballast required
- Can be dimmed but requires special ballast and dimmer.

Metal halide lamps

These lamps come in a range of types and sizes, have low energy consumption and give an excellent crisp white light which improves colour rendering. The lamp life of 6,000/12,000 hours is shorter than high-pressure sodium lamps but they still have a long operating lifetime compared with tungsten lamps. Metal halides are recommended in most applications where good colour rendering is important, such as in retail, high bay areas, area floodlighting, external lighting and hotels.

Electronic control gear is available for low wattage CDM (ceramic discharge envelope) metal halide lamps. This provides improved lamp life (important due to high costs of these particular lamps) with lower lumen depreciation, as well as improved efficiency. Quartz envelope technology has also improved, including miniature 20W and 35W reflector lamps with a similar size to a standard MR16 tungsten halogen lamp.

Advantages:

- Good to excellent efficacy
- Moderate to very good colour rendering
- Long life (6,000 to 15,000 hours).

Disadvantages:

- Long re-strike time (10 minutes) unless hot re-strike models are used
- High cost compared with standard mercury lamps.

Did you know?

Compact metal halide lamps run much cooler than halogen lamps and have much lower running costs. Reduced ultraviolet light versions are available for sensitive display objects. Moreover, lamps with a ceramic discharge envelope (CDM lamps) give improved luminous efficacy, colour rendering and colour stability.

High pressure sodium lamps

High pressure sodium discharge lamps combine high efficacy with very long life and are particularly suited for floodlighting and illuminating larger exterior areas that need to be lit for long periods. They are not made for frequent switching and therefore should not be operated by presence detectors for security lighting. White sodium lamps have good colour rendering but are significantly less efficient.

Advantages:

- Very low running cost
- Very high efficacy
- Long life
- Quick start
- Universal operating position.

Disadvantages:

- High purchase cost
- Very poor colour rendering
- Ballast required
- Requires 1.5 to six minutes to run up to full output
- Delayed restart when hot on most lamps.

White sodium lamps

White sodium lamps have good colour rendering but are significantly less efficient than their regular high-pressure equivalents. They provide an alternative to metal halide lamps in floodlights where a warm white colour is required.

Advantages:

- Medium running cost
- Good colour rendering
- Quick start
- Universal operating position.

Disadvantages:

- High purchase cost
- Low to moderate life (6,000-10,000 hours)
- Poor efficacy
- Ballast required
- Requires 1.5 to six minutes to run up to full output
- Delayed restart when hot on most lamps.

Light emitting diodes

A light emitting diode (LED) is a semiconductor diode that emits narrow-spectrum light. Traditionally LEDs have been low power consumption light sources with low light output. However, with increases in efficiency, LEDs have started to make strong inroads into non-domestic markets that can tolerate quite low light levels, notably external night time illumination and emergency signage. They are regularly used in situations where colour change is required for dramatic effect, and in external applications where their relatively low output[3] is sufficient. The highest efficacy LEDs are coloured, and applications such as mood and other coloured decorative lighting in hotels, bars etc have almost completely transferred to LEDs.

LEDs offer potentially long life and low maintenance if they are designed and controlled appropriately. A rapidly developing technology, the efficiency of LED systems can be variable, and each potential design should be critically compared with other, more conventional options.

Further information

For more information on choosing efficient lamps and fittings, please see the Lighting technology overview (CTV049) available from the Carbon Trust.

[3] At the time of publication, LEDs are relatively low output and low efficacy compared with other display sources. This position is predicted to change rapidly with time and so LED options should be evaluated for both effectiveness and cost compared with other options.

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Advantages:

- An efficient option where coloured light is required
- Can provide changing colours under automatic control
- Can have long life (over 50,000 hours) – can reduce maintenance costs
- Can be focused onto display area.

Disadvantages:

- Not suitable for high light output applications (at time of publication)
- High purchase cost
- Manufacturers' literature is not standardised (difficult to compare products)
- An LED may lose a significant proportion of its original light output without failing completely
- Lamp colour may vary from batch to batch.

Fibre optic systems

Whilst not strictly a lighting technology, fibre optic systems can be used to distribute the light from one large, efficient light source to multiple, smaller display points at which the light can be focused and directed as required. Fibre optic systems can be used to provide small 'sparkly' points of light to display jewellery to good effect or provide a long row of spot lights.

Advantages:

- Flexible – can be designed for particular display requirements
- Can use an efficient light source
- Cool operation
- No electrical wiring in ceiling voids or wall cavities
- Easy to maintain lamp and fibre optics.

Disadvantages:

- May require bespoke design
- All lights extinguish on lamp failure (need to change lamp prior to failure).

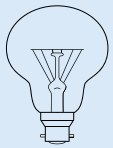
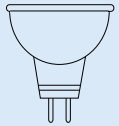
Choice of luminaire

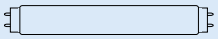
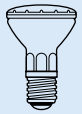
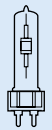
Luminaires or light fittings should be chosen based on their application and efficiency (measured as the light output ratio or LOR), and also on how easily they can be cleaned and maintained.

