LIGHTING AGAINST CRIME
A GUIDE FOR CRIME REDUCTION PROFESSIONALS
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This guide will provide the reader with a basic understanding of some of the terminology used when discussing external lighting systems and the recommended levels of illumination used to combat crime, the fear of crime and antisocial behaviour.

It will not replace the expertise of a qualified Lighting Engineer but it will help in the sensible appraisal of an existing or proposed lighting system.

Throughout the guide the term "Good Lighting" will be used to encompass all the requirements of a high quality lighting installation that is effective, efficient and has appropriate values of illuminance, uniformity and maintenance.

Secured by Design – "Secured by Design is a police initiative to encourage the building industry to adopt crime prevention measures in the design of developments to assist in reducing the opportunity for crime and the fear of crime, creating a safer and more secure environment. Secured by Design is owned by the Association of Chief Police Officers and has the support of the Home Office Crime Reduction and Community Safety Group and the Department for Communities and Local Government."

This guide was compiled and written by Peter Kane, Crime Prevention Design Advisor, Metropolitan Police.

ACPO Secured by Design would like to acknowledge with grateful thanks John Brewis of The Institute of Lighting Professionals who provided the technical detail for this publication and supported the initiative throughout.

"We all like to feel safe, most of us would particularly like to be able to see that we are safe. In order to give us this opportunity at night it is important that those responsible for designing and specifying our built environment provide the most appropriate lighting conditions for where we live, work and play.

This guide is for use by architects, builders, planners, police officers or any other member of design teams who may not necessarily want to know about lighting but do need a basic knowledge of the subject and some technical terms so as to deliver successful developments for people to use at night. Targeted lighting improvements have been proven to reduce crime and the fear of crime and if design partners can discuss lighting values using a common language, they will find it easier to provide a higher quality of night time environment.

Designing out criminal opportunities and thereby making people safer is not the preserve of any single discipline and this guide can be used to establish common ground and language between those who are using light to make the public safer."

Peter Kane
Crime Prevention Design Advisor
Metropolitan Police
Good lighting is an amalgam of qualities and the following is a definition of the term.

A good lighting system is one designed to distribute an appropriate amount of light evenly with Uniformity Values of between 0.25 and 0.40 using lamps with a rating of at least 60 on the Colour Rendering Index. Good lighting will use energy efficient lamps in suitable luminaries. These luminaries will be positioned to minimise any light pollution so as to provide a high quality system only when and where required.

The definition explained:

1. An Appropriate Amount of Light
   Where the level of illumination provided is appropriate for the visual task to be undertaken and is suitable for the environmental conditions for the system.

2. Uniformity (Uo)
   The even distribution of light across the area being illuminated.

3. Colour Rendering
   The ability of lighting to show the colours of objects as close to their true tint, hue and tone as possible.

4. Colour Rendering Index (CRI)
   The method used to indicate the colour rendering properties of a lamp with values ranging from CRI 0 – CRI 100 (where CRI 100 represents the colour rendering qualities of condition close to natural daylight)

5. Light Pollution
   Where the lighting installation causes “nuisance” to others not directly involved.

6. Energy Efficiency
   The lighting equipment specified making efficient use of the electrical energy used.

The following sections will provide details of the good lighting components shown above and the methods used to meet the relevant criteria.
HOW MUCH LIGHT

The lighting of our external environment, the environs of buildings and the spaces between them, our public parks, leisure complexes, advertising signs, roads and pathways must be achieved in the most energy efficient way possible.

Poor design and specification are the most common causes of an inefficient or polluting lighting system and therefore the following questions are to be taken into consideration at the earliest possible stage of the design.

Do we need to light at all?
When safety and security are factors, it is often necessary to provide light but there may be circumstances, such as the lighting of remote foot paths across open spaces for instance, where lighting may encourage the undesirable use of the path.

How much light?
If lighting is necessary, then the values detailed in this guide for differing circumstances, from residential developments to public spaces, are acceptable under current standards.

Do light levels need to be adjusted?
The way the environment is used may produce circumstances where high levels of light are only required at specific times. Outside these times, when lower values of light can be used, a system of lamp dimming should be considered.

In order to set lighting in some context the following are approximate lighting levels, or values to be found in everyday situations.

