SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Libraries

A GUIDE TO ENERGY EFFICIENT AND COST EFFECTIVE LIGHTING

This guide provides advice on principles and techniques to achieve energy efficient and effective lighting for library buildings. By following the information provided, you should be able to reduce the energy consumption of lighting by up to 50%, cut maintenance costs and ensure lighting is appropriate to different library areas.

UP TO **50%** SAVINGS

ENERGY EFFICIENT AND COST EFFECTIVE LIGHTING

Lighting plays an important part in making libraries both functional and inviting. Each of the tasks, i.e. book searching, reading or computer use have individual requirements.

Getting this combination of lighting right can make the library a more comfortable place to relax or study.

LIGHTING REQUIREMENTS AND TECHNIQUES

Energy efficient and effective lighting is achieved by understanding the characteristics of lamps and luminaires and applying this knowledge to lighting design. Consideration of the items covered in the list below and application of the principles covered in this guidance document will help ensure energy efficient and effective lighting schemes.

- Colour appearance of the light source
- Colour rendering of the light source
- Appropriate distribution of the light
- High light output ratios (LORs) from luminaires
- Appropriate lighting levels (lux)
- Controls
- Use of daylight
- Maintenance

Fig.1 *Library, with lights positioned parallel to bookshelves*

COLOUR APPEARANCE AND COLOUR RENDERING

Colour appearance

Figure 2 defines the appearance of a 'white' and is measured on the Kelvin temperature scale (K). A colour temperature of less than 3,500 K is 'warm'; a colour temperature of 3,500 K is mid-white; and a colour temperature of 4,000 K and above is 'cooler'. The colour of 'white', which is often used in general areas is 4,000 K and for areas where people may 'dwell' for long periods a warmer colour of 3,000 K may be more suitable.

- Choose the correct colour appearance to complement each area of the library.

Colour rendering

This is the ability of a light source to give good colour representation of the colour it is illuminating. It is measured on a CRI scale (Colour Rendering Index) of Ra 0-100 with Ra 100 representing the best, which is equivalent to that provided by daylight. Figure 3 below shows the colour rendering characteristics of different light sources.

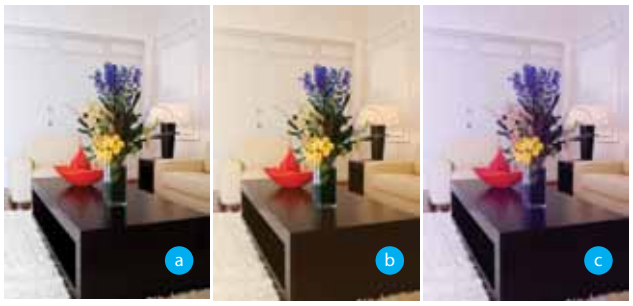

Fig.3 *Colour rendering characteristics of 3 different light sources*
(a) *Daylight = Ra 100,* ***(b)*** *Tungsten = Ra 100,* ***(c)*** *Single phosphor 'cool' white = Ra 58*

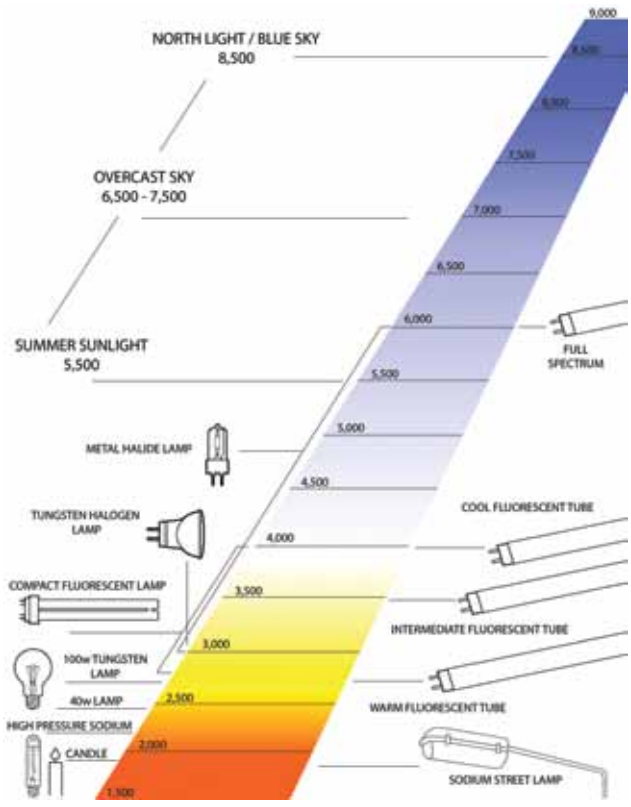

Fig.2 *Colour temperature (K) of various light sources*

APPLICATIONS IN LIBRARIES

For a full description of the different lamp types numbered here, refer to the Lamp Comparison Chart on the back page.

