Guidance Note

CONTROLLING LIGHT POLLUTION AND REDUCING LIGHTING ENERGY CONSUMPTION

smarter scotland
SCOTTISH EXECUTIVE

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INTRODUCTION

BACKGROUND TO GUIDANCE NOTE

1. This Guidance Note has been prepared to support the Partnership Agreement[1] commitment to reduce light pollution and save energy by specifying appropriate lighting standards. This Guidance Note is also referenced to in the Lighting Environmental Protection Regimes Annex of The Scottish Executive's Planning Advice Note 51: Planning Environmental Protection and Regulation.[2] There are no specific legislative controls on light pollution, but the Scottish Executive are considering adding artificial light pollution to the list of Statutory Nuisances under Part III of the Environmental Protection Act in 2007 when a suitable legislative vehicle becomes available. This has been done for England and Wales, commencing April 2006.

COLLABORATIVE WORKING BETWEEN ORGANISATIONS

2. Environmental Protection Regimes operate alongside the land use planning system which aims to ensure that development takes place in suitable locations and is sustainable, while also providing protection from inappropriate development. Planning Advice Note 51 summarises the statutory responsibilities of the environmental protection bodies, as well as informing these bodies about the planning system. To minimise any overlap or duplication of controls it is essential that planning authorities and the protection agencies understand each other's role and work together so that the controls are applied in a complementary way. This is important because many environmental protection decisions are based on quantitative standards whereas planning decisions have to take into account a much wider range of material considerations and the weight to be accorded them. It has been documented in the Institution of Lighting Engineer's 2006 Annual Conference that close working between planners and local authority lighting engineers is having an impact in reducing the amount of light pollution. It is recommended that collaborative working takes place between the relevant local and central government organisations responsible for lighting, planning and environmental issues.

OBTRUSIVE LIGHT AND ENERGY EFFICIENCY

3. Light in itself is not a pollutant and in the context of this document the term Obtrusive Light has been used throughout. Obtrusive lighting installations have a negative impact on the appearance of the night-time environment and can lead to complaints about the quality of their installation. In recent years there have been concerted campaigns, led mainly by the Campaign for Dark Skies to reduce the level of Light Pollution that can be seen above all our major cities. The application of the recommendations in this Guidance Note, along with the use of modern lighting units can help reduce this light obtrusion into our night skies.

4. Poor lighting designs can result in a waste of valuable energy which is at odds with the Scottish Executive's climate change policy[3] of reducing the country's overall energy usage. It is therefore essential that lighting installations are both efficient in their application and in their use of energy. This Guidance Note is intended to encourage developers, architects and lighting designers to consistently provide non obtrusive and energy efficient lighting designs.

5. Well designed lighting installations can provide very positive benefits to communities through the reduction in the perceived risk of crime, the enhancement of general public safety and generally adds to the feeling of well-being of a community through the positive message that well maintained lit areas provide. However the converse is equally true and care should be taken in the design of new and refurbished lighting installations to maximise the aforementioned benefits from good design practice.

6. Obtrusive Lighting is presently not classed as a Statutory Nuisance in Scotland, although in England and Wales it now can be. There are plans however to add light pollution to the statutory nuisance regime in Scotland in the near future, which should be taken into account when considering the guidance on Applicable Lighting Situations referred to in paragraph *7*.

APPLICABLE LIGHTING SITUATIONS

7. This Guidance Note relates to all exterior lighting situations no matter the size or location of the lighting project or whether it is a stand alone project or part of an overall development. Potential developments and lighting situations include but are not limited to:

- Industrial Developments
- Retail Developments
- Housing Developments
- Transport Interchanges
- Roads and footpaths (either stand alone or as part of an overall development)
- Exterior Sports Grounds and Arenas
- Feature Lighting for Civic Enhancement, including both man made structures and naturally occurring ones
- Illuminated Advertisements
- Refurbishment of existing lighting installations, both large and small

PURPOSE OF GUIDANCE NOTE

8. This Guidance Note provides guidance on the factors that require to be considered and the actions to be undertaken to ensure that non obtrusive and energy efficient exterior lighting installations are provided and operated throughout Scotland.

9. The Guidance Note is not intended to provide detailed guidance relating to the design, installation or operation of any particular lighting situation, but to provide general guidance that should be followed by developers, architects, lighting designers and those involved in the design, delivery and operation of lighting infrastructures whether as stand-alone projects or as part of an overall development. Recommendations are also included for local authorities with respect to developing a lighting policy and inclusion of self certified documents recommended in this Guidance Note with the consent management process.

10. This document is not intended to cover the problems associated with poorly installed domestic security lighting which is covered as part of a document published by the Department for Environment, Food and Rural Affairs.[4]

APPLICATION OF GUIDANCE NOTE

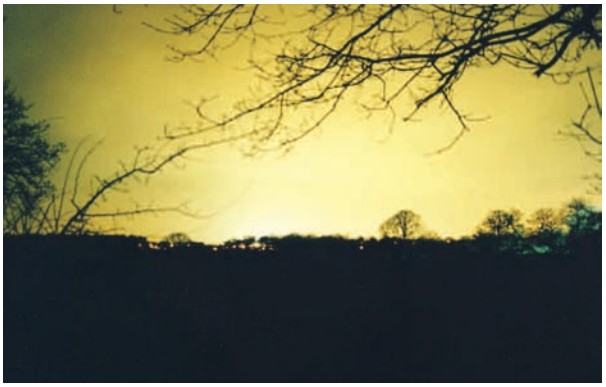
11. Developers, architects, lighting designers and lighting installation contractors should apply the guidance provided within this document. It is essential that developers, architects and lighting designers ensure that the lighting design process, operational statement and installation records to record compliance are prepared for provision to each local authority in accordance with their relevant consent management process. Local authorities staff have a central coordinating role in having this Guidance Note adopted as part of the overall design process.