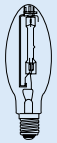
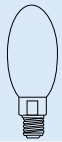
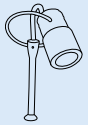
Other factors to take into account specifically for fluorescent lighting are:

- **The direction in which light is emitted** – Luminaires designed for office environments will not necessarily be suitable to light vertical displays of merchandise or stock. There are luminaires especially designed for retail shelves or library shelving that will direct the light onto the product more effectively.
- **Discoloured diffusers** – The older type of plastic diffuser becomes discoloured with age and can absorb more than 50% of the light output from a lamp. Diffusers should be replaced with reflectors where possible, or with those made from prismatic material.
- **UV stabilised diffusers** – Diffusers which are not UV stabilised turn brown from UV light. It is therefore important to specify UV stabilised diffusers at the purchase stage (usually at no extra cost).

Table 3 Characteristics of the key types of display lighting, and a guide to which are most appropriate for use

		Luminous efficacy (Lumens/Watt)		Colour appearance (Kelvin)		Colour rendering (Ra)		Life (Hours)	
Lamp type		**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
	Incandescent tungsten filament	6	14	2,700	2,700	100	100	1,000	1,000
The least efficient type of lighting with the shortest lifetime. Occasionally acceptable if a desired aesthetic is being pursued but in most cases should be replaced with modern alternatives.									
	Tungsten halogen (quartz halogen)	13	26	3,000	3,000	100	100	2,000	8,000
Often used in spot lighting and display lighting. If low voltage tungsten halogen spotlights are installed there is a further saving using, for example, 35W infrared coated (IRC) bulbs instead of the standard 50W bulbs.									
	Compact fluorescent (CFL)	45	70	2,700	4,000	82	82	6,000	15,000
A wide range of attractive modern CFL bulbs are available which can be a direct replacement for standard tungsten bulbs and are also acceptable for downlights, display and feature lighting.									
	38mm T12 ‘Standard’ F/Tube	61	86	2,950	6,000	51	76	7,000	9,000
At least 7% less efficient than T8 or T5 equivalent tubes and now obsolete.									

	Luminous efficacy (Lumens/Watt)		Colour appearance (Kelvin)		Colour rendering (Ra)		Life (Hours)	
Lamp type	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
 25mm T8 'Standard' F/Tube (S/G)	53	80	2,950	6,000	51	76	8,000	9,000
At least 16% less efficient than equivalent triphosphor tubes. Lower capital cost is not cost-effective over whole life.								
 25mm T8 Full spectrum multiphosphor	52	66	3,000	6,000	95	98	15,000	20,000
Recommended when excellent colour rendering is required e.g. colour matching or medical examination but at least 25% less efficient than equivalent triphosphor lamps, so not recommended for general use.								
 25mm T8 Triphosphor	63	100	2,700	6,500	80	85	12,000	60,000
A preferred high frequency lamp for general commercial lighting.								
 16mm T5 H/F Triphosphor	37.5	106	2,700	6,500	80	85	16,000	48,000
A preferred lamp for general commercial lighting. May be more efficient than T8 equivalent if optical benefits of luminaire are maximised.								
 Metal Halide	70	107	3,000	6,000	65	96	6,000	20,000
Good quality white light for areas which require infrequent switching. Ceramic versions are more efficient.								
 Compact metal halide	68	100	3,000	5,900	73	83	2,000	15,000
Good quality, efficient white light with a variety of applications.								

	Lamp type	Luminous efficacy (Lumens/Watt) Min	Luminous efficacy (Lumens/Watt) Max	Colour appearance (Kelvin) Min	Colour appearance (Kelvin) Max	Colour rendering (Ra) Min	Colour rendering (Ra) Max	Life (Hours) Min	Life (Hours) Max
	Mercury	36	58	4,000	4,000	42	49	12,000	20,000
	Provides white light but metal halide lamps are preferable.								
	High pressure sodium	66	130	2,000	2,000	25	25	12,000	28,500
	High luminous efficacy but very poor colour rendition. Deluxe model has better colour rendition than standard high pressure sodium (although still classed as poor) but at the expense of luminous efficacy.								
	White sodium	37	51	2,500	2,500	80	80	6,000	10,000
	Much better colour rendition than standard high pressure sodium (classed as good) but at a heavy cost in luminous efficacy. Consider using ceramic metal halide instead.								
	Light emitting diodes (LEDs)	>25	100	3,000	6,000	Too variable to state	Too variable to state	12,000	>50,000
	Rapidly improving technology. The best choice for coloured effect lighting, particularly in low light level areas. Take care if specifying for white light applications as other lamp options may be more appropriate.								