GENERAL AREAS

- Use luminaires with electronic control gear and a wide distribution.
- Use presence detectors in 'zones' to enable rarely used areas to be automatically switched off when unoccupied.

RECEPTION & ADMINISTRATION COUNTERS

- Highlight or 'accent' lighting can be used to create impact.
- Use either low voltage dichroic or LED lighting.
- For under shelf lighting use fluorescent lamps.

BOOKSHELVES

- Use luminaires with electronic control gear and a wide distribution to illuminate the shelves.
- Use presence detectors in the aisles to enable rarely used aisles to be automatically switched off when unoccupied.
- Always consider appropriate mounting positions for the detectors to avoid the lights in the aisle coming on when people pass by the end of the aisle.

BOOKSHELVES WITH DAYLIGHT

- When there is sufficient daylight entering the space it would be an advantage to automatically switch off the lighting using daylight sensors to the appropriate 'zones'.

BOOKSHELVES WITH CONTROLS

- The use of presence detectors in the aisles of shelving would enable energy and maintenance savings (leave the entry luminaire on during opening times to encourage entry into the aisle).

DISPLAYS

- Use highlight or 'accent' lighting.
- Use low voltage IRC versions of Dichroic/R111 Reflectors or LED lamps.

HERITAGE LIBRARIES

- Wide distribution lamps should be used as retrofit lamps in traditional luminaires.
- Light the edges of the books using localised LED strips which can be positioned vertically or horizontally in the shelving.
- Uplighting adaptations utilising existing pendants (for example) may provide more overall illumination, visual brightness and ambience.

LIGHT DISTRIBUTION

The most appropriate light distribution for libraries in general is to provide sufficient lighting over the whole area with higher lighting levels where required. Both downward lighting and asymmetrical distribution (where light is directed sideways by the luminaire), are appropriate. Figure 4a and Figure 4b show how this can be achieved in practice. Luminaires should be positioned parallel to bookshelves as shown in Figure 1.

Fig.4a *Light distribution for shelving and task areas*

Fig.4b *Light distribution for shelving*

LIGHT OUTPUT FROM LUMINAIRES

The luminaire is the complete lighting unit, consisting of the lamp, the housing/fitting and control gear and is important for achieving the right lighting distribution and light output. Select luminaires with the right light output and distribution for the particular application.

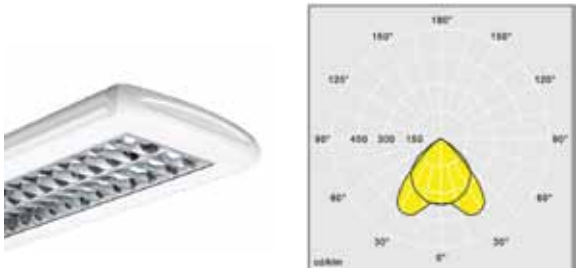

Fig.5a *The graph above shows that only 53% (LOR of 0.53)of the light from the lamps is emitted from this twin fluorescent luminaire with a reflector/louvre*

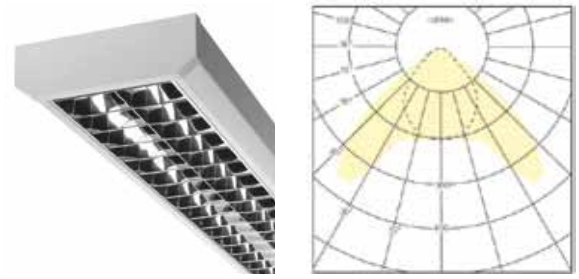

Fig.5b *The graph above shows that 81% (LOR of 0.81)of the light from the lamps is emitted from this twin fluorescent luminaire with a reflector/louvre*

Light Distribution

Light should be directed to the right part of the room using reflectors or diffusers, which can reduce or eliminate obtrusive glare.

Light Output Ratio (LOR)

The LOR is the proportion of the lamp light that emerges from the luminaire. The most popular type of louvred luminaire can have differing light outputs from 36% to 81%. Manufacturers provide graphical LOR information on their products, as illustrated here. Although the luminaires illustrated are similar, they have large differences in their light output ratios.