WHAT IS OBTRUSIVE LIGHT?

12. There are five effects associated with obtrusive light and these are as described in paragraphs 13 through to 17.

13. **Sky Glow**, can occur in two different forms:

Sky Luminance



Site Aura

Sky Luminance occurs when direct upward light reacts with and is diffused through clouds, mists, and airborne particles that exist in the atmosphere. The area and brightness of the resultant sky luminance is entirely dependent upon the presence and quantity of these various diffusing elements and the level of upward light being distributed from the luminaire.

Site Aura occurs in the same way as sky luminance but is related to those lighting effects caused by indirect light reflection local to the lighting installation and is normally restricted to a dome of light issued upwards from the locality of the surface being illuminated.

14. **Light Presence**

Where light emitted from a light source or that projected on to an area or building, can be viewed from outside the area it was provided for, and causes minimal visual discomfort but fails to reach an intrusive level, then this is termed “light presence”. This light presence may draw attention to the existence of a lighting installation, or structure that was previously inconspicuous by day.

Light Presence

Glare

Intrusion

15. **Glare**

This is perhaps the most serious form of obtrusive light and can cause a general visual discomfort, which can seriously impair vision with poorly designed lighting installations. The impact of glare is dependent upon the quantities and directional nature of the glare source, the physiological status and age of the person affected, the general nature of the area in which the glare effects occur, and the surrounding levels of ambient lighting.

16. **Intrusion**

Light trespassing into an area beyond the intended illuminated subject areas, such as into adjacent residential properties. Light intrusion may be the result of a single source or multiple light sources acting together, none of which need be a source of glare. The same measured value of light intrusion is likely to be less of a problem in a well lit urban area than in a previously unlit rural situation.

17. **Flicker**

The periodic, often deliberate, flickering of light used for advertising and attraction-seeking purposes can prove to be distracting and like glare, promote degrees of irritation, annoyance and distress. The rate of flicker and the duration of exposure can cause over-stimulation of electrical activity to the human brain. Over exposure to and excessive stimulation by flicker and similar lighting such as strobe lighting has been known to induce attacks in people who suffer with epilepsy or migraine.

BASIC LIGHTING ENERGY PRINCIPLES

18. The unit into which the lamp is fitted is called a luminaire and all luminaires are required to comply with the relevant European standards. However, in terms of light distribution there can be a wide variance in the light distribution characteristics of differing luminaires and this is an important factor in delivering the required lighting performance and subsequently its energy efficiency: All luminaires used in any lighting scheme should be of a consistent type throughout.

19. In general, the closer the light appearance is to white light then the greater is the energy required to provide the same light output (lumen). However, the whiter the light the greater the visual recognition, and this can result in lower quantities of light being necessary to provide the same task illumination.

20. Although not directly associated with this Guidance Note it is important that health and safety matters are considered for all installations, particular the maintainability of the lighting installation.

LIGHTING POLICY

21. To assist developers, architects, lighting designers and local authority staff in applying a consistent approach to the provision of lighting it is recommended that local authorities document their lighting policy. This policy can be a short statement embracing the principles of this Guidance Note or a more detailed document that in addition to embracing the principles of this Guidance Note provides further details about the Local Authority's Lighting Policy.

22. Where a local authority already has a documented lighting policy the policy should be modified to make reference to this Guidance Note.

23. The Lighting Policy or parts thereof should be referred to or included within relevant local authority public documents.

24. Further guidance about the development of a lighting policy is detailed in the Institution of Lighting Engineers publication - TR24 "A practical guide to the development of a public lighting policy for Local Authorities" (1999),[5] the previously mentioned document published by the Department for Environment, Food and Rural Affairs[4] and the UK Roads Liaison Group document "Well-lit Highways".[6]

EXAMPLE OF SHORT LIGHTING POLICY STATEMENT

25. Where a local authority does not have a formal lighting policy then the following bullet points provide a basic lighting policy statement that can be readily applied.

- The lighting design shall comply with the lighting levels, uniformity and other parameters of current and relevant lighting standards and higher than recommended lighting levels should be avoided.
- In addition to selecting suitable lighting quality objectives that comply with current standards the lighting appearance shall be commensurate with the ambient luminance of the surrounding area. Four environmental zones are now internationally recognised, see Annex A Stage 7, and the design will require to show that control of overspill light is limited to the level required by the particular environmental setting. The local authority may be able to provide guidance on the selection of an applicable Environmental Zone necessary to comply with their night-time environmental strategy plan.
- The lighting design should follow the lighting design process described in this Guidance Note and the relevant information should be recorded and passed, where requested, to the local authority in accordance with their consent management process. The information recorded should be of a good standard to enable the lighting submission proposal to be evaluated. All lighting proposals should be submitted with a completed Lighting Design Check List as provided in Annex B.