Colour appearance

Description	Kelvin
Candlelight	1,500
Warm white	3,000
White	3,500
Cool white	4,000
Sunlight	6,000
Overcast sky	7,000

Colour rendering

Description	Ra
Very poor	20-39
Poor	40-59
Moderate	60-79
Very good	80-89
Excellent	90-100
Daylight	100

Luminous efficacy

Description	Lumens/Watt
Very poor	Less than 39
Poor	40-59
Moderate	60-79
Good	80-99
Excellent	>99

Lamp life

Description	Hours
Low (5,000+)	5,000-10,000 hrs
Moderate (10,000+)	10,000-15,000 hrs
Long (15,000+)	15,000-50,000 hrs
Very long (50,000+)	Greater than 50,000 hrs

Reduce the need

How a lighting system is used has a big impact on the amount of energy consumed and the levels of comfort provided for building occupants.

Decorate in light-reflective colours

Light walls and ceilings allow daylight and electric light to bounce off and be re-directed to other areas of the space, increasing the effectiveness of the lighting used.

Chiller cabinets

An important part of display lighting which is often overlooked is lighting in chiller cabinets. These cabinets often contain a 55W fluorescent lamp which then generates another 30W or so in cooling load, as the heat from the lamp has to be removed. They are often wired on a single electrical supply so the lamp is left on all the time the cabinet is switched on, even at night. There are considerable and highly cost effective savings achievable from switching the lighting off outside trading hours, and this is usually just a case of using the switch on the cabinet.

Lighting the perimeter of the space

Studies have shown that people tend to judge the brightness of a space by looking at the walls; by making the walls brighter, the whole space looks better lit. Linear fluorescent tubes (rather than compact fluorescent ones) are often used to good effect in lighting the edges of spaces, either recessed into the ceiling, or integrated into the tops of wall displays. This gives valuable emphasis and makes the space as a whole look bigger and brighter.

Consider display lighting design

Organise internal space to make the most of the display lighting. Identify what items need display lighting and aim to reduce the overall number of lamps to retain the impact of individual displays. Pools of well lit display lighting can effectively lead a customer through a shop, gallery or museum. Keep the lights as close to the display area as possible to reduce the wattage required but without risking the health and safety of customers, staff or display items. Make sure that the spread (beam angle) of spotlighting is appropriate to the item being displayed to avoid wasted overspill of light.

Case study

One gallery used to have double the illuminance (from high bay lamps) around the perimeter to give the illusion of an enlarged internal space. These lamps were replaced with concealed fluorescent wall washing, saving energy and producing space that is better lit.

Develop a display lighting strategy

Consider whether all display lights need to be on at the same time or if a mood can be created by alternating their use. Colour-changing lights can also provide a lively display where accurate colour rendition is not important. A suitable area with good colour rendition can be provided nearby for customers to critically inspect items or exhibits. Dynamic display lighting schemes are particularly good for selling merchandise to young people, however, too rapid or too slow a lighting change can be counter-productive.

Maintaining existing systems

A maintenance programme can reduce costs by up to 15% as well as improving light output and appearance.

Maximise daylight

Cleaning windows and skylights regularly will allow maximum daylight to enter the building and significantly reduce the need for electric lighting. Cleaning the glass is particularly important for city-based premises where high levels of pollution can cause a film of dirt to settle on windows and particularly rooflights. Moreover, as most lighting installations depend on a certain amount of reflected light from walls and ceilings, these also need cleaning and redecorating periodically (preferably in light-reflective colours).

Check and clean sensors

Lighting control sensors may become obscured by dust over time so they must be cleaned regularly to ensure effective operation. Check timers on lights are showing the correct time and that the settings meet operational requirements. Make sure these are altered when the clocks change during the year.

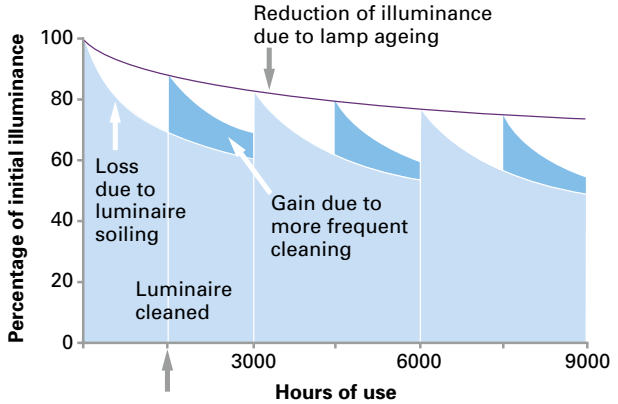
Identify what equipment should be maintained and how frequently this needs to happen. It is a good idea to create a schedule of maintenance activity to ensure nothing is inadvertently missed.

Lighting systems require ongoing maintenance to ensure efficient operation. In fact, the light output of an installation reduces over time and although a lamp may be working, its output can be reduced by up to 50% as illustrated by the diagram below.

The figure shows the effect of increasing the frequency of cleaning. Initially the luminaire is cleaned every 3,000 hours, then cleaning is introduced every 1,500 hours. The saving in light output is shown in the diagram.