(Lux is the measurement of light reaching a surface where 1 Lux is the amount of light from one candle one metre distant from a surface of 1 square metre)

**Average levels of illuminance in Lux**
- Sunny June day: 80000 Lux
- Bad light stopped play at Lords: 1000 Lux
- A well-lit office: 500 Lux
- Main road lighting: 15 Lux
- A residential side street: 5 Lux
- A clear moonlit night: 0.2 Lux

A form of lighting found in many domestic locations is a tungsten halogen flood light controlled by a movement sensor (PIR). There are a number of problems associated with this type of lighting:
- They only illuminate once a criminal has selected a target premises and has crossed the boundary.
- They emit a harsh light which can be intrusive and causes a serious nuisance to neighbours.
- They instantly switch on a powerful light source which, if poorly directed, can be hazardous for motorists using nearby roads.
- They can increase the fear of crime by repeatedly activating for no apparent reason.
- They are energy inefficient and require regular lamp replacement.

For these reasons they are not acceptable in Secured by Design approved schemes except as additional courtesy lighting, near to bin stores for instance.

In domestic situations it is possibly better to think of the quantity of lighting in terms of wattage rather than illuminance.

<table>
<thead>
<tr>
<th>Lamp Type</th>
<th>Watts/Sq Metre</th>
<th>Illuminance Level (Approx)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tungsten Halogen</td>
<td>3 watts</td>
<td>5-10 Lux</td>
</tr>
<tr>
<td>Compact Fluorescent</td>
<td>0.9 watts</td>
<td>5-10 Lux</td>
</tr>
<tr>
<td>High Pressure Sodium</td>
<td>0.6 watts</td>
<td>5-10 Lux</td>
</tr>
</tbody>
</table>
COMMERCIAL LIGHTING
Design specification and values

GOOD
- Place luminaires as high up as possible
- Energy efficient lamps
- Well designed luminaire
- Accurate design calculations
- Accurately-aiming luminaires aiming of luminaire
- Good uniformity of lighting (40%)
- A named staff member made responsible for arranging repairs and maintenance

BAD
- Low mounting height
- Luminaire with poor photometric control
- Passive Infra Red detection (PIR)
- Incorrect choice of lighting values
- Unprotected electrical cable
- Dark patches where uniformity values are below 25%
- Poor or no maintenance

Industrial Lighting
Design specification and values

GOOD
- Use highest practical mounting height
- Energy efficient lamps
- Well designed luminaire
- Good uniformity values (40%)
- Accurate aiming of luminaire
- Accurate design calculations

BAD
- A low mounting height
- Luminaire with poor photometric control
- Passive Infra Red Detection (PIR)
- Incorrect choice of lighting values
- Unprotected electrical cable

Average levels of illuminance (in Lux)
- Office interior (security) 05 Lux
- Private car parks 10 Lux
- Exterior Rural location 10 Lux
- Exterior Urban location 20 Lux
- Walkways 30 Lux
- Loading bays 50 Lux

The choice of luminaire will depend on factors such as:
- Mounting height
  Always use the highest practical mounting height available to reduce the total number of luminaires required but ensure that the luminaire remains accessible for maintenance.
- Area to be illuminated
  Determine the exact area to be illuminated and, following local consultation, pick the right luminaire bearing in mind that different luminaires have differing levels of photometric performance. In this way light pollution and trespass are prevented and only the designated area will be illuminated.
- Type of lamp
  Recommended “Dusk to Dawn” lighting makes it essential to use a lamp which has both a long life expectancy and is energy efficient.
- Luminaire type
  The luminaire selected will be determined by the above criteria as it applies to the area to be illuminated. The nature of the night time use of an area and the desired aesthetic appearance of the light fittings will also influence luminaire choice.
The lighting of public places and amenity areas or privately owned land to which the public have access will be the responsibility of Local Authorities or private land lords respectively but the lighting principles will remain the same.

**GOOD**
- Adequate illuminance levels
- Good uniformity
- Low light pollution
- Good aesthetic appearance
- Regular maintenance
- Vandal resistant equipment and materials

**BAD**
- Incorrect choice of luminaire
- Light pollution / trespass
- Unprotected column positions
- Poor maintenance

The aesthetic value of a lighting installation is an important consideration as the day time street scene suffers greatly if fittings, materials or paint finishes are of lesser quality. The shabby appearance of lighting street furniture can send the wrong signals to the community and contribute to a cycle of grime, crime and decline.