Choose the highest LOR to minimise the number of fittings that are required. This will reduce energy consumption and reduce maintenance and associated costs while still delivering the desired lighting levels and effect.

The luminaire in Figure 5a has a LOR of 0.53, i.e. only 53% of the light output from the lamp emerges from the luminaire, whereas the luminaire in Figure 5b has a LOR of 0.81, i.e. 81% of the light output from the lamp emerges from the luminaire.

Lighting Levels

The standard maintained illuminance (lux) required for library areas are:

- Bookshelves – 200 lux (measured on the vertical surface)
- General illumination – 300 lux (measured at floor level on the horizontal surface)
- Reading Tables – 500 lux (measured at task level on the horizontal surface)
- Counters – 500 lux (measured at task level on the horizontal surface)
- Study Tables – 500 lux (measured at task level on the horizontal surface)

More detailed guidelines on light levels for the a wide range of applications are available from the National Standards Authority of Ireland guide *I.S. EN 12464-1:2002 Light and lighting – lighting of work places – Part 1: Indoor work places.*

CONTROLS

- Use presence detectors for library areas that are infrequently used.
- Use a separate daylight sensor or a daylight sensor which is integrated within the presence detector for areas with good levels of natural light.
- An infra-red sensor reacts to changes in heat patterns and works best if wall mounted in cellular spaces rather than areas with aisles of bookshelves, partitions or cabinets which can block the detection beams.
- Ultrasonic and microwave sensors do not need a direct line of sight of the motion source to detect presence. They will detect very slight movement but this can sometimes lead to false signals, e.g. a draught moving a piece of paper, or movement beyond a glass window or partition.

Note: There is a separate SEAI guidance document on controls.

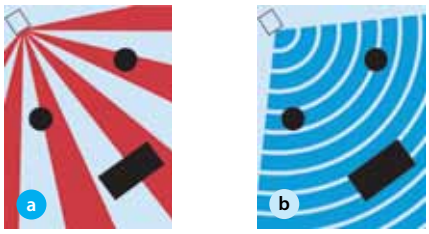

Fig.6 (a) *Infra-red and* ***(b)*** *sonic occupancy detection coverage*

MAINTENANCE

- Do not mount luminaires in positions where they will be difficult to maintain. Also consider the luminaire's effectiveness. Figure 7 illustrates how luminaires can be badly positioned. The ceiling and wall mounted luminaires are particularly ineffective and energy wasteful.

Fig.7 *Poor luminaire positioning wastes energy*

LAMP REPLACEMENT

There are great cost advantages to upgrading existing lamps and fittings, and recommendations for the most common lamp replacements are given below, complete with typical expected savings. Additional lamp comparisons are shown on Page 5. When replacing lamps, the new lamp should have comparable colour appearance and light output to the lamp it replaces. A proposed lamp type should be trialled in an area before widespread lamp replacement is embarked upon.

Existing Lamp Type	Replacement Lamp Type	Benefits
Incandescent GLS 40W 60W 75W 100W 150W	CFLi (integral ballast) 9W-11W 11W-14W 15W-19W 20W-25W 26W-29W	Up to 75% energy saving Up to 12 times the lamp life of an incandescent lamp – use 'warm white' (2,700 K) CFLi lamps
Mains Voltage Tungsten Halogen 35W 50W	CFLi (GU10 Fitting) 7W 11W	Over 80% energy saving 7 times the lamp life of tungsten halogen – Use for 'accent' or 'feature' lighting rather than general illumination – As the light distribution differs between these two lamp types lower light levels may be expected
Mains Voltage Tungsten Halogen Dichroic Reflector 35W 50W	Low Voltage (12v) IRC Tungsten Halogen Dichroic 20W 35W	40% energy saving 3 times the lamp life of mains voltage tungsten halogen
T12 (38mm) Fluorescent tube with conventional ballast	T5 (16mm) High Output fluorescent tube with electronic adaptor conversion kit 35W 50W	30 – 50% energy saving if the existing luminaires are using switch start or quick start electromagnetic ballasts – A conversion kit is required which includes the new electronic control gear (kits can also be used for T12 to T8 conversions) *Example: A 20W T12 lamp with switch-start control can be replaced with a 14W T5 tube. The conversion kits have a high frequency ballast available as a plug-on to the end of the T5 tube, so the original T12 fitting can be used.* Running cost savings = 6W x 8760 hours x €0.16 (per kWh) = €8.40 per year if lamp is on 24 hours/day. Further savings can be made by using fewer fluorescent tubes when the luminaires have opal or prismatic diffusers, which have no internal reflectors. The electronic adaptors are also available with 'clip-on' reflectors which can increase the luminaire light output by up to 50% and reduce the number of lamps required.
T8 (26mm) Halophosphor fluorescent tube	T8 (26mm) Triphosphor fluorescent tube	10% energy saving Twice the lamp life when used with electronic ballasts – Use electronic control gear