- The proposed lighting equipment shall comply with current standards and to the greatest extent possible, the luminaries and their settings should be optically set to direct light only to where it is required and to minimise obtrusive effects and where necessary additional shielding should be considered.
- The installer of the proposed lighting shall comply with the approved design and no changes shall be permitted to this design unless the installer submits a revised lighting design submission proving that the change does not lessen the light quality objectives achieved by the original approved design. It is the responsibility of the developer to ensure that the lighting being installed in the development does not cause obtrusive light.
- To minimise obtrusive light a condition shall be attached to lighting consents that requires the developer to comply with this Guidance Note.
- The lighting design shall consider measures that ensure that the lighting installation is resistant to vandalism and can be readily maintained throughout its intended life.
- In architectural lighting situations the lighting infrastructure shall not detract from the day-time appearance of the structure and wherever possible shall be located so that as far as is practicable it is concealed from view.
- Lamps burning during daylight hours are a waste of energy and the public shall be provided with the necessary information on reporting such faults with Local Authority owned lighting.
- To minimise the spares holding of the Local Authority the designer may be required to select lighting equipment from a Local Authority approved range of lighting materials.
- Where possible, consideration should be given to switching off lighting when it is not required and the developer should prepare a Lighting Operational Statement as recommended within this Guidance Note.

26. To develop a design that considers the overall night-time environment it is essential that the lighting designer follows a common design process. This design process should be followed for all lighting designs and the outputs readily available for the local authority to evaluate the lighting design. The lighting design process that should be followed by the lighting designer is contained in Annex A and a Lighting Design Check List is contained in Annex B and these should be available with the consent submission.

OPERATIONAL STATEMENT

27. The consent submission should contain an operational statement that details how the lighting installation or how each different lighting situation submitted will be operated. The purpose of this is to ensure that the developer and the lighting designer have considered operational regimes that can provide energy savings. For example in a retail development the operational statement would confirm that the access road lighting would be group switched from a photocell but that the car park areas will be switched off/dimmed from an hour after the retail centre closes to an hour before the retail centre opens. The lighting designer should consider the use of the car park areas when the retail centre is closed in terms of both retail centre security and public safety when determining which lighting units should be switched off/dimmed.

28. The operational statement shall provide details of how the lighting will be maintained in terms of gaining access to each luminaire. The purpose of this part of the operational statement is to ensure that the lighting designer has fully considered the maintenance issues. For example a simple statement could be that all road and car park luminaries would be maintained from a tower wagon and that footpath columns would be hinged. The lighting operational statement shall indicate the proposed lighting maintenance regime required to address circumstances that are wasteful of energy.

INSTALLATION OF THE LIGHTING DESIGN

29. It is important to realise that the overall performance of any lighting installation depends on both the equipment used and on its correct setting up. Any changes, substitutions or errors can have a profoundly negative impact on the resulting lighting installation performance. The designer will produce a scheme using specified luminaires with a unique distribution, optical settings, lamps, mounting heights and aiming angles and it is therefore essential that the luminaire used in the installation complies precisely with the light output characteristics of the luminaire specified in the original design for the final results to be acceptable. Even superficially similar luminaires can have markedly different optical performances and in all situations the luminaire selected by the designer and approved by the local authority shall be used. Other parameters of the design such as the mounting height of the luminaire, the spacing between columns and any luminaire tilt or any luminaire lamp position are equally critical in obtaining the design performance envisaged and if not complied with by the installer they also may have a detrimental impact on the overall lighting performance.

30. To enable the developer to self certify that the lighting installation complies with the lighting design the developer shall require the installer to complete a Lighting Installation Check List as included within Annex C.

MEASURES TO MINIMISE USE OF ENERGY

31. It is clearly important that the lighting designer considers the overall energy requirements of the installation in the final design. In addition to ensuring that the design limits obtrusive light and complies with the appropriate lighting design standards, it is important that the lighting designer should consider the electrical distribution design to take into account operational requirements and ensure the utilisation of energy efficient equipment.

A number of energy efficiency measures are listed below.

- Full consideration and preparation of the Operational Statement.
- Ensure that modern and energy efficient luminaires are used throughout.
- Ensure the use of luminaires that distribute light efficiently and that the correct optic and lamp positions are selected and adhered to for the required design.
- Electronic lamp control equipment can provide more energy efficient installations than that provided by standard wire wound ballast units.
- Ensuring that the specified capacitor is used to maximise power factor correction.
- An electrical design that allows sections of lighting not operationally required to be switched off or dimmed.
- The use of energy efficient LED light sources should be considered where possible.
- Further energy saving measures are detailed on both the UK Road Lighting Board and the Institution of Lighting Engineers websites.

CONCLUSION

32. Minimising obtrusive light and reducing lighting energy usage are important environmental factors and compliance with this Guidance Note should result in the provision of a lighting design that minimises both obtrusive light and reduces the energy required to provide the necessary level of lighting for any installation. The key responsibility lies with those designing any lighting to ensure that obtrusive light is not caused by their lighting design. The developer also has the responsibility that the lighting installer installs what is detailed in design. As concluded in PAN 51 it is the responsibility of planning authorities and the environmental protection bodies to collaborate in the task of protecting the environment, and to apply controls so that duplication is minimised and overlap is avoided whenever possible.

ENQUIRIES

33. General Enquiries about this Guidance Note and requests for further copies should be addressed to Scottish Executive, Enterprise Transport and Life Long Learning, Transport Group Bus, Freight and Roads, Area 2-F, Victoria Quay, Edinburgh EH6 6QQ or by contacting telephone number 0131 244 0848.

34. Technical enquiries about this document should be addressed to Transport Scotland, Buchanan House 58 Port Dundas Road, Glasgow G4 0HF or by contacting telephone number 0141 272 7380.