### Average levels of Illuminance in Lux
- Pedestrian only traffic: 20 Lux*
- Mixed vehicular and pedestrian: 30 Lux*
- Bus station passenger areas: 25 Lux*
- Urban large car park: 30 Lux
- Long stay: 15 Lux
- Urban small car park: 20 Lux
- Short stay: 15 Lux
- Long stay: 10 Lux
- Urban local car park: 10 Lux
- Rural large car park: 10 Lux
- Short stay: 15 Lux
- Long stay: 15 Lux
- Rural small car park: 10 Lux
- Short stay: 10 Lux
- Long stay: 10 Lux
- Rural local car park: 10 Lux
- Sports stadium and similar venues (Escape, Anti Panic): 30 Lux**

*Dependent on Environmental Zone (see Light Pollution section on page 24)

**Minimum for Stands and Exit Areas

### ROAD LIGHTING

The lighting of public places and amenity areas or privately owned land to which the public have access will be the responsibility of Local Authorities or private land lords respectively but the lighting principles will remain the same.

#### British Standard 5489:2003 and the European Standard CEN/TR 13201 provide guidance for the recommended standard of lighting for many different environmental circumstances, from busy roads and subsidiary routes to pedestrianised town centres and cycle paths.

The requirements for road lighting are covered extensively in European and British Standard particularly EN13201 and BS5489. These documents cover the lighting of public areas from amenity spaces to motorways.

It is not possible to provide a full explanation of the Standards in this document therefore the following information/extracts are intended as a guide only. Full compliance of the Standards requires the expertise of a qualified Lighting Engineer.

The following initial process is suggested:

1. Decide on the lighting class to be used from table B.4 in British Standard 5489-1:2003 considering the level of vehicular and pedestrian traffic, the type of environmental zone and the required colour rendering of the lamps.

2. An assessment of the crime and the fear of crime in the area should be made by consulting the local Police Architectural Liaison Officer (ALO) outside London or the Crime Prevention Design Advisor (CPDA) in London.

3. If street robberies or violent crime prevails in a given area, it might be advisable to use semi cylindrical lighting (illuminating people at face height rather than the horizontal surface they are standing upon). TR13201-1 provides the conversion figures.

### BS EN 13201-2:2003 Table 3. Lighting values for residential and subsidiary roads

<table>
<thead>
<tr>
<th>Class</th>
<th>Horizontal Illuminance (Lux)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum maintained</td>
</tr>
<tr>
<td>S1</td>
<td>15-22.5</td>
</tr>
<tr>
<td>S2</td>
<td>10-15</td>
</tr>
<tr>
<td>S3</td>
<td>7.5-11.25</td>
</tr>
<tr>
<td>S4</td>
<td>5-7.5</td>
</tr>
<tr>
<td>S5</td>
<td>3-4.5</td>
</tr>
<tr>
<td>S6</td>
<td>2-3</td>
</tr>
<tr>
<td>S7</td>
<td>Not determined</td>
</tr>
</tbody>
</table>

*Dependent on Environmental Zone (see Light Pollution section on page 24)

**Minimum for Stands and Exit Areas
The British and European Standards advise the lighting professional on many aspects of design such as the recommended levels of luminance and illuminance for specific situations, the figuration and siting of lighting columns and the mounting height and maintenance of luminaires.

An assessment of how much and what type of light is required in an area will be made not only by reference to this standard but also to the relevant Environmental Zone classification. Environmental zones, of which there are 4, reflect the environmental sensitivity of an area to types and levels of light. For example, bright lighting would not be allowed in National Parks but would be appropriate in busy city centres. (See page 18 for more detail).

The recommended levels of illumination under the British Standard are arrived at by consideration of the following criteria:
- Traffic volumes (both vehicular and pedestrian)
- Road configuration (are there junctions and/or roundabouts etc;)
- Traffic speeds
- Environmental Zone
- Lamp colour rendering index

The three general categories (classes) used are:
- ME - Traffic Routes (High/Medium speed)
- CE - Conflict Areas (Roads with junctions and or roundabouts etc;)
- S - Roads with predominantly Pedestrian, Cyclists and/or Slow moving traffic

<table>
<thead>
<tr>
<th>Reference class</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>S6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional class</td>
<td>E4</td>
<td>E5</td>
<td>E6</td>
<td>E7</td>
<td>E8</td>
<td>E9</td>
</tr>
</tbody>
</table>

CEN/TR 13201:01:2004 Table 5. Cross reference of lighting classes (extract)