Note: *Always use reputable suppliers and products that comply with all national and EU lighting regulations. Trial newer products for their suitability before widescale upgrades. Refer to* ***www.seai.ie/aca*** *for energy efficient products*

LIGHTING TECHNICAL DETAILS

LAMP COMPARISON CHART

	Lamp Description	Lamp Image	Colour Rendering (Ra)	Colour Temperature (K)	Lighting Type				Lamp Life (Hours)
					General	Accent	Decorative Dendent	Table Top	
1	**Tungsten Lamps, GLS** Common low efficiency light source, Is hot and has short life (1,000 hours)		100	2,600	✗	✗	✗	✗	1,000
2	**Tungsten Halogen GU10** Mains voltage dichroic lamps provide approx. 35% of the illumination of (12V) IRC versions for the same wattage and have short life (1,500 hours)		100	3,000	✗	✗	✗	✗	1,500 - 8,000
3	**Mains Voltage Tungsten Halogen** These lamps save 30% energy when compared with GLS and have an expected life of 2,000 hours		100	3,000			✓	✓	2,000
4	**Compact Halogen Lamp c/w Integral Transformer-Low Voltage (12v) GLS** These lamps save 50% energy when compared with GLS and have an expected life of 3,000 hours		100	3,000	✓		✓	✓	3,000
5	**Mains Voltage GU10 CFLi** These lamps save 80% energy but they are only available in low wattages and therefore do not have high levels of illumination (lamp life 8,000+ hours)		80	2,700		✓			8,000+
6	**Low Voltage (12v) Tungsten Halogen Infra-Red Coated (IRC)** Infra-red Coated (IRC) versions are brighter and more efficient than standard (12v) tungsten halogen lamps and 300% brighter than GU10 mains voltage models with an expected lamp life of 5,000 hours		100	3,000	✓	✓			3,500 - 5,000
7	**Mains Voltage GU10 LED Lamps** Many models of high-efficiency LEDs are available with lamp lives of 50,000 hours		70-80	3,000 - 6,000	✓	✓			35,000 - 50,000
8	**T8 Triphosphor Fluorescent Tubes** Use T8 with Electronic High Frequency (EHF) control gear with a lamp life of 20,000+ hours		80	2,700 - 6,000	✓				20,000 - 60,000
9	**T5 Triphosphor Fluorescent Tubes** These tubes are available in High Efficiency (HE) and High Output (HO) with a lamp life of 16,000+ hours		80	2,700 - 6,500	✓				16,000+
10	**Compact Fluorescent Lamps (CFLs)** Use models with electronic high frequency control gear for higher efficiency with a lamp life of up to 12,000 hours		85	2,700 - 4,000	✓				8,000+
11	**Compact Fluorescent Lamps with Integral Control Gear (CFLi)** These lamps are available from 3W to 29W equal in lumen output as GLS from 15W to 150W and some dimming models are available		85	2,700 - 4,000	✓		✓	✓	8,000+
12	**Retrofit Inductive Lamps** This lamp is only available in 23W equal to a 100W incandescent lamp		85	3,000	✓				10,000+

Low Efficiency | Low/Medium Efficiency | Medium Efficiency | Medium/High Efficiency | High Efficiency

Efficacy is the ratio of light emitted by a lamp to the power consumed by it, i.e. lumens per Watt. Lamp efficacy values are available from SEAI's document, *"A guide to energy efficient and cost effective lighting."*

Lamp life is the expected operating life hours of the lamp. When lumens fall to 80%, this is the rated 'life' and when the lamp should be replaced.

Lux is a measure of illuminance, where one lux is defined as an illumination of one lumen per square metre. It can be determined from manufacturer's data or measured with a handheld digital lux meter.

General Lighting: Used to provide the main light source for the space or area.

Accent Lighting: Used to highlight an object or a particular feature of the space or area.

Table Lighting: Used to provide localised lighting on table-tops.

Decorative Lighting: Typically describes lamps in fittings used for visual effect rather than general illumination.

A tax incentive is available through the accelerated capital allowance (ACA) scheme for approved lighting products. Further information and details of manufacturers and suppliers of eligible products are available from **www.seai.ie/aca**

Accelerated Capital Allowance
Eligible Products www.seai.ie/aca

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