35. A copy of this Guidance Note is also available on The Scottish Executive website at www.scotland.gov.uk.

36. Lighting Units and Terms

lumen	A unit of light (luminous flux) emitted from a point source of one candela intensity, usually expressed in kilolumens - **(kLm)**.
candela	A unit of luminous intensity radiated in a particular direction.
illuminance	The quantity of luminous flux incident upon a unit area, expressed as lumens per square metre or **lux**.
luminance	The luminous intensity (or brightness) of a surface or source expressed in terms of surface area, i.e. candelas per square metre.
reflectance	The reflection factor (or index) of a surface or material.
inter-reflection	The result of various reflections.
efficacy	In lighting terms - the value of light obtained per unit of electrical energy input, i.e. **lumens per watt.**
wattage	The nominal load rating of a lamp (excludes any allowances for associated operating gear losses).
luminaire	The total package of lantern, lamp and all associated integral items of operating control gear.
projector	A special luminaire designed to provide a concentrated pattern of light.
skylight	The variable brightness value of daytime sky caused by sunlight scattered by particles of dust and vapour in the earth's atmosphere (skylight can reach values in excess of 2000 candelas per square metre).
moonlight	The luminous flux emitted by the moon received at the earth's surface at an average value of between 0.2 and 0.4 lux (a rural surface under moonlight conditions will have an average brightness of about 0.002 candelas per square metre i.e. 1/500 cd/m^2).
sky glow	The variable brightness value of night-time sky caused by upward components of light from direct and inter-reflected light off the earth's surface (the brightness of sky glow is dependent on the amount of upward light and the presence and density of atmospheric particles and their distance above ground level).
aura	The hemisphere of light rising up from ground level encircling a light source or lighting array caused by low level mist and fog particles.

ANNEX A – LIGHTING DESIGN PROCESS

Introduction to the Lighting Design Process

Applications for external lighting installations are often presented to local authorities in formats that make it difficult to appraise the overall lighting design, both visually and technically.

To improve the quality of both the design and of the information provided with the application a structured lighting design process should always be employed. When employing this design process detailed consideration should be taken to ensure that obtrusive light is minimised and that measures are taken to minimise the use of electrical energy. The lighting design process detailed in Table A1 can be employed for both large and small scale lighting designs. The stages in this process indicated as essential, are those that should be undertaken as the absolute minimum in order to achieve a compliant lighting design and provide the documentation essential for the submission assessment. By following this design process the lighting designer is encouraged to appraise any potentially negative effects of obtrusive light in conjunction during the development of the lighting design. This is in preference to the appraisal being carried out as a discrete study after the design has been finalised when it is often too late to make any alterations.

The lighting design process draws on technical information explained in other publications listed in the Bibliography and the stages of the design process form the index to this Annex. The design process follows the chronological order usual to a lighting designer's design stage methodology plan. Generally within each stage there is an explanation of the importance for the inclusion of each stage in the lighting design process and details of the lighting designers action and output required.

TABLE A1 LIGHTING DESIGN PROCESS

Stage	Requirement	Stage Name
1	Essential	**Statement of Client Needs/Operational Statement**
2	Essential	**Site Survey**
3	Essential	**Critical Viewpoints**
4	Desirable	Existing Lighting Conditions
5	Desirable	Baseline Conditions
6	Essential	**Task Analysis**
7	Essential	**Establishment Environmental Setting**
8	Essential	**Lighting Design Objectives**
9	Desirable	Lighting Design Methodology
10	Essential	**Calculated Predictions**
11	Essential	**Obtrusive Light Calculation**
12	Essential	**Comparing Design with Baseline Values**
13	Desirable	Designer's Critique
14	Desirable	Viewpoint Visualisation
15	Desirable	Virtual Walkthrough
16	Desirable	Surface Colour Schedule
17	Essential	**Luminaire Schedule**
18	Essential	Energy Usage
19	Essential	**Schedule of Luminaire Profiles**
20	Essential	**Layout Plan**

STAGE 1 - STATEMENT OF CLIENT NEEDS/OPERATIONAL STATEMENT (ESSENTIAL)

As part of this design process the lighting designer should establish and document the precise design requirements along with any local design constraints and to the greatest extent possible confirm the developer's overall lighting requirements. As part of this process the lighting designer should consider all the information required to prepare the operational statement described in paragraphs 27 and 28 of this Guidance Note. Any general lighting policy requirements of the local authority should also be determined at this stage and if necessary a preliminary submission should be made if the lighting project is large, or of an unusual nature or associated with a listed building or conservation area. Other affected external parties and special interest groups should be consulted at this stage.

The output of this process should list any issues that require to be addressed by the lighting design and by the operational statement. An operational statement should be provided with the submission.

STAGE 2 - SITE SURVEY (ESSENTIAL)

It is not unknown for a lighting design, for reasons of economy, to be conducted without the lighting designer ever having visited the development site. Even with a site survey it is not always possible to immediately identify all the potential lighting problems of an installation. Failure to carry out a site survey can create serious deficiencies in the lighting designer's overall understanding of the lighting environment and of what property and land will be impacted on by the proposed lighting installation. This lack of a site survey may place a risk on the designer with respect to the Construction Design and Management (CDM) obligations and to other health and safety legislation duties.

The site survey is the starting point for a baseline study from which various visual and technical elements may be identified. This survey should include the location and identification of all existing lighting equipment in the area, in terms of equipment type and their wattages. This information is required to complete the requirements of Stages 3, 4 and 5. Additionally the survey should record site access restrictions which could have an effect or constraint on the intended lighting design and on the subsequent maintenance of the lighting equipment.

STAGE 3 - CRITICAL VIEWPOINTS (ESSENTIAL)

All new lighting installations will be overlooked by various parties and it is therefore essential that the lighting designer selects and considers the relevant viewpoints of these parties. When the lighting statement is carried out in conjunction with a landscape impact assessment then it is important to maintain the same critical landscape viewpoints from where the magnitude of the day-time visual impact of the new development will be quantified in non technical terms. By following the process in Stage 11 the lighting designer can quantify the visual aspects of the lighting in terms of the four or five measured or calculated light control values. However, luminaire orientation can sometimes provide different night-time visual priorities to those produced by day-time visual aesthetic techniques and it may be necessary to identify additional viewpoints or alternative installation options to address these night-time sensitive locations.