The rate at which light output decreases depends on the lamp type and its location. The rate of reduction for a particular type of lamp is usually predictable. From this information manufacturers can estimate the average time for lamp output to fall below an acceptable level. This is known as the 'expected' lamp life and is provided in manufacturers' published literature.

***Figure 2** Cleaning can increase light output*



Many factors, such as overheating, frequent switching and voltage fluctuations can affect the life of a lamp and replacement decisions should be based on the practicality of changing the lamp as well as the falling level of illumination.

- Ensure that the correct cleaning materials and techniques are used to prevent losses caused by chemical action, or scratching of optics and electrostatic dust accumulation.
- Plastic diffusers or prismatic controllers discolour with age and contribute to the gradual loss of light over a period of time. Replacing ageing diffusers can lead to a significant improvement. Acrylic plastics generally have the longest useful life.
- Where access to lamps is difficult, involving out-of-hours working, ladders or platforms, it is usually cheaper to replace lamps on a group basis. If access is easy to arrange and uniform illumination less important, for example, in stockrooms, replacing on failure is usually acceptable.
- Consider maintenance aspects at the design stage since, if access is difficult, maintenance could be neglected. Allow for removal of luminaires without causing damage to the display and ensure that the quality of the installation is not affected by maintenance operations.
- Select lamp types with long service lives to ease maintenance problems (see table page 17). For example, compact metal halide lamps have a service life of 2,000-15,000 hours compared to only 1,000 hours for an equivalent tungsten halogen reflector lamp. Novel lighting techniques such as fibre optics and induction lighting (see glossary) have distinct advantages in terms of long life and ease of maintenance.
- Take care in the disposal of lamps. They may contain a variety of chemicals which are environmentally damaging and harmful if released by breakages. Manufacturers are now providing systems for recycling fluorescent lamps in line with the requirements of the WEEE Directive (2006)[4]. Old lamps must be collected and recycled by the supplier of the new lamps.

Top tip

Always replace or remove fluorescent tubes that are not working. The ballast uses around 25% of the energy of a lamp and fitting for mains frequency lighting and around 10% for high frequency lighting. Energy is still consumed even when the failed tube is not lit, so removing it is important for energy and cost savings.

[4] The Waste Electrical and Electronic Equipment Directive aims to minimise the impact of electrical and electronic goods on the environment. Go to www.berr.gov.uk or www.recolight.co.uk for more details.

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Understanding and using controls

Using lighting controls can ensure that the correct amount of light is provided in the right place for the required time.

There are two main types of lighting controllers – switches and dimmers. For display lighting applications, these can be activated manually or automatically by time switches and photocell or light sensing controls (see below). The different control elements can be used on their own or in combination, depending on the requirements. This helps to maintain appropriate lighting levels and provide optimum light output whilst minimising energy consumption.

It is advisable to consider the following points when discussing lighting controls with a designer or supplier.

Wiring circuits

Plan the wiring of circuits carefully so that different parts of the lighting installation can be controlled or switched separately if required. Display lighting should be on a different circuit from the general lighting so that it can be switched off when the building is closed to customers or visitors.

There may be areas that can be switched off at night, for example, allowing window displays to be left on for longer when lights for the rest of the premises are switched off.

Control options

Savings are possible through the use of controls that automatically switch off lights when not needed. Various control options are available and the method selected will dictate the hardware requirements. Common techniques include:

Localised switching – allows greater flexibility in the selection of appropriate lighting, for example, for reduced levels during cleaning and restocking periods.

Time switching – varies lighting by switching off lights out of hours and varying the levels throughout the day. Switching or dimming lamps outside core opening hours to a lower level to allow for cleaning or restocking is a good strategy. Sophisticated systems can leave different lamps on each night to ensure even ‘wear and tear’ across the whole installation. This type of approach has been shown in major retail stores to save 20% of total lighting energy use.

Daylight linking by on/off or dimming control – varies lighting automatically throughout the day in response to changing levels of natural light. Modern fluorescent lamps equipped with high-frequency control gear can be readily dimmed in this manner.

Occupancy linking – is suitable for stockrooms and ancillary areas (staffrooms, corridors for example). This method is not recommended for sales areas in the retail environment.

High frequency control – Light flicker from discharge lamps can be both annoying and uncomfortable to building occupants. This can be avoided by running the lamps at high frequency (usually 30kHz), and using special control gear circuits, which has the added advantage of improving energy efficiency.

Soft start controls – help to reduce the surge of electricity at switch-on, thus alleviating the damage that this can cause to certain lamps. It can help to extend lamp life by as much as eight times when compared with a typical 'hard start' set up.

Top tip

The provision of controls on all display lighting should ensure that it is switched off when not required. In retail stores, museums and galleries, internal display lighting should be switched off once the premises close; the only exception is any lighting of display windows. For best practice, these should also be switched off or dimmed once the streets are deserted late at night.

Did you know?

Well designed automatic lighting controls can save 30% on lighting costs.

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Upgrading and refurbishment

Refurbishment projects present an ideal opportunity for many energy efficiency measures to be incorporated into an existing building.