<table>
<thead>
<tr>
<th>Class</th>
<th>Semi cylindrical illuminance E_min (Lux)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Es1</td>
<td>10</td>
</tr>
<tr>
<td>Es2</td>
<td>7.5</td>
</tr>
<tr>
<td>Es3</td>
<td>5</td>
</tr>
<tr>
<td>Es4</td>
<td>3</td>
</tr>
<tr>
<td>Es5</td>
<td>2</td>
</tr>
<tr>
<td>Es6</td>
<td>1.5</td>
</tr>
<tr>
<td>Es7</td>
<td>1</td>
</tr>
<tr>
<td>Es8</td>
<td>0.75</td>
</tr>
<tr>
<td>Es9</td>
<td>0.5</td>
</tr>
</tbody>
</table>

BS EN13201-2 Table 5. Lighting values for semi cylindrical illuminance

<table>
<thead>
<tr>
<th>Crime rate</th>
<th>Ra Value</th>
<th>Lighting class</th>
<th>Low traffic flow</th>
<th>Normal traffic flow</th>
<th>High traffic flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Ra &lt; 60</td>
<td>S5 S4</td>
<td>S4 S3</td>
<td>S3 S2</td>
<td>S3 S2</td>
</tr>
<tr>
<td></td>
<td>Ra ≥ 60</td>
<td>S6 S5</td>
<td>S5 S4</td>
<td>S4 S3</td>
<td>S4 S3</td>
</tr>
<tr>
<td>Moderate</td>
<td>Ra &lt; 60</td>
<td>S4 S3</td>
<td>S3 S2</td>
<td>- S1</td>
<td>- S2</td>
</tr>
<tr>
<td></td>
<td>Ra ≥ 60</td>
<td>S5 S4</td>
<td>S4 S3</td>
<td>- S1</td>
<td>- S2</td>
</tr>
<tr>
<td>High</td>
<td>Ra &lt; 60</td>
<td>S2 S2</td>
<td>S2 S1</td>
<td>- S1</td>
<td>- S2</td>
</tr>
<tr>
<td></td>
<td>Ra ≥ 60</td>
<td>S3 S3</td>
<td>S3 S2</td>
<td>- S1</td>
<td>- S2</td>
</tr>
</tbody>
</table>

BS5489-1 Table B4. Selection of class for residential and subsidiary roads
There are also three methods of stating the recommended lighting levels for roads which are:

**Luminance**
Where the brightness of the road surface is specified in candelas/sq metre. This method is used for Traffic Routes where vehicular traffic use is high, the principle being to provide silhouette vision whereby a vehicle or object appears in shadow against the brighter road surface.

**Illuminance**
Where the amount of light falling on an object is the criteria, this method is used for specifying the lighting requirements of residential roads and roads with junctions and roundabouts.

**Semi Cylindrical Illuminance**
Where the amount of light falling on a semi cylindrical surface is the criteria, this method is used to illuminate people's faces to aid recognition and the assessment of their intentions.

To arrive at an accurate recommended lighting level for a specific location requires the use of a selection matrix which takes account of the items already covered above and summarised below:

- Typical speed and type of the main road user
- Other types of user (or those excluded from use)
- Road geometry
- Traffic volumes
- Weather (predominantly wet or dry)
- Ambient luminance (Rural, Urban or City Centre)

Having made certain judgements based on these criteria, it is possible to identify the “Lighting Class” to be used. The class most relevant to this document is S which covers the lighting of residential areas (termed subsidiary roads in the British Standard and reproduced in full in Section 2).

The “S” specification ranges from S1 to S6. S1 is the brightest level and applicable to areas with high pedestrian or vehicular traffic flows or where there is a high crime rate or where a combination of these factors exists.

The recommended values of Horizontal Illuminance taken from the table range from:

S1 = 15 Lux to S6 = 2 Lux (with minimum values stated at 5 and 0.6 Lux respectively)

The value also takes into account the Colour Rendering Index (CRI) of the light source adjusted for lamps above or below a CRI of 60. The CRI is scaled from 0 to 100 and indicates the colour rendering qualities of the lamps. Where 0 is a non-existent ability to render colour under illumination, such as with Low Pressure Sodium Lamps, and a rating of 100 would be the colour rendering qualities of daylight.