Residential properties close to new developments should always form the most important viewpoint and there are recommended illuminance levels on the night-time light levels that impinge on these properties. However, distant viewpoints, with a clear view of the development may require the need for glare limiting measures. It is often the magnitude of this light intensity, which provides the major source of complaint. If there is only one critical viewing direction then the lighting designer can use this to direct light away from the affected observer but not to the detriment of other viewpoints.

From each critical viewpoint the importance of each of the 5 light limitation values, viz. overspill; sky glow; light into bedroom windows; line of sight (source) intensity and overall building brightness, will vary relative to each of the different viewpoints and human interest. The inclusion of a Table of Importance in the lighting design submission, example shown in Table 3.1 below, will demonstrate the designers approach to visual risk analysis.

TABLE 3.1 EXAMPLE TABLE OF IMPORTANCE

Viewpoint at	Overspill	Sky Glow	Light into Windows	Source Intensity	Building Luminance
Location 1	Medium	Low	High	High	Medium
Location 2	High	Low	Low	High	Low
Location 3	High	High	Nil	High	Low
Location 4	High	High	Nil	High	Nil

STAGE 4 - EXISTING LIGHTING CONDITIONS

The assessment or measurement of existing lighting conditions has to consider both the lighting situation immediately adjacent to the application site and the general ambient luminance of the local area.

Existing Lighting Situation
Some light limitation values are based on maximum permissible limits. Lighting effects are accumulative and if an adjacent residential window illuminance has already reached its maximum recommended limiting value, then the new development should show that it has been designed to provide for a zero increase in illumination on that property. It is therefore inappropriate in an application to merely state that the limit will not be exceeded without stating the existing baseline criteria. The lighting designer should assume that there is no record kept of existing illuminance values and undertake the design relative to site measured or calculated levels.

Existing Ambient Luminance
Unless the local authority has produced a night-time environmental strategy plan it is necessary for the lighting designer to assess the existing ambient luminance condition of the area (see Stage 7) so that the control of stray light from the new design can be shown to be commensurate with and not exceeding existing conditions.

STAGE 5 - BASELINE CONDITIONS

To support the requirement of Stage 4 a baseline table showing calculated or measured values at defined locations should be prepared. If there is no existing lighting in the area prior to the new development being implemented there is no need to establish the baseline measurements.

When measurements, or calculations, are undertaken, values of illuminance should show whether they have been measured horizontally or vertically, providing their height from ground level.

STAGE 6 - TASK ANALYSIS (ESSENTIAL)

Most tasks have a particular lighting quality objective published as a recommended value but it is sometimes necessary to compare that task with other similar operations where there are no specific task recommendations. The essential point at this stage is to show that the lighting design quality objectives are not excessively high by comparing the design objectives with other similar task lighting recommendations.

An example of this can be found in the lighting for sports grounds where there are different lighting levels recommended for the playing of individual games. Applications often show the average illuminance that the design has achieved without declaring the playing requirement and thereby possibly using more energy than is needed.

The submission should clearly state the lighting quality objectives that have been complied with and the publication from which the lighting quality objectives were selected as detailed in Stage 8.

STAGE 7 - ESTABLISH ENVIRONMENTAL ZONE (ESSENTIAL)

The lighting designer shall require to determine the relevant environmental zone either by making reference to the local authority's lighting policy or by self assessment. Nationally recognised environmental zones are defined as follows, together with typical topographical areas:

E1:	*Intrinsically dark Areas*	*National Scenic Areas*
E2:	*Areas of low district brightness*	*Rural or small village locations*
E3:	*Areas of medium district brightness*	*Urban or small town locations*
E4:	*Areas of high district brightness*	*Large town or city centre with high levels of night time activity*

The lighting designer should clearly indicate which zone has been selected together with the justification for selecting that zone.

STAGE 8 - LIGHTING DESIGN OBJECTIVES (ESSENTIAL)

This should take the form of a short section where the designer creates a technical picture of the predicted "lighting technical parameters" which the development will be designed to achieve. The lighting quality will be described in terms of illuminance (volume) and sometimes luminance (brightness) and should be compared with a professionally published recommended lighting quality objective.

The lighting designer has access to many sources of published data and should state the source document(s) from which the data used in his design has been extracted. A good design will compare lighting quality recommendations with other publications and equivalent task related recommendations when an exact task fit has not been found in published data.

STAGE 9 - LIGHTING DESIGN ITERATIVE METHODOLOGY

There is often more than one method of achieving the same lighting quality objectives and the lighting designer will often consider these different methods as a general assessment at the pre-design stage. The various options are often not considered worthy of documenting and only one option is normally presented in the application to assist in simplifying the approval stage. However, it is now important to show alternative considerations where there are electrical energy implications and this point is reinforced later (see Stage 13 - Designer's Critique).

For larger projects small areas are sometimes used for trial calculations to demonstrate typical lighting levels for different options. For each option the designer should be assessing the likely implications of potentially obtrusive situations. CIE Report 150:2003 has a section showing a matrix of known pitfalls and the benefits of different design options as a generalised flowchart.

This iterative process of design and appraisal can identify at an early stage any perceived weaknesses in the design, preventing the abortive work that could result should the obtrusive light reduction process be conducted at the end of the design process. Again the process of change as the design progresses is not often documented to avoid presenting a perceived weakness in the design methodology but if this is documented correctly it can show the local authority that external concerns have been allowed for and how the design has been constrained to accommodate the concerns.