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In addition to improving light levels and saving energy, it is possible to alter the look of an entire building by the choice of luminaires. This is an important consideration when costing lighting systems – re-lamping schemes which may not be profitable on energy savings alone may be able to increase business through the change in focus of the building interior.

It is important to achieve the minimum standards of energy conservation required by the building regulations, (See page 4).

Principal areas for consideration should address the basic lighting philosophy:

- Would the presentation of products or exhibits benefit from an increased level of display or accent lighting and a reduction in background lighting?
- Could customers be directed around the building by 'corridors' identified by lower levels of light?

Consult a designer

Consult a lighting designer for new build or refurbishment projects. Contact the Association of Lighting Designers for help finding a suitable local designer or consultant. In most cases, a qualified designer will be able to identify savings whilst maximising the quality and aesthetics of the final result. When commissioning an appropriate lighting designer, it is important to work through actual requirements of the finished design so the designer can suggest options for meeting these. Ask them to specifically consider:

- The safety and comfort of the occupants.
- The building's architecture and layout.
- How the design can help to achieve the display lighting requirements, for example, in a shop to help showcase products and achieve better sales.
- How the design can assist staff, customers and other building users to carry out their tasks effectively.
- How the use of daylight can be maximised.
- The costs of installing and operating the system.
- The most energy efficient design possible – make sure that low energy options are specified from the outset.

Case study

A well known supermarket chain used 70W CDM/T lamps with a 40° beam angle, mounted around four metres above the floor. Changing these to a 35W version with a 20° beam angle halved the power used and gave increased emphasis on the displays.

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Refurbish for colour

Always consider the colour appearance and rendering requirements of display lighting when refurbishing. Appearance, including the creation of cool and warm effects and the ability to perceive colours accurately is especially important for retail display lighting.

Top tip

Consider labelling or colour coding light switches so that display lighting can be differentiated from general lighting. This leaves staff in no doubt as to which lights should be on for display purposes.

Spotlighting savings

For display lighting, low voltage tungsten halogen lamps can be a good alternative to mains voltage equivalents. Filaments in low voltage lamps are smaller and hence the light can be optically controlled more effectively. Significant savings can be achieved by upgrading to 35W bulbs with an infrared reflective coating (IRC) instead of the standard 50W bulbs. The IRC reduces the power required to light the lamp but gives the same equivalent light output as a standard 50W bulb, whilst achieving a 30% energy saving and a 60% heat reduction.

Compact metal halide lamps with reflectors for use in spotlighting are now being produced in lower wattage variants (down to 20W). These are fast becoming the spotlight of choice for display lighting, particularly where high light levels are required. Metal halide lamps are 4-5 times more efficient than halogen lamps so it might be possible in some applications to replace 50W-100W halogen lamps with 20W compact metal halides. White sodium lamps are also used in some display lighting fittings. These are more efficient than halogen but not as efficient as metal halide.

Case study

New lighting equipment has been fitted as part of a well known store's refurbishment programme. This comprises a regular array of high frequency, dimmable fluorescent lamp luminaires combined with wall lighting and illuminated signs. Time controls provide for two different lighting levels – cleaning and restocking; and two different trading levels – busy and quiet. This control also ensures that all display lighting and illuminated signs are switched off when the store is closed.

Photocell control provides a constant maintained illuminance to ensure maximum efficiency and increased lamp life. Stockrooms are fitted with occupancy sensors to reduce the light level to a low illuminance when unoccupied. All lights are switched off manually when the last person leaves the building.

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Consider light spread for spotlighting

In display lighting, it is crucial to get the right quantity of light in the desired location. A more efficient lamp may produce the same overall light output for a much reduced wattage, but if it does not effectively deliver the light on to the item being displayed, much of the light will be wasted.

Choosing the correct light spread (via the beam angle of the reflector) is of vital importance. Beam angles of reflector lamps can vary from a very tight 4° to 50° or more. The smaller the beam angle, the more intense the light will be in the centre of the beam. Choosing the beam angle so that the beam adequately illuminates the subject but not the surrounding area will ensure maximum efficiency of the lighting scheme.

Extra lamp efficiency can also lead to unwanted light, so it is important to decide on the light level and light spread required, and choose the lowest wattage lamp that will achieve these requirements.

High frequency control gear

When replacing older lighting systems, specify modern high-frequency fittings. These reduce energy use and heat output, eliminate flicker and hum, extend lamp life and can allow dimming – all of which can make an internal environment more attractive to building occupants.

Upgrade to light emitting diodes

Light emitting diodes (LEDs) can be very efficient, relying on a pure semi-conductor to emit light (but not heat or noise) as a response to an electric current. Common business applications include illuminated signs and emergency lighting, for which they are excellent.

Recent advances in technology have led to a new generation of LEDs which offer better colour properties than previous models and can be fitted directly into existing fittings. This could mean that LEDs are now appropriate for a wider range of applications. To explore these options, contact a specialist manufacturer or an experienced designer of LED lighting systems.