Also to be considered is what Environmental Zone the location falls into (see Light Pollution section).
CLOSED CIRCUIT
TELEVISION (CCTV)

Design specifications and values

<table>
<thead>
<tr>
<th>Camera</th>
<th>Minimum illuminance in Lux</th>
<th>Overall Uniformity Not less than</th>
<th>Threshold Increment Not less than (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monochrome</td>
<td>5</td>
<td>0.4</td>
<td>10</td>
</tr>
<tr>
<td>Colour</td>
<td>15</td>
<td>0.4</td>
<td>10</td>
</tr>
</tbody>
</table>

Monochrome cameras will provide useable images under most lighting sources including Infra Red (IR) lighting. However, IR lamps have a practical range of approx 80 metres, beyond this extra IR lamps or another lighting source would be required.

Colour cameras need more light than black and white ones, and that light must be a quality light source with a CRI rating greater than 60 so as to produce an accurate colour rendering of the picture. Most colour cameras will not operate in colour mode under infra red lighting.

Camera specifications sometimes claim to work in lighting conditions as low as 0.5 Lux. However, the nature of the materials being photographed may affect this characteristic, e.g. grass is more reflective of light than a tarmac covered surface.

As a general rule: monochrome cameras will require a 5 Lux minimum level of horizontal illuminance and colour cameras a 15 Lux level of horizontal illuminance.

VARIABLE LIGHTING
Design specification and values

In the last few years new electronic control systems for street lighting have made the possibility of varying light levels available at a reasonable cost with good reliability. These systems will allow the lighting to be at full output when required, such as peak commuting times, and at an agreed lower level when there is little demand, for example in the early hours of the night. It can also be linked to a remote management system and/or local sensors that can bring the light level back up to 100% when needed. The level of dimming will vary with lamp type; for example with typical lamps used in Street Lighting:

<table>
<thead>
<tr>
<th>Lamp-type</th>
<th>Dimming Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Son</td>
<td>100% – 20%</td>
</tr>
<tr>
<td>Metal Halide</td>
<td>100% - 50%</td>
</tr>
<tr>
<td>Fluorescent</td>
<td>100% - 1%</td>
</tr>
<tr>
<td>LED’s</td>
<td>100% – 0%</td>
</tr>
</tbody>
</table>

This will allow significant energy savings whilst still providing a uniform level of illumination instead of switching off lights after a curfew time. It is recommended that a consultation process to include key participants be undertaken to agree when lighting levels could be reduced and by how much.

Dimming gives the flexibility to be efficient with light levels
**UNIFORMITY**

The appropriate lighting of places and spaces is like spreading butter on toast; it is no good having it only around the edges and you do not want just a big lump in the middle; it needs to be spread evenly across the slice. In terms of lighting, this even quality is called Uniformity, it is represented on lighting plans by the symbol Uo and is a ratio of the minimum illuminance level to the average illuminance level.

A Uo value of 0.4 or 40% is recommended to ensure that lighting installations do not create dark patches next to lighter patches where our eyes would have difficulty in adjusting quickly enough for us to see that it was safe to proceed along any route.

The evenness of light distribution is almost always more important than the levels of illumination being achieved by the system. The exception would be if the Lux levels were so low that a Uo value of 0.4 would only mean a good distribution of an insufficient amount of light. A 0.4 Uo value is a good standard for Secured by Design developments but it could, in a few cases, be argued that it is neither achievable nor appropriate for various technical reasons. In these circumstances the very best levels of Uo should be achieved under the prevailing circumstances but not permitted to fall below a Uo rating of 0.25.

The horizontal Uo ratio referred to above can be calculated by dividing the minimum point Lux level by the overall average level as follows. NB Common sense needs to also be applied to ensure that the uniformity is calculated for a visual scene that lies within the field of view of an observer. e.g. if the minimum point value lies around a corner then it is probably meaningless to take it into consideration but if it is in the middle of the car park then it is highly relevant to the calculation.

If a lighting system has a minimum of 8 Lux and an average of 20 Lux, divide 8 by 20 which results in a value of 0.4 (sometimes expressed as 40%). Therefore the Uniformity value for this lighting system would reach the recommended 0.4 Uo value. An example of this is shown below:

**ISOLUM DIAGRAMS**

IsoLux diagrams give a graphic representation of the light distribution of a given lighting installation. Just as map contours indicate the height of the land above sea level, the lines on an IsoLux diagram represent the amount of light at any point in the area it is proposed to illuminate.

The diagram above shows a floodlight (indicated by the black square) mounted at 8 metres above ground level lighting an area 24m x 16m showing the illumination levels (in Lux) as contours.