STAGE 10 - CALCULATED PREDICTIONS (ESSENTIAL)

It is essential that all applications contain details of the light level calculations showing a horizontal grid of predicted values of not only for the task area but also for the overspill area beyond the site limits. There are many computer programmes available which can perform these two simple tasks but only a few have integrated the processes necessary to calculate potential obtrusive light impact values as outlined in Stage 11. In order to assist in visual recognition of the task area horizontal light overspill, relative to surrounding properties, the computer software should be able to import suitable mapping of the adjacent area and display this in conjunction with horizontal predictions.

Calculated assessments are normally based on laboratory measured intensity values radiating at various angles from the luminaire. Each luminaire has a unique photometric fingerprint of light distribution and calculated predictions are only correct for the particular luminaire make and type selected for the calculation. As

indicated in paragraphs 29 and 30 care should therefore be taken at the installation checking stage to ensure that the same make and type of luminaire is installed as that proposed in the original design.

Substitute luminaires cannot therefore be assumed to produce the same fingerprint and consent should always be conditional on the luminaire type, mounting height, quantity, lamp type and wattage and luminaire orientation being as used in the prediction being maintained through to installation.

STAGE 11 - OBTRUSIVE LIGHT CALCULATIONS (ESSENTIAL)

The ILE Guidance notes and the CIE Report 150 provide lighting designers with national and internationally recognised technical limitations on obtrusive light levels. The design should therefore be carried out in conjunction with the monitoring of these calculated limits as an iterative process as the design progresses and not at its end when it may be too late to influence the final design. However, regardless of this point in time no application should be accepted which does not clearly outline the calculated values for all, or at least the first three, of the following items.

A Direct line of sight of the light emitted from luminaires is probably the principal source of obtrusive lighting complaints as it can produce the offensive glare effect that is referred to in the Introduction. This is light radiated directly from the luminaire where the limits quoted by the ILE and CIE relate to intensity values from individual luminaires when viewed from external view points into the site.

It is normal practice to calculate that the design mitigates the recommended limiting values, shown in the table below, from the critical viewpoints identified at Stage 3.

Source Intensity	**E1**	**E2**	**E3**	**E4**
Pre Curfew (cd)	2500	7500	10000	25000
Post Curfew (cd)	0	500	1000	2500

B Light intruding in through property windows can be predicted by calculating values on a vertical grid representing a window, or series of windows. The recommended limits are additive to what is already being experienced, pre development. If the pre development limits, shown in the table below, are already exceeded, the new design will require to show, by calculations, that zero light intrusion will be provided by the new development.

Intrusion Control	**E1**	**E2**	**E3**	**E4**
Pre Curfew (LUX)	2	5	10	25
Post Curfew (LUX)	1	1	2	5

Both A and B above are essential elements in proving that the new development proposal will mitigate the majority of residents' concerns and in the case where the development requires the use of all night lighting the more onerous **"post curfew"** limiting values should be chosen as the maximum limit.

C The upward light ratio will vary between individual luminaires depending on the respective tilt angles and light distribution in their intended installed arrangement. Since the upward light ratio calculation is done for the complete installation the proposal application should state the individual luminaire elevations against which the calculation is based. Many quality luminaires produce a 0% upward light ratio at zero degrees of tilt but will produce an upward light ratio of 2.5% with 10° of tilt. Some luminaires can produce as much as 50% upward light ratio at tilt angles greater than 40° and if this was the case then the lighting installation could rightly be classed as being an obtrusive and inefficient lighting solution.

Sky Glow Control	**E1**	**E2**	**E3**	**E4**
Upward Light Ratio	0%	2.5%	5%	15%

It should be remembered that the purpose of any lighting installation is to illuminate an area and will normally be projected downwards on to the desired area, be it road or area lighting. It is how this downward light is managed and its effects mitigated and controlled that are important: there will always be a degree of reflected upward light. Although the evaluation covers the direct upward component of light from the complete installation it does not include the light reflected upwards from the ground. Neither the ILE nor the CIE have defined or quantified this reflective element since no two developments have the same ground cover. As a general rule the darker the building or ground cover surfaces are, the lower the upward reflected component and conversely the lighter and wetter the building or ground cover then the higher the upward reflected component will be.

D The effect of glare, as viewed by an external observer, can be controlled by limiting the viewed intensity as described in **A**, however, sometimes it is necessary to carry out a second glare assessment with sports lighting to protect the interests of spectators and players. This calculation process is additional to that already carried out in **A** and is not a substitute evaluation.

E An additional glare evaluation may be required to protect the interest of all road users, including pedestrians and cyclists. The term Threshold Increment (TI) has been used in street lighting quality assessment calculations for at least 15

years but its use is now being extended to ensure that vehicle drivers are not subjected to a threshold increment level greater than 15% from non-street lighting installations situated adjacent to a public highway. Again this is an additional assessment and is not a substitute for the requirements described in A and should be carried out as a cumulative process with the existing street lighting provision included in the calculation.

F Building luminance is normally only carried out for structures, which are architecturally transformed at night by the application of illuminating techniques. Different surface textures and colours reflect light in different proportions and any luminance calculation should include for a schedule of surface colours and reflection factor characteristics to be assumed in the calculation process.

G The calculation of the combined effects of direct and upward reflected light is generally unnecessary, and as stated in **C**, there are currently no national or international recommended limits on measuring success or failure with a proposed lighting design. It can, however, be used to good effect to demonstrate a visual comparison between the old and new lighting installation techniques. It can also be used to demonstrate the difference in upward reflections where new lighting has been designed in conjunction with landscaping techniques that soften their effect by reducing the area allocated to hard landscaping.