White LEDs have also developed significantly over the last five years and the improvements in efficacy are expected to continue at a rapid pace. The latest advance is that of spot lamps designed to take the place of the small tungsten halogen spotlights extensively used in retail and hospitality premises as accent and display lighting; a niche not currently filled by any efficient light source.

At present, LEDs are typically the system of choice when colour or colour change effects are required in a display scheme. They have the advantage of not requiring filters (which reduce efficiency) and are also very flexible in their design possibilities. They can be used as small light sources or in clusters to provide spot or flood lighting. The light can be easily focused to ensure that it reaches the specific display area.

Note

The lack of standardised information on LED products means that making an informed choice can be difficult. Not all LED installations will save energy. The efficiency of some types can vary so it is important to choose the light level and beam spread required and to select the light source that provides these requirements with the lowest energy use. LEDs are likely to provide a good solution for applications such as display case lighting for which small point source lights are required.

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Consider the fitting

Fluorescent tubes usually sit within one of two types of fitting: one with a plastic case fitted to the outside of the light to reduce glare (diffuser) or one with mirrors within the fitting to reflect the tube light into a space. Reflectors allow a greater amount of light into an area and therefore require lower wattage tubes or fewer tubes to obtain the same light output. If applied in a retail situation, consult a lighting specialist to ensure that the final aesthetics of the display will be acceptable.

Labelling for lamps

Domestic incandescent filament lamps and fluorescent lamps are labelled according to their energy efficiency classification in accordance with European energy labelling directives. The classification system ranges from A to G with A being the most efficient.

Although reflector lamps do not come within the remit of the labelling scheme, they could be considered to be broadly equivalent to their non-reflector counterparts.

Metal halide lamps are also not within the remit of the scheme but their efficacies would generally be equivalent to class A.

Tax incentives

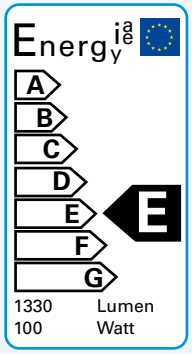
Enhanced Capital Allowances (ECAs) are a straightforward way for a business to improve its cash flow through accelerated tax relief. The ECA scheme for energy-saving technologies encourages businesses to invest in energy saving plant or machinery specified on the Energy Technology List (ETL) which is managed by the Carbon Trust on behalf of Government.

The ECA scheme provides businesses with 100% first year tax relief on their qualifying capital expenditure. The ETL specifies the energy-saving technologies that are included in the ECA scheme. The scheme allows businesses to write off the whole cost of the equipment against taxable profits in the year of purchase. For further information please visit www.carbontrust.co.uk/eca or call the Carbon Trust on 0800 085 2005.

CE marking on lamp packaging indicates that the product meets the requirements of:

- Low Voltage Directive for Electrical Safety (73/23/EEC as amended by 93/68/EEC)
- EMC Directive for electromagnetic compatibility (89/336/EEC as amended by 92/31/EEC)
- For household lamps – Energy Labelling directive (91/11/EU)

Figure 3 CE marking and energy labelling for lamps



Energy efficiency classification	Typical lamp types
A or B	Fluorescent tubes and CFLs
C or D	Tungsten halogen
E	GLS(25W – 200W)
E or F	Candle lamps
G	Striplights

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Lighting design criteria

Lighting systems must be carefully and holistically designed, taking into account the requirements and constraints of an organisation to ensure excessive amounts of energy are not consumed.

Without an effective lighting design, the internal environment may be inappropriately lit, having an adverse affect on the productivity and morale of building occupants.

The following elements are crucial to the design of an effective lighting system. They may not carry equal weight, nor do they need to be considered in any particular order, but they should all be taken into account:

Visual function – this relates to how well a lighting system provides for the requirements of users and their activities, addressing issues such as reducing glare, providing the correct colour appearance, light levels, luminance and intensity of light.

Visual amenity – this relates to the quality of the lit environment which can be described in terms of visual lightness and visual interest. 'Visual lightness' describes the 'light' appearance of an interior, incorporating room surfaces such as the walls and ceiling. 'Visual interest' relates to the light distribution. In general, people prefer a room to have a measure of light and shade in the light pattern (depending on application).

Architectural integration – this relates to the importance of lighting being considered as a natural extension to the architecture of a building. The amounts and patterns of daylight, positioning of windows and rooflights, choice of light fitting, lamp type, style and provision of effective control strategies should all be taken into account.

Energy efficiency – this is integral to the design of any lighting system and can provide substantial reductions in energy costs and carbon emissions. Factors to consider include daylighting, use of controls and choice of efficient lamps and luminaires.

Top tip

Always use experienced and qualified lighting designers for the best results.

The basic design rules for energy efficient lighting are:

- Design for adequate but not excessive levels of lighting
- Use the most efficient lamps and fittings suitable for the task
- Use light colours on walls and ceilings to best reflect light
- Use the minimum number of lamps and fittings possible
- Use appropriate controls
- Establish an effective maintenance programme.