The levels shown are based on 1000 lumens of lamp output therefore requiring the calculated figure to be multiplied by the total lamp output in lumens divided by 1000.
COLOUR RENDERING

Colour rendering qualities of light refers to their ability to reproduce the colour of objects being illuminated.

To help in the selection of a light source a measure is given to this effect and uses a scale of 0 to 100 where 100 is the perfect colour rendering ability of daylight and 0 is no colour rendering ability. When stating a lamp’s colour rendering properties, the above scale is used and stated as either the Colour Rendering Index (CRI) or Ra.

The first picture opposite is taken under lighting with an Ra rating of 0 and the second under lamps with an Ra rating of 20 followed by the third which as an Ra rating of 80.

There are two ways in which the colour of a lighting installation is referred to:

Colour Appearance
This is the description of the apparent colour when someone views the source of light. A common description of Low Pressure Sodium street lighting is that it is an orange light.

The following table gives an indication of the colour rendering properties of popular lamps:

<table>
<thead>
<tr>
<th>Lamp Type</th>
<th>Colour Rendering Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tungsten Filament (GLS)</td>
<td>100</td>
</tr>
<tr>
<td>Tungsten Halogen (TH)</td>
<td>100</td>
</tr>
<tr>
<td>Fluorescent (MCF/U)</td>
<td>50 to 90</td>
</tr>
<tr>
<td>Compact Fluorescent (CFL)</td>
<td>85 to 95</td>
</tr>
<tr>
<td>Low Pressure Sodium (SOX)</td>
<td>0</td>
</tr>
<tr>
<td>High Pressure Sodium (SON)</td>
<td>20</td>
</tr>
<tr>
<td>White SON (SDW)</td>
<td>83</td>
</tr>
<tr>
<td>Metal Halide (MBi)</td>
<td>65 to 90</td>
</tr>
<tr>
<td>Ceramic Metal Halide (CDM)</td>
<td>85 to 95</td>
</tr>
<tr>
<td>Light Emitting Diode (LED)</td>
<td>66 to 80</td>
</tr>
<tr>
<td>Cosmopolis White (CPW)</td>
<td>80</td>
</tr>
<tr>
<td>Cosmopolis Gold (CPG)</td>
<td>20</td>
</tr>
</tbody>
</table>
Light pollution occurs when unwanted light falls outside the area intended for illumination. Unnecessary, excessive or badly designed and installed systems that allow light to go upwards or trespass outside the target area are wasteful and are of no benefit to anyone.

Light pollution wastes precious natural resources, adversely affects the lives of animals, is a common cause of complaint when it shines into neighbouring property and makes the night sky too bright for astronomers to view the stars as demonstrated below.

Older street lighting installations are a major cause of ‘urban sky glow’. Poorly designed and installed domestic lighting that has lamps of a high wattage and is switched by a Passive Infra Red detector will often cause light pollution. A survey by the Institution of Environmental Health Officers in 1994 revealed this to be the most complained about source of lighting in the UK.

In order to reduce light pollution we need to consider the following:

- Is it necessary to provide lighting? If lighting must be provided then it is important to make sure that the level of light is appropriate. More light is not necessarily better and care must be employed to ensure that the light levels are right for the circumstances and commensurate with the risk and fear of crime.
- High Uniformity values make for effective lighting systems.
- Careful specification of lamp types make the system fit for purpose. Lights that can be turned down when less illumination is required should be considered. When lighting is installed make sure it only illuminates the area it is intended for.

Local Planning Authorities use the following method of specifying restrictions on exterior lighting within their Development Plans.

The criteria is based on four “Environmental Zones” which relate to a particular environment and are specified as:

- E1 Intrinsic dark landscapes—National parks & areas of natural beauty
- E2 Low district brightness areas—Rural, small village or relatively dark urban locations.
- E3 Medium district brightness areas—Small town centres or urban locations.
- E4 High district brightness areas—Town/city centres with high levels of night-time activity.

The table at the foot of the page sets out the criteria for each of the four Zones. Some definitions used within the table are:

- Curfew – this is the time after which stricter requirements for the control of obtrusive light may apply a suggested time being 23.00 hrs.
- ULR – Upward Light Ratio is the amount of light expressed as a percentage of the total installation which is permitted to go directly into the sky.
- Source Intensity – this is the intensity of the actual light source outside of the area being illuminated.