STAGE 12 - COMPARING DESIGN WITH BASELINE (ESSENTIAL)

A robust design methodology will carry out those assessments (Stage 11) as part of an iterative process during the formulation of the design. This iterative process involves providing trial assessments of the likely outcome of different lighting arrangements in small trial pockets within very large projects. In this way the impact assessment, in technically calculated magnitudes, can be formulated as the overall design progresses.

Since some of the light spill control values are based on cumulative lighting results, it is important to carry out calculations or take varied measurement assessments of the existing lighting arrangement to show that the new design overspill does not impinge or provide excess values when added to the existing arrangement.

Where an existing lighting arrangement has been calculated or measured to be providing excessively obtrusive light values but does not form part of the new development it may be judged unfair to over-constrain or penalise the new

development for a previous generations' over-lighting techniques. However, it may be possible to encourage the new development to enlarge the scope of their lighting assessment to provide alternative arrangements for the existing lighting to reduce the overall impact when the combined lighting values are found to be over the obtrusive limit recommendations.

STAGE 13 - DESIGNER'S CRITIQUE

A robust design will have often considered different elements and applications during the formulation stage, and the application may only have the final version to approve or reject. In providing a critique the lighting designer can outline some or all of the lighting options, which have been considered together with the technical reasons for not progressing with some of these lighting options. This can assist the local authority in reaching a decision without referring the proposal back to the lighting designer with the request to *try something different.*

STAGE 14 - VIEWPOINT VISUALISATION

In addition to the calculations necessary to prove that the design does not produce obtrusive light towards the critical viewpoints the production of a lit environmental model can add visual simplicity to what can, for many, be a very complicated and technical presentation.

There are several visualisation software packages now available, however, the construction of an electronic model can be an expensive and labour intensive process and not all projects warrant this additional overhead cost.

STAGE 15 - VIRTUAL WALKTHROUGH

The production of a virtual walkthrough is the "icing on a cake" and can only be provided as a result of producing an electronic model of the installation as described in Stage 14. However, its main advantage is that different viewpoints, other than the critical ones, can be considered and "visualised".

STAGE 16 - SURFACE COLOUR SCHEDULE

All electronic virtual artwork relies on the construction of electronic model surfaces and some software produces very lifelike images. Lighting calculation software, which uses the light distribution fingerprint particular to an individual luminaire manufacturer's production model, does not have as wide a range of surface textures to visualisation software which has no lighting calculation facilities. Lighting calculation software relies on the designer creating a natural daytime colour match and a night-time reflection factor to create the model.

A general analysis of the electronic model surfaces should be provided in the form of a schedule containing all the surface colours, in terms of the general colour description, the red/yellow/blue co-ordinate reference and the light reflection factor characteristics.

At the application stage this information is not essential to illustrate compliance with most common light control analysis but it does become important when the building luminance requires to be analysed. It also becomes important in demonstrating which version of the colour scheme has been used in the design calculations, particularly so where building material changes have been made during the structure design stage.

STAGE 17 - LUMINAIRE SCHEDULE (ESSENTIAL)

The luminaire schedule forms an essential element in both the approval and the subsequent construction stage of the development. The schedule should contain, as a minimum, the seven items listed below which determine the luminaire's potential performance in terms of the following:-

A **Luminaire light distribution type and bowl type** (often included in a manufacturer's catalogue number).
B **Lamp type and wattage.**
C **Mounting height.**
D **Orientation direction** (between 0º and 359º with 0º relative to a declared point in the development plan. Some software calculation algorithms use North and others use East as 0º but all use an anti-clockwise direction as the angle increases).
E **Luminaire tilt** (between 0º and 90º and the greater this angle the greater the potential for producing obtrusive light in the form of viewed intensity and upward light ratio).
F **Lamp position** (optic setting).
G Type of control gear.

With some calculation software the orientation and tilt are given as a composite X,Y,Z co-ordinate relative to the main calculation grid, e.g. on a sports field, and this sometimes makes it difficult to make a quick visual assessment of the luminaire orientation and elevation relative to distant property outside the site boundary. Most software calculation processes have an automatic conversion process and although the designer may have used an X,Y,Z co-ordinate to accurately aim each floodlight, relative to the playing surface, the software can automatically convert this

3-dimensional number into a 2-angle notational representation of the same positional aim without additional design work. The 2-angle system is easier to visualise at the application appraisal stage.

STAGE 18 - ENERGY USAGE (ESSENTIAL)

There is currently no government legislation covering the limitations on the electrical load for external lighting installations, equivalent to that which exists in Building Regulations for new interior lighting projects. However, there are two values that can be utilised to indicate the efficiency of a proposed lighting installation.

1. The first and foremost being the electrical load distributed over the area of the site in watts per square metre. This value is likely to become the key measurement of the installation efficiency in the same way that the current Building Regulations attempt to limit the use of less efficient light sources.
2. The second value may be the total lamp lumens per square metre of development in an attempt to prove that the use of less distribution efficient luminaires has been mitigated in the design.

Neither of these two methods directly demonstrate obtrusive light mitigation and should not be used in isolation since their main function is to show an energy control factor. An example of recent landmark projects results, using luminaires with high quality light control, are shown in Table 18.1 below. Budget priced luminaires will often return higher watts per square metre.

Table 18.1 Energy monitor target examples

	Road	Port Dock	Town Square
Average	7.5 lux	25 lux	50.0 lux
Uniformity	0.35	0.3	0.28
Watts/m^2	0.2	0.34	1.7

The lighting designer should review the market place to ensure that the most efficient luminaire, control gear and lamp are employed to minimise the watts/square metre required to provide the required lighting level.