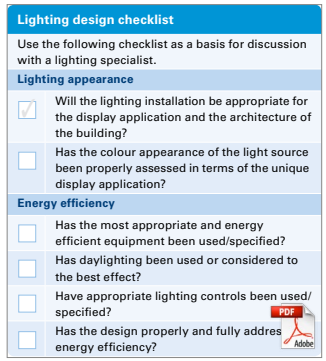
Installation maintenance – regular maintenance of lighting systems is vital for maximising energy savings and maintaining a comfortable working environment. Light provision diminishes over time due to dust and dirt build up so consider setting up a planned preventative maintenance programme to keep light levels at their optimum.

Costs – it is important to consider the capital and operational costs to ensure that an overall economic solution is achieved over the full life cycle of the lighting installation. The capital costs include the cost of the design, the equipment (lamps, luminaires and controls) and installation including commissioning and testing. The operational costs include the cost of the electricity consumed, maintenance costs and possibly the cost of lamp disposal.

Lighting design checklist

Use the following checklist as a basis for discussion with a lighting specialist.

Download



Lighting design checklist

Use the following checklist as a basis for discussion with a lighting specialist.

Lighting appearance

- ☑ Will the lighting installation be appropriate for the display application and the architecture of the building?
- ☐ Has the colour appearance of the light source been properly assessed in terms of the unique display application?

Energy efficiency

- ☐ Has the most appropriate and energy efficient equipment been used/specified?
- ☐ Has daylighting been used or considered to the best effect?
- ☐ Have appropriate lighting controls been used/specified?
- ☐ Has the design properly and fully addres energy efficiency?

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Next steps

There are many easy low and no-cost options to help save money and improve operation of the display lighting within your building.

Step 1. Understand your energy use

Find out what lighting you have, where it is installed and how it is used. Ask staff to report any lighting issues and act on any feedback. Check the condition and operation of lamps and fittings and monitor how the lighting is used over, say, one week to obtain a base case against which energy efficiency improvements can be measured.

Step 2. Identify your opportunities

Compile an energy checklist of your lighting. Walk round your building and complete the checklist at different times of day (including after hours) to identify where energy savings can be made. An example checklist is available in the Carbon Trust publication Energy management guide (CTG054).

Step 3. Prioritise your actions

Draw up an action plan detailing a schedule of improvements that need to be made and when, along with who will be responsible for them. Short-term actions could include launching an awareness campaign and writing a usage policy; long-term plans could include planning a major refit of lighting controls and zoning the lights. Investigate interest-free loans and ECAs for new equipment.

Step 4. Seek specialist help

It may be possible to implement some energy saving measures in-house but others may require specialist assistance. Discuss the more complex or expensive options with a qualified technician. Some organisations qualify for tailored consultancy from the Carbon Trust, and all are welcome to get advice from the Customer Centre.

Step 5. Make the changes and measure the savings

Implement your energy saving actions and measure against original consumption figures. This will assist future management decisions regarding your energy priorities.

Step 6. Continue to manage your business for energy efficiency

Enforce policies, systems and procedures to ensure that your business operates efficiently and that savings are maintained in the future.

Further information

The following publications are available from the Carbon Trust:

Management guides

Creating an awareness campaign (CTG056)

Technology overviews

Lighting (CTV049)

Glossary

Ballast
A component of conventional control gear which controls the current through the lamp. A modern electronic ballast working at high frequency uses about 30% less current than older ballasts.

Beam angle (beam spread)
Defines the area in which the majority of the light from a spotlight is concentrated.

Building lighting
The lighting of the main surfaces of a building, particularly walls, the surround to work stations and the ceiling in large rooms. Building lighting design will depend on the required visual amenity and the architectural design and should be considered alongside the design of task lighting (see below).

Colour appearance
Expressed in terms of the warmth or coolness of the lamp and the colour of 'white' that the light appears. Ranges from 1,800K (very warm, amber) to 8,000K (cool). There are many colours of 'white' available in the ranges of lamps: for general use these are a warm colour (2,700 to 2,900 degrees Kelvin); a medium colour (3,000 to 3,500 degrees Kelvin) and a cool colour (4,000 degrees Kelvin).

Colour temperature
The colour temperature provides an indication of the light colour appearance (see above) and is expressed in Kelvin (K). Most lamps are rated between 2,700K (warm) and 6,500K (daylight). See Appendix A.

Colour rendering
An indicator of how accurately colours can be distinguished under different light sources. The colour rendering index compares the ability of different lights to render colours accurately, with an Ra of 100 being ideal. Colour rendering properties of a light source are specified by the colour rendering index (CRI). Good colour rendering equates to a high CRI (CRI 100 = daylight), poor colour rendering equates to a low CRI.

Choke
Alternative name for ballast.

Control gear
Refers to the apparatus to start and control the current through the lamp. Typically consists of a 'package' of electrical or electronic components including ballast, power factor correction capacitor and starter. High frequency electronic control gear may include other components to allow, for example, dimming.