Clean Neighbourhoods and Environment Act 2005
The act makes it a statutory nuisance to create light pollution. Therefore if advising on lighting it is of paramount importance that light spill into adjacent properties is assessed, not only before planning, but also after installation.

Light pollution will be reduced by the use of appropriate lamps, luminaires and switching gear, thereby ensuring that the light is on at the right time and illuminating only the intended target area.
ENERGY EFFICIENCY

LAMP TYPES AND THEIR LUMENS PER WATT

The energy efficacy of lighting is the ability of the light source, that is the lamp or what some refer to as the bulb, to convert electricity into light. Energy efficiency is expressed in lumens per watt and indicates how much light, or lumens of light, is produced by the lamp for each watt of electricity it consumes.

In addition to a lamp’s quality in terms of its colour rendering abilities, the lamps lumens output and its life expectancy must be considered. The choice of lamp will normally take account of these three considerations as well as lumen depreciation (which is the speed with which the amount of light emitted by the source diminishes. This is generally rapid for a source like Metal Halide and also LEDs. The table below identifies these factors for a selection of popular lamp types.

<table>
<thead>
<tr>
<th>Lamp Type</th>
<th>Lumens per Watt</th>
<th>Average Life (hrs)</th>
<th>Colour Rendering Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tungsten</td>
<td>10 to 12</td>
<td>1,000</td>
<td>100</td>
</tr>
<tr>
<td>Tungsten Halogen</td>
<td>12 to 22</td>
<td>2,000</td>
<td>100</td>
</tr>
<tr>
<td>Fluorescent</td>
<td>50 to 95</td>
<td>18,000</td>
<td>50 to 90</td>
</tr>
<tr>
<td>Compact Fluorescent</td>
<td>80 to 90</td>
<td>10,000</td>
<td>85</td>
</tr>
<tr>
<td>Low Pressure Sodium</td>
<td>160 to 190</td>
<td>16,000</td>
<td>0</td>
</tr>
<tr>
<td>High Pressure Sodium</td>
<td>85 to 120</td>
<td>20,000</td>
<td>20 to 60</td>
</tr>
<tr>
<td>White Sodium</td>
<td>35</td>
<td>10,000</td>
<td>83</td>
</tr>
<tr>
<td>Metal Halides</td>
<td>80 to 100</td>
<td>15,000</td>
<td>65 to 90</td>
</tr>
<tr>
<td>Ceramic Metal Halides</td>
<td>90</td>
<td>12,000</td>
<td>85 to 95</td>
</tr>
<tr>
<td>Light Emitting Diodes</td>
<td>65*</td>
<td>50,000</td>
<td>66 to 80</td>
</tr>
</tbody>
</table>

The compromise that lamp choice can present is illustrated below with the Low Pressure Sodium lamp. This lamp type produces more lumens per watt than any of the others and has a long average life expectancy but has a colour rendering index rating of a mere 0. With these characteristics in mind, careful consideration of what people want the light to do for them is paramount.

THE JARGON OF THE LIGHTING PROFESSIONAL

Colour Appearance
This means the ‘apparent’ colour of the lamp when looking directly at it. In general terms lamps are classed as ‘cool’, ‘intermediate’ or ‘warm’. This colour appearance is defined by the colour temperature of the lamp and is measured in Degrees Kelvin (K). A cool lamp would be rated at about 4000K, an intermediate lamp at 3500K and a warm lamp at about 3000K.

Colour Rendering
The term is used to describe the effect the lamp has on the perceived colour of objects being viewed by the human eye. Lighting that is being provided for safety, security and for fear of crime reducing purposes should have good colour rendering qualities i.e. a rating of 60 or above on the Colour Rendering Index. This is particularly true if CCTV is to be deployed or if describing suspects for criminal offences is likely to be an issue.

Some lamps have a very poor colour rendering qualities, the most common being Low Pressure Sodium lamps which have in the past been used all over the country in road lighting and have a distinctive orange glow.

Colour Rendering Index
The Colour Rendering Index (CRI) scaled from 0 to 100 indicates the colour rendering qualities of lamps. 0 is a non-existent ability to render colour under illumination, such as Low Pressure Sodium (SOX) lamps, and a rating of 100 would be the colour rendering qualities of daylight. The whiter the light the better the colour rendering qualities. Appropriate levels of controlled white light will illuminate an area to higher levels of satisfaction and security for people and for this reason SOX lighting is no longer suitable for use in Police approved Secured by Design schemes.
IP Rating
An IP rating is the numerical method of defining the effective sealing of a luminaire, the enclosed structure that holds the lamp. Luminaires need to be protected from the ingress of dust and moisture because if these elements do penetrate the luminaire, the lamp will be obscured and the amount of light reaching the target area will be reduced.