STAGE 19 - SCHEDULE OF LUMINAIRE PROFILES

On large projects it is often necessary to utilise different types of luminaire to light specific areas effectively and efficiently, however care should be taken to limit a proliferation of design types throughout the design.

The luminaire schedule should provide pictorial images together with design reference numbers, manufacturer's catalogue numbers and a cross reference to the luminaire schedule prepared as part of Stage 17.

Luminaire manufacturers usually produce composite data sheets for their luminaire range but this can sometimes be too general to be included in an application and are not precise enough to itemise exact model and beam distribution proposed for each luminaire type included in the design.

STAGE 20 - LAYOUT PLAN (ESSENTIAL)

This is the last item of the 20-point design process and is essential for presenting accurate details of the proposed lighting equipment layout. It is not the only information that should be provided and it is essential that the layout plan be submitted along with all other information indicated throughout the design process. The layout plan is another form of visualisation as far as the application is concerned and it is important to include details of the surrounding landscape, property and existing lighting arrangements to assist in creating a more comprehensive picture that indicates that the developer and lighting designer have considered the baseline lighting conditions and that the new lighting proposal minimises possible obtrusive light.

The layout plan should show the new column and luminaire positions together with a reference number for each location necessary to provide a relationship with the luminaire schedule described in stage 17 and each luminaire orientation should be shown by an extended line from the mounting location. The location and details about all other lighting equipment should be indicated on the layout plan together with any other details that may be specifically required by each local authority.

SUBMISSION STAGE

When the developer/lighting designer has prepared all essential information as indicated in the design process the Lighting Design Check List in Annex B should be completed to indicate what is included in the application submission package. The number of copies required shall be specific to each local authority.

ANNEX B – LIGHTING DESIGN CHECK LIST

Lighting Design Stages	Required by Local Authority	Provided by Proposal Designer	Designer / Developer Notes
Statement of interested parties' comments	✓		
Survey of surrounding night environment	✓		
Identification of critical viewpoints	✓		
Establishment and calculation of existing lighting conditions	✓		
Summary of baseline measurements and/or calculations	✓		
Analysis of task lighting level recommendations	✓		
Establishment of environmental light control limits	✓		
Statement of new lighting design quality objectives	✓		
Outline of iterative lighting design methodology	✓		
Calculated measurement of task working area(s)	✓		
Overspill area(s)	✓		
Obtrusive light calculation of property intrusion	✓		
Viewed source intensities	✓		
Nominal glare assessment	✓		
Direct upward light ratio	✓		
Building luminance	✓		
Combined upward illuminance grid	✓		
Compare design achievement with baseline values	✓		
Designer's critique of final design constraints	✓		
Viewpoint visualisation	✓		
Virtual walkthrough of illuminated site	✓		
Schedule of model reflection factors	✓		
Schedule of luminaire types, mounting height and aiming angles	✓		
Schedule of energy usage and distribution	✓		
Schedule of luminaire profiles	✓		
Layout plan with beam orientation indication	✓		

ANNEX C – LIGHTING INSTALLATION CHECK LIST

Environmental and Local Data

Environmental Zone	E1	E2	E3	E4

Local Environs	Coastal/Rural/Urban/Residential/Mixed/Industrial/ANOB
Development Type	Residential/Industrial/Commercial/Car Park/Sports/Other
General Topography	Hilltop/Hillside/Essentially Flat/Valley Side/Valley Floor
Nearest Feature	Public Path ...m Traffic Route ...m Road Junction ...m
	Railway ...km Navigable Waterway ...km Airport ...km

Equipment Details							
Posts/Columns					**Lamps**		
Mounting Height (m)	Manufacturer	Catalogue Reference	Tilt (Degrees) Max / Min	ULR (%) at Max'm	Type	Wattage	RA Index

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3 Changing Our Ways: Scotland's Climate Change Programme
http://www.scotland.gov.uk/Publications/2006/03/30091039/0

4 *"Assessment of the Problem of Light Pollution from Security and Decorative Lighting"*
http://www.defra.gov.uk/environment/localenv/light/pdf/lightpollution-templereport.pdf

5 Institution of Lighting Engineers publication - TR24 "A practical guide to the development of a public lighting policy for Local Authorities" (1999) Link to Institution of Lighting Engineers Home Page
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The following documents provide related information and guidance on good lighting practice for all forms of lighting installation.

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[2]	ILE Guidance notes for the reduction of obtrusive light	Free download at www.ile.org.uk
[3]	Guide on the limitation of the effects of obtrusive light from outdoor lighting installations CIE Report 150:2003	Society of Light & Lighting CIE Publications 222 Balham High Road London SW12 9BS
[4]	Guidelines for Landscape and Visual Impact Assessment	Landscape Institute and IEMA Spon Press ISBN 0-415-23185-x
[5]	Lighting Guide No 4 Sports + others e.g. Sports Council, Lawn Tennis Association	CIBSE Society of Light & Lighting 222 Balham High Road
[6]	The Outdoor Lighting Guide 2005	The Institution of Lighting Engineers ISBN 0-415-37007-8
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[10]	PAN 51 Planning, Environmental Protection and Regulation (Revised 2006)	The Scottish Executive Publications
[11]	NPPG 11 Sport, Physical Recreation and Open Space	The Scottish Executive Publications (available from website only)
[12]	Assessment of the Problem of Light Pollution from Poorly Installed Domestic and Security Lighting	ODPM March '06 (Now available from the DEFRA website)

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