Diffuser
A translucent screen used to shield a light source, at the same time softening the light output and distributing it evenly.

Discharge lamp
Lamps which produce light by discharging an electric current through a gas or a mixture of gases and vapours.

Efficacy (luminous efficacy)
The ratio of light emitted by a lamp to the power consumed by it, i.e. lumens per Watt (l/W). When control gear losses are included, it is expressed as lumens per circuit Watt.

Expected lamp life
The expected lamp life for most lamps refers to the mean time for half the lamps in a sample to fail. For LEDs, which reduce dramatically in light output before they fail, it is often defined as the mean time for the light output to reduce to 70% of the initial light output.

Induction lighting
A special type of long lasting lighting which creates light using an internal antenna powered from an external high-frequency generator to create an electromagnetic field.

Iluminance and maintained illuminance (lumens/m2 or lux)
Illuminance is the term used to describe the level of light on a surface in lumens/square metre or lux (1 lux is equal to one lumen per square metre). Maintained illuminance is the term used to describe the average illuminance on a reference surface e.g. a desktop. Maintenance is needed when light drops to this minimum level.

Light output ratio (LOR)
The ratio of the total amount of light output of a luminaire (lamp and fitting) to that of just the lamp. A luminaire that emits less than 50% would not be regarded as efficient, whatever the light source.

Luminaire
A light fitting including all components for fixing and protecting the lamps, as well as connecting them to the supply.

Lumen
Unit of luminous flux, used to describe the amount of light produced by a lamp or falling on a surface.

Lux
An international unit of measurement of illuminance equal to one lumen per square metre.

Maintained illuminance
See illuminance.

Ra
The colour performance of a lamp is described by its general colour rendering index (Ra) which defines its ability to show surface colours accurately. It is described by a number: 100 is considered to be excellent whilst a value of 80 and above is good and appropriate for most situations where people are present. Where colour identification is important, a value of 90 or above should be used.

Rated average lamp life
The time when half the number of lamps in a batch fail under test conditions.

Reflector lamps
A lamp with a built-in reflector. This can be a mirror backing to the lamp or a reflective coating on the lamp envelope.

Restrike
Term used to describe the time taken for a lamp to illuminate after being switched off and then on again.

Task lighting
The lighting provided for specific tasks within a lighting design. Task lighting design will depend on the particular tasks undertaken and the building lighting design.

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Lamp abbreviations	
Tungsten lamps	GLS – general lighting service (incandescent lamps)
	TH – tungsten halogen lamps
High pressure sodium lamps	SE and ST are used in this text as a general abbreviation for high pressure sodium lamps, with ST denoting tubular and SE denoting elliptical
	SON DL is used for SON deluxe lamps, which have an improved colour rendering
	White sodium is a high pressure sodium lamp which achieves a high Ra rating and around 2,500 degrees Kelvin
Mercury lamps	MBF/U is used for standard Mercury filled lamps, available in elliptical or internally silvered reflector types or with integral ballast
Multi-vapour lamps	MH Multi metal vapour: in this text used as a general abbreviation
	MBI/MH/HID/HQI/HPI are sometimes used to denote these lamps
	CDM/HIT/HCI is a metal halide lamp which has a ceramic arc tube and retains its initial colour properties longer, therefore mainly eliminating 'colour shift'
Light emitting diode	LEDs – presently available in 'white' and colours.

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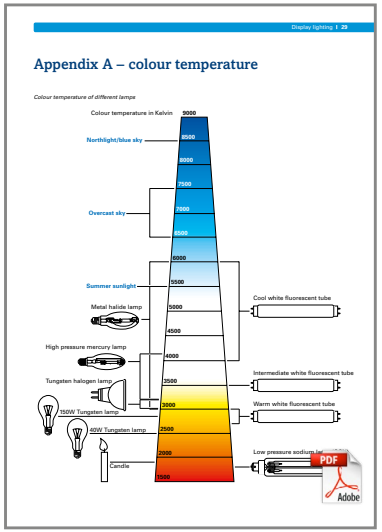
Appendix

A. Colour temperature



Download this guide to see the colour temperature of different lamps.

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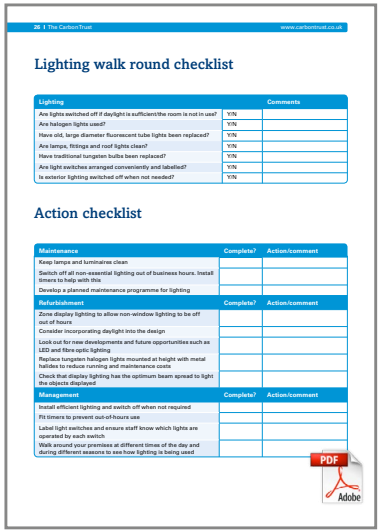
B. Checklists



Download these checklists to monitor your progress implementing energy efficient lighting measures.

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- investing in early-stage low carbon companies.

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