The rating is defined by two digits:
First Digit 0 to 6 defines the degree of protection against contact with electrically live terminals where 0 = no protection and 6 = total protection.

Second Digit 0 to 8 defines the degree of protection to the ingress of liquid where 0 = no protection and 8 = protection against indefinite immersion in water.

IK Rating
The IK rating denotes the level of shock resistance of a luminaire and is defined by ratings ranging from IK1 to IK10 where 1 specifies an impact 0.14 joules of energy and 10 is 20.00 joules of energy.

To put these values in perspective, a steel ball bearing fired from a catapult could typically exert 18 joules of energy.

Light Pollution and Light Nuisance
Light pollution and light trespass are general terms used to describe circumstances where light has been allowed to get into areas where it is not wanted and where the lighting design did not intend it to go. It is sometimes referred to as light trespass, though light nuisance is the legally correct term to use.

This diagram shows a number of examples of light pollution, from upward light, which produces a sky glow effect and obstructs the observation of the night sky, to light trespass into windows that is obtrusive and causes a nuisance.

Mounting Height
The Mounting Height of lighting is an important factor when designing an installation, whether in an office where lights are fixed to the ceiling or externally where lighting is to be installed on the wall of a building or on a column or post. Generally speaking, the higher up a lamp is fixed, the bigger the area of illumination but a higher mounting height will require lamps with greater lumen outputs.

Lumen
Lumens measure the total flow of light energy from a lamp. As heat is given off from a central heating radiator so lumens is visible energy emanating as light from a lamp.

Luminance
Is the term used for the amount of light reflected back from a surface and reaching the eye and it is measured in candelas per square metre.

Lux
This is the measurement of light reaching a surface where 1 Lux is given by one lumen falling evenly on a square metre.

1 Lux is the light from 1 candle 1 metre away from a surface of 1 sq metre.
APPENDIX

Obtrusive Light (see Light Pollution)

Re-strike Time
Restrike refers to the time a ‘discharge’ lamp takes to come back on following an interruption to its power supply.

The re-strike characteristic of a lamp is a major consideration when choosing lamps to be used where large crowds of people may be present at night such as at sports grounds or in city centres.

Run Up Time
This is the term used to describe the time a discharge lamp takes to reach its full lumen output from initial switch on (If a lamp of this type is inadvertently switched “off” this run up time may be doubled due to the lamp needing to cool before it will re-strike).

Spacing
This means the spacing between luminaries - either wall or column mounted - and has a major bearing on the levels of uniformity a lighting system will achieve.

Threshold Increment
Threshold increment is the measure of the loss of visibility caused by disability glare of the luminaries.

Uniformity (Uo)
Uniformity is a measurement of how evenly light is being distributed across a designated area. Higher uniformity values will mean that bright areas of illumination are not adjacent to patches of darkness as these are circumstances within which the human eye finds it very difficult to see clearly.

In order to calculate the Uo value of a lighting system the minimum levels in Lux are divided by the average levels in Lux.

Secured by Design standards ask that lighting Uniformity values for developments achieve a value of 40% or 0.4Uo.

Vertical Illuminance
Vertical illuminance is used to light objects or people in the vertical plane. It is the measure of light delivered at a sufficient height from the ground to enable people to recognise the expressions on the faces of other pedestrians. Areas suffering from high levels of street robbery or where CCTV is being used benefit greatly from high values of vertical illuminance.

Semi Cylindrical Illuminance
Semi cylindrical illuminance is used in reference to measuring the quality of a street lighting installation with respect to the facial recognition of a person.

The Building Regulations
Amendments to The Building Regulations Part L1 for new buildings states the following:

“A way of keeping within reasonable design limits would be to enable effective control and/or the use of efficient lamps such that:

a. Either lamp wattage does not exceed 150 watt per luminaire and automatically switches off:

When there is adequate natural light AND
When it is not required at night

b. or the luminaire should have a lamp holder, which allows lamps with an efficacy greater than 40 lumens/watt to be installed.

Compact fluorescent lamps would meet the standard in (b) whilst GLS tungsten lamps with bayonet cap or Edison screw bases, or Tungsten halogen would not.”